Scientific Papers. Series B, Horticulture. Vol. LXVII, No. 2, 2023
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

EFFECT OF CLIMATE CHANGES ON THE GRAPEVINE PHENOLOGY

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Abstract

This research presents a summary of the observed winegrape phenological characteristics and trends. Thirteen wine grape accessions maintained in germplasm collection considered old, autochthonous and neglected genotypes at risk of extinction were analysed for their main phenological evolution. The weather data are recorded from 1979 to 2023, and the phenological data were compared for the last 3-year period. Changes are usually greater at minimum temperatures than maximum temperatures, with an average study-year warming of 1.55°C during the growing season over the multi-year analyzed 1970–2020. Results showed 5 to 14 days earlier budding, 8 to 23 days earlier flowering onset. 'Rară albă' genotypes, the advance for the beginning of flowering was 23 days earlier in 2023 and 21 days earlier in 2022, compared to the beginning recorded in 2021. The advancement of the phenological stages of the vine is similar in other countries with a continental climate and not only, and the risk of the extension of late frosts has increased.

Key words: *grapevine phenophases, climate parameters, Vitis vinifera L., Stefanesti germplasm collection.*

INTRODUCTION

Phenology as a study of phenological events, or the stages of plant development that occur during their active life cycle is in strong relatedness with the climatic conditions from growing area. Any change in the morphological aspect of the plants, or the moment of expression of this change represents, the first biological indicator that highlights the effect of climate change on vine development (Cameron et al., 2021).

Worldwide, the frequency of extreme weather events recorded during the recent decades had a negative influence on the phenology of the grapevine.

The accelerated increase, from year to year, of the average monthly temperatures, as well as the large changes in the amounts and distribution of precipitation, especially during the growing season, had direct effects on the onset and duration of plant development periods, determining new challenges in terms of stress for vine plant adaptation (Bock et al., 2011). The changed climatic conditions strongly affect not only the quantity, but also the quality of harvested grapes, meaning: sugar concentrations, acidity levels in must and wines, and modified varietal aroma compounds.

In addition to climatic conditions, numerous studies have shown that grapevine genotype, vineyard location and pruning techniques are important factors influencing grapevine phenology (Gatti et al., 2016). These separate factors, or as a whole, influence the initiation of budding, flowering, changes in ripening periods, implicitly in the technological activities carried out in the vineyard and finally wine characteristics (Tiffon-Terrade et al., 2023).

For Romania, as in most countries with a millenary tradition in wine production, climate change is a topic of great interest to researchers (Dejeu et al., 2008; Bucur and Dejeu, 2016).

Viticulture in Romania is increasingly faced with climatic phenomena with increased risk to the life cycle of plant culture.

The purpose of the present study is to evaluate the influence of climatic factors (temperature and precipitations) on the main phenological phases of grapevines from *ex situ* Germplasm Collection of NRDIBH Stefanesti, Arges.

The analysis of the stages of annual plant development is important for proper planning of technological activities as well as for maintaining the genetic diversity in the viticultural germplasm collections.

MATERIALS AND METHODS

The study was carried out in the *ex situ* germplasm collection located at the NRDIBH Stefanesti, Arges county. The wine-growing area is characterized by a humid temperate-continental climate, according to the multiannual averages (period 1979-2021), with an average annual temperature (T_{mean}) of 11.06°C and the amount of precipitation of 781.5 mm per year.

From 1979 to 2010, there was a continuous record of weather data with instruments read by a meteorologist four times a day. Since 2010, all measurements were recorded by an IMETOS automated weather station at Spectrum. The weather station is equipped with sensors Watermark Soil Moisture Sensors 6450WD, sensors to read temperature, relative air humidity, wind speed, solar radiation.

The main meteorological indicators in our study, such as minimum and maximum average temperatures, precipitation during the vegetative years, were recorded with the Meteorological Station located in the experimental field.

For this study, were selected 13 white accessions considered valuable and with high risk of extinction, in agreement with Popescu et al. (2017). To record the growth stages of the vine, the BBCH scale known and used by scientists around the world was used (Maier, 2001). The total number of days of vine phenological stages covering the entire cycle,

of growth starting from budding and ending at senescence, was observed: Bud development (BBCH 00-09), Leaf development (BBCH 11-19); Inflorescence emerges (BBCH 53-57); Flowering (BBCH 60-69); Development of fruits (BBCH 71-79); Ripening of berries (BBCH 81-89).

Aiming to highlight the differences among the phenological data recorded during the studied period was applied the Duncan test (test with multiple intervals) for a statistical assurance of 5%. For characteristics phenology and trends were used simple descriptive statistics were calculated for each phenological event.

RESULTS AND DISCUSSIONS

Climate parameters evolution during the grapevine growing seasons

The averages of the annual parameters for the main climate indicators are presented in Table 1. All the data showed that the climate conditions have changed from year to year, becoming overall warmer and drier from year to year. Compared to long-term multiannual averages (1979-2020), the average annual temperature increased by 2.46^0C in 2023.

The maximum temperature in the study years increased by 6.18^0C in 2023, 3.76^0C in 2022 and 1.76^0C in 2021, compared to the maximum that was recorded as an average value in the years 1979-2020. The precipitation deficit recorded was also relevant, with 217.95 less in 2023, 124.45 mm in 2022 and only 10.75 mm in 2021, compared to the multi-year averages.

The large amplitude of meteorological conditions occurring during the vegetation period from 2023 at NRDIBH Stefanesti, has the specificity of an excessively continental climate, this year's vegetation season being a very dry one (with only 563.2 mm compared to the multi-year average of 781.5 mm (Table 1).

Analysis of phenological data from the years of study

The average number of days of the main phenological stages (Sprouting/Bud development BBCH 00-09; Leaf development - BBCH 11-19; Inflorescence emerges -BBCH 53-57; Flowering -BBCH 60-69; Development of fruits -BBCH 71-79; Ripening of berries - BBCH 81-89) for each accession and year were analysed and represented in the Chromatogram from Figure 2. According to our results of the three years of study, the onset of the main vegetation phenophases, as well as the number of days were different even within the same genotype, depending on climatic conditions of each year. Thus, the number of days for the onset of budding varied from 19 days for the 'Muscat tămâios' genotype in 2023, to 26 days for the 'Om rău' and 'Rară albă' genotypes in 2021. A higher average annual temperature in the growing season for 2022 and 2023 influenced both the phenological onset of the genotypes, their flowering and, finally ripening (Figures 1, 2).

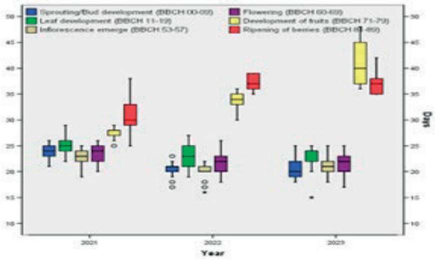

Figure 1. Graphic representation of the phenophases in the cycle of life of the vine depending on the year of study

Table 1. The main climatic parameters registered during the three analysed years (2021-2023) in comparison

Climatic indicator	Multianual average (1979-2020)	2021	2022	2023 (01.01-31.08)
Average annual temperature, ^{0}C	11,06	11,8	12,51	13,52
Average temperature in the growing season, ^{0}C (IV-X)	16,79	17,41	18,27	18,67
Average temperature in summer (°C) (VI-VIII)	21,90	23,08	23,85	30,47
Average annual minimum temperature (°C)	6,87	9,86	6,23	7,84
Absolute minimum temperature (°C)	-17,81	-13,9	-8,4	-10,21
Average January minimum temperature (°C)	-8,84	-10,9	-3,89	-4,69
Average annual maximum temperature (°C)	22,08	23,84	25,84	28,26
Average July maximum temperature (°C)	34,94	37,9	37,21	33,06
Annual total precipitation, mm	781,5	770,4	656,70	563,2
Total precipitation in the growing season, mm (IV-X)	534,13	440,6	559,7	437,8
The total precipitation in summer (VI-IX)	269,27	213,2	234,5	266,4

The trends of the climatic indicators during the three years of the study clearly highlighted the advancement and shortening of the necessary duration for the main phenophases in the development of the studied accessions. The increasing temperatures registered during the growing seasons affected both the onset of the vegetation phenophases and required number of days to reach each development stage, having a significant impact on the growth of the plants. It was noticed that the higher temperatures in the vegetation period of 2023 (Table 1) induced an advance of 5 ('Balaban alb') up to 14 days ('Galbenă măruntă') in terms of the onset of budding in most of the studied genotypes, except for the 'Muscat tămâios' accession, the differences between them being significant (Table 2). They registered an advanced stage of budding 14 ('Pîrciu') and 13 ('Rară albă') days earlier than in 2021, which led to a shortening of the number of days by 6 days and 4 days, respectively. It can be seen that the weather factors of the study years significantly influenced both the flowering period and the duration of flowering (Table 2) in all the analyzed accessions. With high differences regarding the beginning of flowering, the genotypes 'Zghihară rară' and 'Muscat tămâios' also stood out. The climatic conditions of high spring temperature in 2023 resulted in a shorter flowering duration (BBCH 60-69) and the "full flowering" phenophase lasted only a few weeks for the whole range of genotypes. Similar results from the southern part of Romania were also reported by Zaldea et al. (2021), in the northern part of the country.

This may also be due to the phenological progress regarding the first stages (BBCH 00-09).

With 'Balaban alb', 'Rară albă', 'Tigvoasă' and 'Zghihară rară' genotypes, although it was noticed a flowering peak with 8 -26 days earlier in 2022 and 2023 than 2021, the number of days required for full blooming was similar, without significant differences among years. The advance of flowering was 19 days, 15 earlier in the years 2023 and 2022, respectively, compared to 2021 for the "Muscat tămâios" genotype. The full maturity of the grapes evolved depending on the genotype and the climatic conditions of the year.

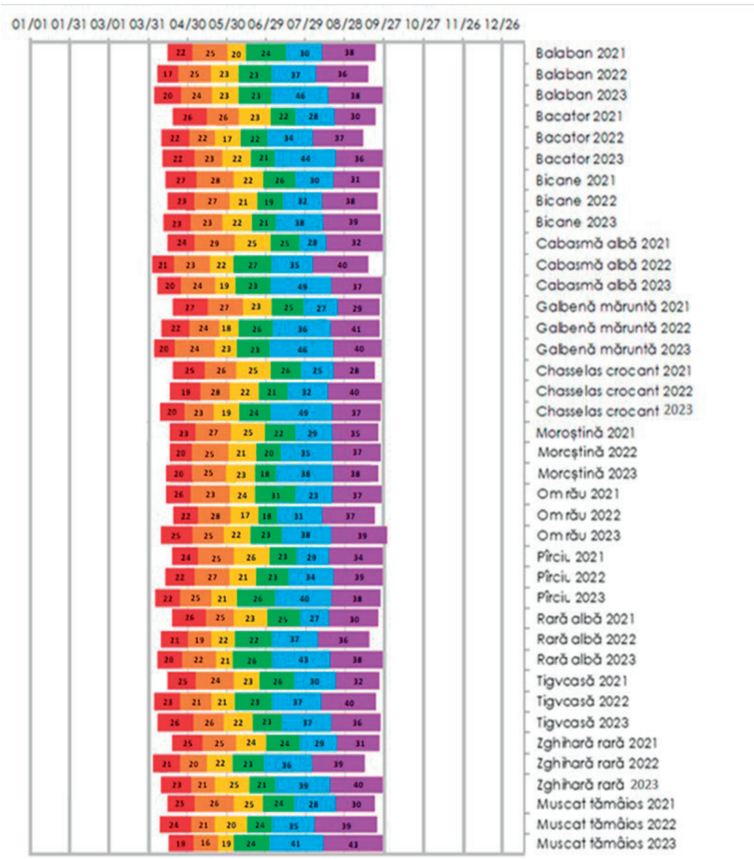

Figure 2. Chromatogram with evolution on the number of days for each genotype and year registered in phenological stages: red/Bud development (BBCH 00-09), orange: Leaf development (BBCH 11-19); yellow: Inflorescence emerges (BBCH 53-57); green: Flowering (BBCH 60-69); blue: Development of fruits (BBCH 71-79); purple: Ripening of berries (BBCH 81-89)

The ripening phase lasted an average of 39 days, for all the analyzed accessions. The shortest number of days regarding ripening was registered for 'Rară albă' with 30 days in 2021, and the longest for 'Muscat tămâios' with 43 days elapsed, in 2023. For all the analyzed accessions, the number of days for ripening phase was significantly different over the 3 years, with the fewest days registered in 2021.

Also, significant changes in the harvest dates were highlighted for some studied genotypes where harvesting starts earlier (Table 3).

With a phenological advance of 8 days in 2023 and 9 days earlier in 2022 than in 2021, the 'Bicane' genotype had an extension of days regarding ripening, the differences being significant. The same very significant differences were also revealed in the case of the genotypes 'Pîrciu', 'Rără albă', 'Tigvoasă', 'Zghihară rară', 'Muscat tămâios'. For all these genotypes, the length of the number of days was extended by 9 days for 'Zghihară rară' genotype in 2023, respectively 8 in 2022, up to 13 days in the case of the 'Muscat tămâios' genotype, in 2023, compared to the data recorded in 2021 (Table 3).

The extension of the ripening period of the analyzed grapes, especially in the years 2022 and 2023, can be due on the one hand to the lower temperatures during the nights in September, and, on the other hand, to the higher rainfall during this period, compared to the year 2021.

Table 2. Evolution of principal phenophase stages (BBCH 00-09 and BBCH 60-69) from the three years of analysis

Genotypes	Indicators	Sprouting/Bud development (BBCH 00-09)			Flowering (BBCH 60-69)		
		2021	**2022**	**2023**	**2021**	**2022**	**2023**
'Balaban alb'	Variation limit	April 15	April 07	April 05	June 21	June 11	June 11
		May 06	April 23	April 24	July 14	July 03	July 03
	No. of days/ phenophase	22±0.22^{b}	17±-0.41^{a}	20±0.36^{b}	24±0.23^{a}	23±0.62^{a}	23±0.35^{a}
'Bacator'	Variation limit	April 19	April 10	April 13	July 03	June 10	June 19
		May 14	May 01	May 04	July 24	July 01	July 08
	No. of days/ phenophase	26±-.41^{b}	22±0.22^{a}	22±0.34^{a}	22±0.33^{a}	22±0.26^{a}	21±0.43^{a}
'Bicane'	Variation limit	April 13	April 15	April 12	June 29	June 25	June 19
		May 09	May 07	May 04	July 24	July 13	July 08
	No. of days/ phenophase	27±0.51^{b}	23±0.23^{a}	23 ±0.44^{a}	26±0.48^{b}	19±0.12^{a}	21±0.32^{a}
'Cabasmă albă'	Variation limit	April 15	April 03	April 07	July 03	June 08	June 09
		May 08	April 23	April 26	July 27	July 04	July 02
	No. of days/ phenophase	24±0.12^{ab}	21±0.42^{a}	20±0.35^{a}	25±0.23^{a}	27±0.19^{ab}	23±0.41^{a}
'Galbenă măruntă'	Variation limit	April 19	April 10	April 05	July 05	June 13	June 11
		May 15	May 01	April 24	July 29	July 08	July 03
	No. of days/ phenophase	27±0.48^{b}	22±0.15^{a}	20±0.35^{a}	25±0.41^{a}	26±0.29^{b}	23±0.39^{a}
'Chasselas crocant'	Variation limit	April 19	April 17	April 07	July 03	June 25	June 09
		May 13	May 05	April 27	July 28	July 15	July 02
	No. of days/ phenophase	25±0.16^{b}	19±0.56^{a}	20±0.23^{a}	26±0.17^{ab}	21±0.22^{a}	24±0.60^{a}
'Moroștină'	Variation limit	April 17	April 17	April 14	July 01	June 23	June 23
		May 09	May 06	May 04	July 22	July 12	July 10
	No. of days/ phenophase	23±0.33a	20±0.33a	20±0.47a	22±0.48^{b}	20±0.39^{a}	18±0.38^{a}
'Om rău'	Variation limit	April 15	April 20	April 10	June 27	June 26	June 21
		May 10	May 11	May 04	July 27	July 13	July 13
	No. of days/ phenophase	26±0.22^{b}	22±0.46^{a}	25±0.12^{b}	31±0.44^{b}	18±0.32^{a}	23±0.41^{a}
'Pîrciu'	Variation limit	April 19	April 14	April 06	July 03	June 23	June 13
		May 12	May 05	April 27	July 25	July 15	July 08
	No. of days/ phenophase	24±0.51^{a}	22±0.32^{a}	22±0.26^{a}	23±0.36^{a}	23±0.41^{a}	26±0.25^{a}
'Rară albă'	Variation limit	April 19	April 10	April 07	July 02	June 11	June 09
		May 14	April 30	April 26	July 26	July 04	July 04
	No. of days/ phenophase	26±0.44^{b}	21±0.42^{a}	20±0.39^{a}	25±0.21^{a}	22±0.46^{a}	26±0.12^{ab}
'Tigvoasă'	Variation limit	April 1	April 05	April 08	June 27	June 09	June 21
		May 09	April 27	May 03	July 22	July 03	July 13
	No. of days/ phenophase	25±0.32^{b}	23±0.66^{a}	26±0.18^{b}	26±0.23^{a}	23±0.46^{a}	23±0.42^{a}
'Zghihară rară'	Variation limit	April 19	April 04	April 10	July 02	June 06	June 18
		May 13	April 24	May 02	July 25	June 29	July 08
	No. of days/ phenophase	25±0.44^{b}	21±0.38^{a}	23±0.25^{a}	24±0.22^{a}	23±0.56^{a}	21±0.38^{a}
'Muscat tămâios'	Variation limit	April 15	April 10	April 16	June 30	June 15	June 09
		May 09	May 03	May 04	July 23	July 08	July 02
	No. of days/ phenophase	25±b	24±b	19±a	24±0.56^{a}	24±0.41^{a}	24±0.50^{a}

Table 3. Evolution of principal phenophase stages (BBCH 71-79 and BBCH 81-89) from the three years of analysis

Genotypes	Indicators	Development of fruits (BBCH 71-79)			Ripening of berries (BBCH 81-89)		
		2021	**2022**	**2023**	**2021**	**2022**	**2023**
'Balaban alb'	Variation limit	July 15	July 04	July 04	August 14	August 10	August 19
		August 13	August 09	August 18	September20	September14	September 25
	No. of days/ phenophase	30±0.32^{a}	37±0.51^{ab}	46±0.34^{b}	38±0.19^{a}	36±0.66^{a}	38±0.42^{a}
'Bacator'	Variation limit	July 25	July 02	July 09	August 22	August 05	August 22
		August 21	August 04	August 21	September20	September10	September 26
	No. of days/ phenophase	28±0.55^{a}	34±0.31^{b}	44±0.28^{b}	30±0.44^{a}	37±0.40^{a}	36±0.31^{a}
'Bicane'	Variation limit	July 25	July 14	July 09	August 24	August 15	August 16
		August 23	August 14	August 15	September23	September21	September 23
	No. of days/ phenophase	30±0.25^{a}	32±0.17^{ab}	38±0.49^{b}	31±0.56^{a}	38±0.49^{b}	39±0.28^{b}

'Cabasmă albă'	Variation limit	July 28	July 05	July 03	August 25	August 09	August 21
		August 24	August 08	August 20	September25	September17	September 26
	No. of days/ phenophase	28 ± 0.51^{a}	35 ± 0.42^{b}	49 ± 0.23^{b}	32 ± 0.48^{a}	40 ± 0.35^{b}	37 ± 0.23^{ab}
'Galbenă măruntă'	Variation limit	July 30	July 09	July 04	August 26	August 14	August 19
		August 25	August 13	August 18	September23	September23	September 27
	No. of days/ phenophase	27 ± 0.58^{a}	36 ± 0.39^{b}	46±0.28b	29 ± 0.66^{a}	41 ± 0.42^{b}	40 ± 0.31^{b}
'Chasselas crocant'	Variation limit	July 29	July 16	July 03	August 23	August 17	August 21
		August 22	August 16	August 20	September19	September25	September 26
	No. of days/ phenophase	25 ± 0.51^{a}	32 ± 0.54^{b}	49 ± 0.41^{c}	28 ± 0.46^{a}	40 ± 0.39^{b}	37 ± 0.25^{b}
'Moroștină'	Variation limit	July 23	July 13	July 11	August 21	August 17	August 18
		August 20	August 16	August 17	September24	September22	September 24
	No. of days/ phenophase	29 ± 0.64^{a}	35 ± 0.40^{b}	38 ± 0.31^{b}	35 ± 0.33^{a}	37 ± 0.58^{a}	38 ± 0.55^{a}
'Om rău'	Variation limit	July 28	July 14	July 14	August 20	August 14	August 21
		August 19	August 13	August 20	September25	September19	September 28
	No. of days/ phenophase	23 ± 0.45^{a}	31 ± 0.33^{b}	38 ± 0.24^{c}	37 ± 0.44^{a}	37 ± 0.19^{a}	39 ± 0.27^{a}
'Pîrciu'	Variation limit	July 26	July 16	July 09	August 24	August 19	August 18
		August 23	August 18	August 17	September26	September26	September 24
	No. of days/ phenophase	29 ± 0.33^{a}	34 ± 0.42^{ab}	40 ± 0.18^{b}	34 ± 0.48^{a}	39 ± 0.35^{b}	38 ± 0.22^{b}
'Rară albă'	Variation limit	July 27	July 05	July 05	August 23	August 11	August 17
		August 22	August 10	August 16	September21	September15	September 23
	No. of days/ phenophase	27 ± 0.27^{a}	37 ± 0.38^{b}	43±0.55c	30 ± 0.48^{a}	36 ± 0.45^{b}	38 ± 0.30^{b}
'Tigvoasă'	Variation limit	July 23	July 04	July 14	August 22	August 12	August 20
		August 21	August 11	August 19	September22	September20	September 24
	No. of days/ phenophase	30 ± 0.55^{a}	37 ± 0.38^{ab}	37 ± 0.24^{ab}	32 ± 0.46^{a}	40 ± 0.39^{b}	36 ± 0.27^{ab}
'Zghihară rară'	Variation limit	July 26	July 30	July 09	August 24	August 04	August 17
		August 23	August 03	August 16	September23	September11	September 25
	No. of days/ phenophase	29 ± 0.62^{a}	36 ± 0.34^{b}	39 ± 0.24^{c}	31 ± 0.51^{a}	39 ± 0.41^{b}	40 ± 0.22^{b}
'Muscat tămâios'	Variation limit	July 24	July 09	July 03	August 21	August 13	August 13
		August 20	August 12	August 12	September19	September20	September 24
	No. of days/ phenophase	28 ± 0.51^{a}	35 ± 0.41^{b}	41 ± 0.23^{b}	30 ± 0.44^{a}	39 ± 0.38^{b}	43 ± 0.23^{b}

Relationship between climatic condition and phenological trends

The descriptive statistical indicators and the trends of phenological, of the corresponding stages and intervals of the 13 genotypes resulting from the data recorded in the 3 years, are presented in Table 4.

The average date of the thirteen analyzed genotypes for the onset of budding was April 12 with an interval of 22 days to complete. The earliest genotypes were 'Cabasmă albă', 'Balaban alb' and 'Galbenă măruntă' which budded on April 8 and 12 respectively, with a length of 21 and 22 days respectively. The latest genotypes were 'Chasselas crocant' and 'Moroștină', where the beginning of budding was on average, April 16.

According to the descriptive statistics, the beginning of budding showed the significant trends for some of the studied genotypes, with the exception of the genotypes 'Balaban alb', 'Bicane', 'Moroștină', 'Om rău', 'Tigvoasă', 'Zghihară rară', and 'Muscat tămâios'.

The average date for the onset of flowering, on average across all genotypes, has a trend of 0.4 days/year.

The strongest linear trend of the phenophase at the beginning of flowering was observed in the genotypes 'Cabasmă albă', 'Rară albă' and 'Zghihară rară'. The phenological advance was for these genotypes over 0.7 days/year, and the lowest advance, with approximately 0.3 days/year, was recorded for the genotypes 'Moroștină' and 'Muscat tămâios'.

Table 4. Statistical and trends indicators descriptive for the phenophases of the beginning of budding (BBCH 00-09) and the flowering (BBCH 60) in the period 2021-2023.

Phenological stage	Beginning of budburst/Bud development (BBCH 00-09)						Beginning of Flowering (BBCH 60)					
Statistics indicators (dates and days)	Mean	Range	S.D	Tend	R^2	P	Mean	Range	S.D.	Tend	R^2	P
'Balaban alb'	9 April	21	6.5	0.3	0.09	NS	14 June	23	6.8	0.15	0.08	NS
'Bacator'	14 April	23	7.14	**0.38**	0.42	<0.05	15 June	23	7.2	**0.67**	0.18	<0·001
'Bicane'	13 April	24	8.8	0.24	0.04	NS	24 June	22	9.3	0. 21	0.09	NS
'Cabasmă albă'	8 April	22	5.9	**0.31**	0.38	<0.05	7 June	25	8.4	**0.78**	0.13	<0.01
'Galbenă măruntă'	12 April	22	1.2	**0.21**	0.12	<0·001	10 June	25	4,8	**0.54**	0.12	<0.05
'Chasselas crocant'	16 April	21	5.1	**0.3**	0.41	<0.05	19 June	24	9,8	**0.62**	018	<0·05
'Moroștină'	16 April	21	3.1	0.15	0.02	NS	21 June	20	7.2	**0.34**	0.19	<0·001
'Om rău'	15 April	23	7.3	0.17	0.08	NS	24 June	24	8.1	0.12	0.22	NS
'Pîrciu'	13 April	23	6.4	**0.23**	0.30	<0·001	16 June	24	6.6	**0.48**	0.19	<0.05
'Rară albă'	12 April	22	10.3	**0.68**	0.33	<0·001	19 June	23	4.8	**0.75**	0.22	<0.01
'Tigvoas'	10 April	22	5.3	0.3	0.02	NS	18 June	24	7.8	0.31	0.06	NS
'Zghihară rară'	13 April	23	9.1	0.17	0.07	NS	14 June	23	9.9	**0.71**	0.21	<0·001
'Muscat tămâios'	14 April	23	5.6	0.25	0.09	NS	19 June	24	8.8	**0.38**	0.12	<0·001

The high temperatures, especially in the first part of the year, obviously affect the period of budding and flowering, and less so the ripening phase. Neethling et al. (2012) report shorter ripening rates (0.3 days/year), with long rates of flowering advance to vine. On the average of the years of study, the intensity of the correlations between the phenophases of the vine, in the genotypes analyzed, presented in Table 5, showed that, due to the phenological advance regarding budding, there was also an advance for the Flowering (BBCH 60-69). Significant positive correlations were found for these (r= 0.377***).

Table 5. Correlation matrix between the phenophases of the vine

Pearson Correlation	Flowering (BBCH 60-69)	Development of fruits (BBCH 71-79)	Ripening of berries (BBCH 81-89)
Sprouting/Bud development (BBCH 00-09)	0.377 (***)	-0.647 (**)	-0.664 (**)
Sig. (2-tailed)	0.018	0.000	0.000
Sig. (2-tailed)	0.280	0.029	0.009
Flowering (BBCH 60-69)	1	-0.184	-0.319 (*)
Sig. (2-tailed)		0.261	0.048

A negative and significant correlation is observed between the flowering phase and fruit ripening (r= -0.319*). Even if, in most genotypes, the flowering phase lasted less, the number of ripening days was extended.

CONCLUSIONS

The climatic parameters recorded in the Stefanesti germplasm collection during the three consecutive years (2021-2023) affected all phenological growth development of the plants starting from budding and ending to the technological harvested moment. Each genotype responded differently to changes in the main climatic factors, being proof of their different plasticity of response and adaptation to climatic changes.

The following trends were highlighted:

- a trigger of budding earlier with 3 days for 'Bicane' and 'Moroștină' accessions up to 14, respectively 15 days in the case of 'Galbenă măruntă' and 'Zghihară rară' accessions;
- on the average of the years studied, the date of the start of flowering for all genotypes had an advance trend of 0.4 days/year. The significant trend was observed with 'Cabasmă albă', 'Rară albă' and 'Zghihară rară' genotypes, with an advance of 0.7 days/year, and the lowest tend for 'Moroștină' and 'Muscat tămâios' accessions with an advance more than 0.3 days/year;
- the 'Rară albă' genotype had the shortest number of days to ripen with 30 days in 2021,

and the longest for the 'Muscat tămâios' genotype with 43 days passed, in 2023.

For the future, knowing the stages of development and the different adaptation responses of the grapevine in the context of climate change will be useful to reconsider the old and autochthonous genotypes. Moreover, this plant material could be essential to be used in specific breeding programs, or as proper grapevine genotypes in specific growing areas.

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