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PIWI grape varieties Cabernet Dorsa and Cabernet Mitos –phenological development under extremely hot climate

Veselin Ivanov, Anelia Popova, Ludmil Angelov*

Agricultural University – Plovdiv, Bulgaria
***Corresponding author: vitis.vin_29@abv.bg**

Abstract

The vine phenological development is closely related to the regional climatic specifics. Changes in temperature, precipitation, and other factors can significantly affect the course of individual phenophases. The red wine varieties Cabernet Dorsa and Cabernet Mitos, characterized by increased resistance to fungal diseases and low winter temperatures, have been selected for specific conditions of countries with a cool climate and a short growing season. The presence of valuable economic and technological qualities in these varieties justifies research related to their regenerative and reproductive performance under conditions of a long growing season and extreme temperatures. The phenological phases and their duration were monitored – bud burst, first leaf appearance, first inflorescence appearance, flowering, veraison, and the onset of technological ripeness. Climatic and soil indicators were recorded - average air temperature, relative atmospheric humidity and precipitation, soil humidity and temperature, while the total and active temperature sum for the onset of the main phases and the entire growing season was determined. The period from bud burst to technological ripeness lasted from 141 to 157 days, which is 30 to 50 days less than the most widely distributed local and introduced varieties. The active temperature sum required to reach technological ripeness is between 1655°C and 1831.1°C. Varieties have low thermal requirements and good adaptation to the climatic conditions of the semi-continental climate. The data would serve to determine suitable terroirs for growing these varieties, depending on the set agrotechnical and technological goals.

Keywords: PIWI, phenology, climate change, vegetation, terroir

INTRODUCTION

Phenology studies the timing and duration of plant life stages and plays a key role in viticulture, as the timing of bud burst, flowering, fruiting, veraison, and grape harvesting is closely linked to the quality, yield, and sustainability of grapevine development (Cameron et al, 2021). The onset is closely linked to climatic conditions, which have a direct impact on grape yield and quality (Parker et al., 2013; Molitor et al., 2014). In the grapevine, phenological phases are significantly influenced by climatic conditions, in particular temperature, sunlight, and water regime, which undoubtedly makes them a key indicator in studying the impact of climate change (Piña Rey et al., 2021). High temperatures accelerate the phase progression, leading to ripening before the optimal balance of sugars and acids is achieved or loss of aromatic compounds (Schellingerhout et al., 2024). Dinu et al. (2021) reported cases of premature bud burst in winter, associated with unusually high temperatures in southern Italy. In a number of European wine-growing regions, the development phases occur 7-10 days earlier than in previous decades, which requires changes in agronomic techniques and variety selection (Fraga et al., 2012; Teker, 2024).

According to a study by Schultz, H. R. (2016), the temperature requirements in the different phases of vine development are extremely precise, and small deviations can lead to physiological disorders. With climate change, phenological phases are shifting to earlier dates, which creates the need for adapted varieties and accurate development models (Ramos et al, 2019). Changes in temperature, precipitation, sunshine, as well as extreme events (cold, heat, drought) have a direct impact on the onset and duration of phenological phases, and hence on the quality and quantity of the yield (Bernáth et al., 2021).

Local climatic conditions, such as altitude, terrain slope, exposure, and wind, can modify the influence of the macroclimate. Vineyards located at high altitude have lower average daily temperatures, which can delay phenology. In this regard, Bernáth et al. (2021) note that despite global warming, local conditions in Central Europe have not led to drastic changes in phenology, which highlights the importance of the microregion. Monitoring the relationships between climatic parameters and vine development is essential for refining varietal selection, the timing of agrotechnical measures, and the long-term sustainability of viticultural systems (Molitor et al., 2014). Furthermore, with climate change, phenology may change (e.g., early bud burst, accelerated ripening) and varieties with different phenological profiles may prove more or less suitable for certain terroirs.

In the context of a changing climate, research on the phenology of resistant varieties is becoming increasingly important for optimizing viticultural practices and adapting viticulture to future climate conditions (Fraga et al., 2016). Climate change requires the search for alternatives in the varietal composition, such as the use of resistant (PIWI) varieties, which are more adaptable to changing conditions and allow sustainable production with minimal pesticide use. Among them are the varieties Cabernet Dorsa and Cabernet Mitos, which offer interesting options for red wine grape vineyards, especially in changing climate conditions. Lack of detailed data on these varieties indicates the need for local research and database development.

The study aims to monitor the phenological development and analyze the relationship between climatic factors and the dynamics of phenophases in the varieties Cabernet Dorsa and Cabernet Mitos, adapted to the local climatic conditions of the Plovdiv region. The varieties are grown in regions with a continental climate, and the study will determine their reaction to warmer climatic conditions and their adaptive abilities. The obtained phenological data can be used to optimize the practices in their cultivation, as well as to compare the influence of climatic factors on traditional varieties for a given region or other varieties with increased resistance.

MATERIALS AND METHODS

The study included two red wine varieties (Cabernet Dorsa and Cabernet Mitos), grafted on Berlandieri x Riparia SO4 rootstock, characterized by increased resistance to fungal diseases and low winter temperatures. The study was conducted in the period 2024-2025, and the vines were planted in the Educational, Experimental, and Implementation Base in Viticulture at the Agricultural University-Plovdiv, located in the land of Kuklen town, on the border with Brestnik village, Rhodope Municipality. The varieties were selected for areas with a cool climate and low levels of sunlight, some of the coldest wine regions in Europe.

CABERNET MITOS (CM)

Cabernet Mitos is a red wine grape variety, obtained by crossing Cabernet Sauvignon and Blaufränkisch in 1970 by Helmut Schleip and Bernd Hill (Röckel, F., 2017). It is grown mainly in Germany, especially in the Rheinhessen and Pfalz regions. This variety is also cultivated in Austria and Switzerland (https://morenaturalwine.com/collections/cabernet-mitos).

Figure 1. Cabernet Mitos - bunch and leaf
Source: Ursula Brühl, Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Institute for Grapevine Breeding Geilweilerhof - 76833 Siebeldingen, GERMANY

The variety has a medium to late bud burst. Growth is medium to strong with a vertical arrangement of shoots and weak bunch growth. Cabernet Mitos is medium to late ripening, with juice loss observed during overripeness. Raising the fruit leads to concentration of the grape juice, which significantly reduces susceptibility to Botrytis. Yield is medium to high.

The clusters are medium to large with small to medium-sized berries, loose to very compact (Figure 1). To achieve the desired ripeness (sugar, aroma, acidity), only good growing sites should be selected. On poorer soils, rootstocks that induce poor growth should not be used.

Cabernet Mitos is known for its deep, intense color and strong flavors. The wines produced have rich aromas of blackberries, blackcurrants, and dark cherries. The taste is characterized by density, firm tannins, and a good level of acidity.

CABERNET DORSA (CD)

Cabernet Dorsa is a German red wine variety obtained by crossing the varieties Blaufränkisch and Dornfelder. It was recognized in 1971 by the Staatliche Lehr- und Versuchsanstalt für Wein- und Obstbau in Weinberg (Maul, E. et al., 2013).

The variety has medium to good wood maturity and excellent resistance to low winter temperatures. Bud burst time is early and growth is vigor and vertical. Flowering time is in the middle range and there is a medium to high degree of pollination.

The variety is medium-ripening, and the bunch mass is medium to large. The bunch is winged, with a good strength of the stalk. The berries have a high to very high mass of the must, with medium to low acidity. Cabernet Dorsa has a relatively high resistance to rot, but increased sensitivity to powdery mildew, especially in young plants. It is recommended to carry out a consistent preventive treatment against powdery mildew in young plants. High yields can affect the wine quality, so bunch thinning gives good results. The bunch is loose, with small, blue-black berries, ripens later and has smaller berries and bunches than Dornfelder (Figure 2). Cabernet Dorsa grows particularly well on medium-rich soils. The variety has medium site requirements with a medium length of growing season. Budburst occurs early, so areas at risk of late frost should be avoided. It is a relatively hardy variety with great prospects for the future. The wines are intensely coloured and can be rich in tannins. They present an attractive play of fruit aromas, especially cherry aromas are clearly perceptible, offering balanced harmony, plenty of body and a long persistent finish.

Figure 2. Cabernet dorsa- bunch and leaf
Source: Ursula Brühl, Julius Kühn-Institut (JKI) Bundesforschungsinstitut für Kulturpflanzen Institut für Rebenzüchtung Geilweilerhof - 76833 Siebeldingen – GERMANY

The vineyard is fruitful, it was planted in 2023, the planting distance is 2.90 m between rows and 1.00 m between vines in the row - 3330 pcs per ha. The training system is a head with a trunk height of 50 cm. The bud loading is carried out by pruning of spurs with two buds (2 spurs per plant). The inter-rows are grass-covered, and the soil surface between the vines is kept clean by applying herbicides and hand mulching. The vines are grown under non-irrigated conditions, and the average terrain altitude is 194 m.

Phase beginns when 5% of the vines have entered it, mass entry - 50% and the end at 95%. The duration in days of bud burst, bud burst-beginning of flowering, flowering, end of flowering-beginning of veraison, veraison, end of veraison-technological ripeness and bud burst-technological ripeness is presented. The indicators are tracked using the generally accepted methods described in the Manual for Viticulture Exercises (Roychev, 2014).

Climatic indicators are represented by average air temperature, average atmospheric humidity, and precipitation. The total and active temperature sum necessary for the onset of the main phases and the entire vegetation period is determined. Soil parameters are represented by soil moisture at a depth of 50 cm and soil temperature at a depth of 20 cm. Data for climatic indicators are taken from the meteorological station located in the Regional Department of Viticulture, near the Brestnik village. Selyaninov hydrothermal coefficient (HTC) - calculated for the period March - August according to the formula, HTC = Sr / 0.1 x St, where: HTC - Selyaninov hydrothermal coefficient; Sr - sum of precipitation for a period with average daily temperatures > 10 °C; 0.1 - equalization coefficient; St - sum of average daily air temperatures > 10 °C for the period. The data correlation analysis was performed by statistical processing in Microsoft Excel.

RESULTS AND DISCUSSION

In 2024, early and rapid warming is observed (Figure 3). Average temperatures from April to May are above 16°C, in the summer months (June, July, August), respectively 26-28°C, with maximums above 34-36°C.

Early warming shows that calendar phases start earlier, bud burst in early March, and summer was hot with high maximum temperatures, low precipitation with risks of water stress.

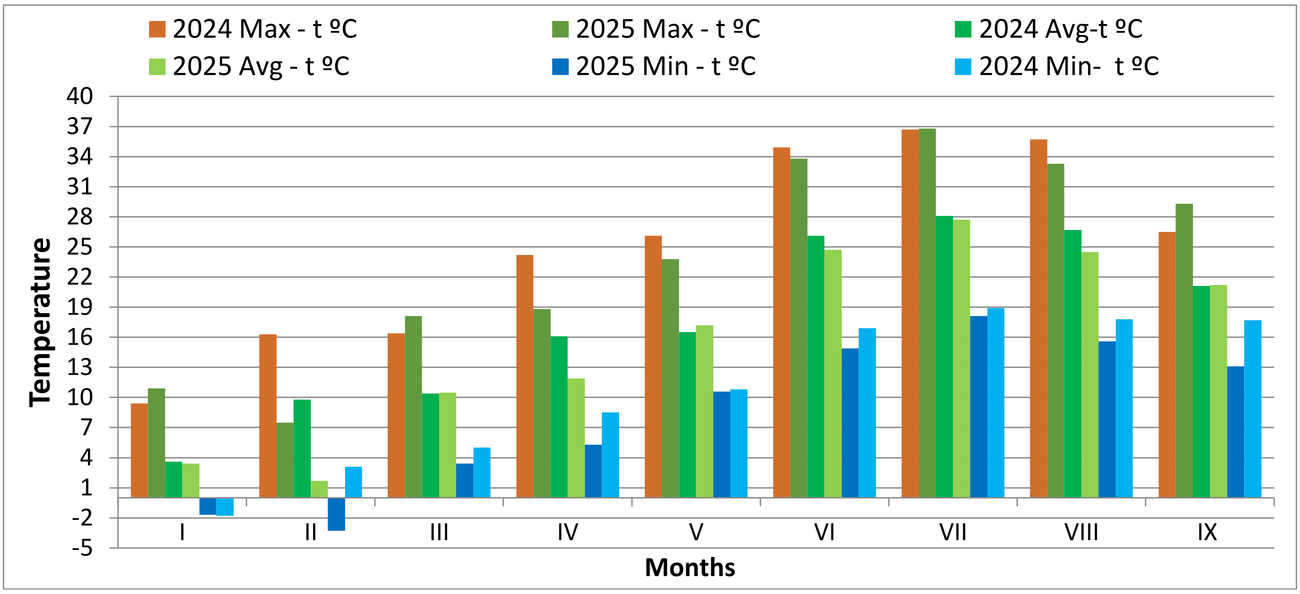

Figure 3. Average monthly, maximum, and minimum air temperature for the period January - September, 2024-2025

The spring of 2025 was cold. In February, the average temperature was 1.7°C, and the minimum was 3.3°C. Bud burst occurs in late March to early April. A small difference in minimum temperatures during the summer period was recorded: in 2025, the average for July is 18.1°C, and in 2024 it is 18.9°C. Spring of 2025 was wet in March and May, and the summer was drier, compared to 2024. The amount of precipitation in 2025 is greater compared to 2024, but in both years, it is unevenly distributed throughout the growing season (Figure 4).

Regarding soil moisture at a depth of 50 cm during the winter months (January to March), the differences are minimal, the humidity is high and stable (94-98%), similar winter conditions in both years, due to more precipitation (Figure 4). In the spring (April to May) in 2025, the humidity is noticeably higher, especially in April (+12%) as a result of more precipitation. In the summer (April to August), the difference is the largest, and in 2025, the humidity is 15-20% higher compared to 2024. July-September (52-58%), creating a prerequisite for water stress. The beginning of autumn (September) in 2025 remains wetter (+9%).

The calculated HTC, for the period March-August, shows in 2024 the value of 0.57 (Figure 4).

This is a sure sign of drought and insufficient soil moisture supply. Such conditions have an adverse effect on the growth and vine development, especially during critical phases of vegetation. In 2025, the HTC is 0.83, leading to better moisture storage, even below optimal values. More favorable for vine development is 2025, but conditions remain moderately dry, which may partially limit yields.

Calendar time of onset and course of phenological phases:

Sap flow (Table 1): Due to the cooler spring of 2025, sap is delayed by 20 days, and the vegetation period is pushed back by 23-26 days compared to the previous year.

Bud burst (Table 1): Starts 23-26 days earlier than in 2025, which is due to the higher average daily temperatures in February. In 2024, bud burst begins on 07.03 for KD, and on 08.03 for KM. In the spring of 2025, bud burst is delayed at the end of March for KD and the beginning of April for KM. The phase duration depends on the year and is 8 to 10 days.

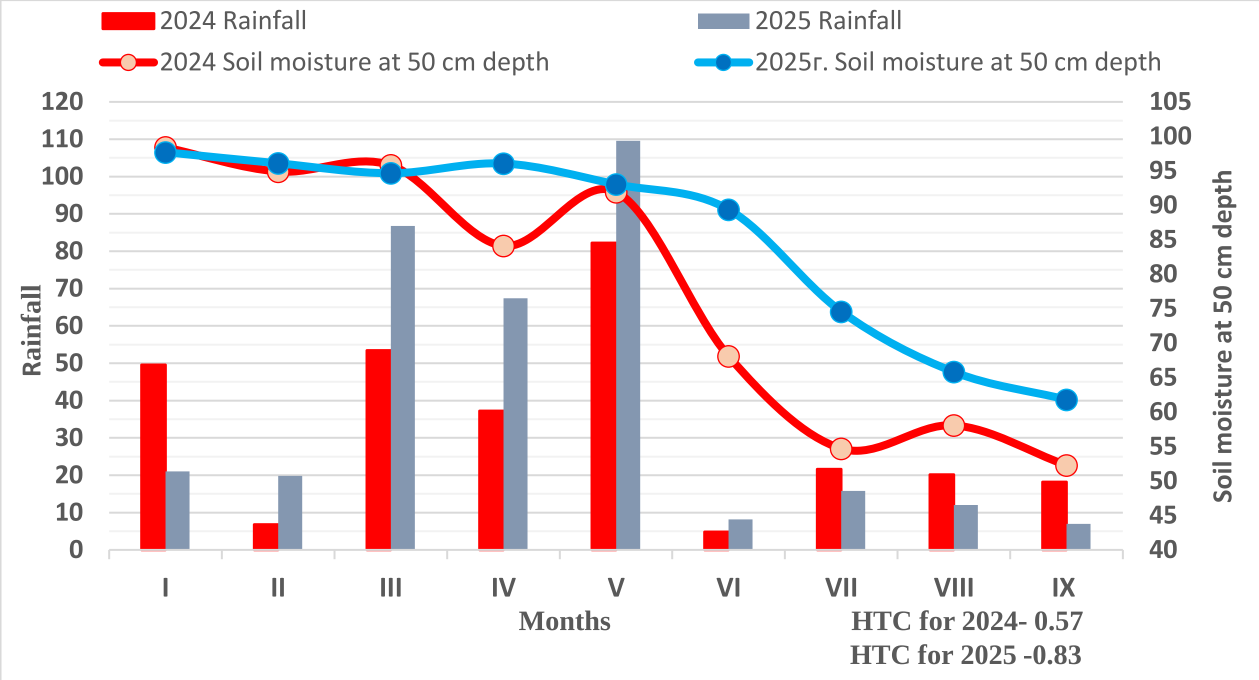

Figure 4. Amount of precipitation and average monthly soil moisture at a depth of 50cm for the period January – September, 2024-2025

First leaf and first inflorescence appearance (Table 1): For KD, the phase begins on 20.03, respectively on 22.03 in KM. In the second year, the sequence is maintained, but the period is delayed by one month due to the cool spring. First inflorescence appearance in both varieties occurs 4 to 8 days after the previous phase. Three to four days after, shoots reach a length of 10-15 cm.

Flowering (Table 2): The beginning of flowering in both varieties in 2024 begins on 08.05, and mass flowering is in the same sequence after 7 to 8 days. It ends on 25.05 for KD and 27.05 for KM. In 2025, flowering begins first for KD on 28.05, and for KM on 30.05, and ends in 9-12.06.

Veraison (Table 2): In 2024 starts earlier at KD (04.07) and at KM on 10.07. Mass veraison starts from 9 to 11 days from the beginning in the same sequence, ending on 27.07 at KD and on 23.07 at KM. In 2025 it starts and runs in the same sequence in the period 11.07- 01.08.

Technological ripeness (Table 2): In 2024, it occurs earliest for KM (08.08), and for KD it is on 10.08, while in 2025, technological maturity occurs first for KD on 19.08, and for KM variety on 20.08. The period duration from the beginning of budburst to the beginning of flowering for KD is 59 days, and in KM it is 57 days (Table 3). In 2024, the period is 3 days longer in KD and 4 days in KM.

The period passes at almost the same average daily air temperature - KD - 14ºC, KM - 14.3ºC. The active temperature sum is an average of 347.05ºC C at KD and 353.05ºC at KM. The relationship between temperature and period duration in 2024 is moderately strong positive (R+0.59 and R+0.56), while in 2025 it is completely positive (R+0.70 and R+0.71). At high temperatures, the duration increases, but a delay is possible at extremely high or low temperatures. The shortening of the period from bud burst to flowering by 3 to 4 days in 2025 is due to the higher soil moisture (KD-94.7%, KM-94.5%) and the higher average soil temperature at a depth of 20 cm (KD-14.8ºC and KM-15.2ºC), compared to 2024 - 88.8% and 88.7% and soil temperature at a depth of 20 cm (KD-14.0ºC and KM-14.1ºC).

Table 1. Phenological stages from the beginning of sap flow to shoot length of 10-15 cm, 2024-2025

Variety	Period	SAP, date		Bud burst, date			1st leaf appearance, date	1st inflorescens appearance, date	Shoot 10-15 cm long
		start	mass	start	mass	end			
Cabernet Dorsa	**2024**	01.03	04.03	07.03	12.03	15.03	20.03	24.03	28.03
	2025	22.03	25.03	30.03	05.04	09.04	15.04	22.04	26.04
Cabernet Mitos	**2024**	01.03	04.03	08.03	13.03	16.03	22.03	27.03	30.03
	2025	22.03	26.03	03.04	08.04	13.04	20.04	28.04	30.04

Table 2. Phenological stages from the beginning of flowering to technological ripeness, 2024-2025

Variety	Period	Flowering, date			Pea size, date	Veraison, date			Technological ripeness, date
		start	mass	end		start	mass	end	
Cabernet Dorsa	2024	08.05	15.05	25.05	12.06	10.07	19.07	27.07	10.08
	2025	28.05	2.06	09.06	26.06	16.07	22.07	01.08	19.08
Cabernet Mitos	2024	08.05	16.05	27.05	17.06	04.07	13.08	23.07	08.08
	2025	30.05	04.06	12.06	28.06	11.07	18.07	29.07	20.08

Table 3. Bud burst to flowering and related climatic parameters

Variety	Year	Period in days	Average daily air temperature, t^oC	Atmospheric humidity, %	Soil moisture at 50 cm depth, %	Soil temperature at a depth of 20 cm, t^oC	Precipitation, mm	Total Temperature Sum, $\sum t^oC$	Active Temperature Sum, $\sum t^o C$
Cabernet Dorsa	**2024**	62	13,9	68,6	88,8	14	107,6	866,6	376,6
			R +0.59	***R - 0.04***	***R +0.11***	***R +0.78***	***R - 0.88***		
	2025	59	14.1	74.1	94.7	14.8	220.4	837.5	317.5
			R +0.70	***R - 0.24***	***R – 0.14***	***R +0.78***	***R - 0.27***		
	Avg.	**60.5**	**14**	**71.3**	**91.7**	**14.4**	**164**	**852.05**	**347.05**
Cabernet Mitos	**2024**	61	14,1	68,2	88,7	14,1	104	860,2	370,2
			R +0.56	***R - 0.01***	***R +0.11***	***R +0.77***	***R +0.56***		
	2025	57	14.6	72.1	94.5	15.2	135	835.9	335.9
			R +0.71	***R - 0.15***	***R – 0.15***	***R +0.77***	***R +0.71***		
	Avg.	**59**	**14.35**	**70.15**	**91.6**	**14.65**	**119.5**	**848.05**	**353.05**

Legend: R – correlation coefficient

The strong negative relationship (R - 0.88 and R -0.88) with soil moisture in 2024 indicates the presence of a limiting effect, but the following year, the influence weakens due to more precipitation, which provided high humidity (R-0.27 and R-0.27). High soil moisture shortens the period due to favorable growing conditions.

The duration from the beginning to the end of flowering in 2025 for KD is 13 days, and for KM is 14 days. In 2024, the period is longer by 5 to 6 days for both varieties (Table 4).

The process takes place at an average daily air temperature of 19.35ºC for KD and 19.58ºC for KM. The active temperature sum is 174.25ºC and 166.4ºC, respectively. Air temperature has the strongest and most stable influence on the duration of flowering, especially in the second year (R+0.80). From the end of flowering to the beginning of veraison in 2025, 36 days are required for the KD variety, while 29 days are required for the KM. In 2024, the interval is longer by 9 days for KD and 8 days for KM (Table 5).

The average air temperature at KD is 25.63ºC, and at KM-25.75ºC, while the active temperature sum is 632.5ºC and 519ºC. Accumulation of a large active temperature sum is due to the lower soil moisture at a depth of 50 cm in 2024 (67.89% for KD and 69.1% for KM), compared to 2025 (83.9% for KD and 84.8% for KM), which, combined with the high temperature, causes moderate water stress (vines temporarily slow down their physiological processes).

This delays plant development and extends the duration of the phases. Moderately strong positive correlation (R+0.61) indicates that on some days during this period, temperatures are above the optimal range for active growth (25 - 30°C), which slows down physiological processes.

Table 4. Start to end of flowering and related climatic indicators

Variety	Year	Period in days	Average daily air temperature, *tºC*	Atmospheric humidity, %	Soil moisture at 50 cm depth, %	Soil temperature at a depth of 20 cm, *tºC*	Precipitation, mm	Total Temperature Sum, *∑tºC*	Active Temperature Sum, *∑tº C*
Cabernet Dorsa	**2024**	18	16,5	81,8	96,7	16,8	49,6	288,9	188,9
			R +0.57	***R-0.23***	***R-0.29***	***R+0.48***	***R+0.33***		
	2025	13	22.2	67.3	93.4	22.6	4	289.6	159.6
			R+0.81	***R-0.47***	***R-0.12***	***R+0.97***	***R-0.80***		
	Avg.	**15.5**	**19.35**	**74.55**	**95.05**	**19.7**	**26.8**	**289.25**	**174.25**
Cabernet Mitos	**2024**	20	16,26	80,4	96,3	17,1	49,6	325,2	152,2
			R+0.57	***R-0.23***	***R-0.29***	***R+0.48***	***R+0.33***		
	2025	14	22.9	67.6	93.2	23.9	4	320.6	180.6
			R+0.74	***R-0.57***	***R-0,10***	***R+0.95***	***R-0.92***		
	Avg.	**17**	**19.58**	**74**	**94.75**	**20.5**	**26.8**	**322.9**	**166,4**

Legend: R – correlation coefficient

Table 5. End of flowering to beginning of veraison and related climatic indicators

Variety	Year	Period in days	Average daily air temperature, *t°C*	Atmospheric humidity, %	Soil moisture at 50 cm depth, %	Soil temperature at a depth of 20 cm, *t°C*	Precipitation, mm	Total Temperature Sum, ∑*t°C*	Active Temperature Sum, ∑*t° C*
Cabernet Dorsa	**2024**	45	25,2	58,28	67,89	27,5	15,2	1136,5	686,5
			R+0.61	***R-0.75***	***R+0.19***	***R+0.77***	***R-0.97***		
	2025	36	26.07	54.28	83.9	28	8.2	938.5	578.5
			R+0.49	***R-0.62***	***R-0.01***	***R+0.61***	***R-0.99***		
	Avg.	**40.5**	**25.63**	**56.28**	**75.89**	**27.75**	**11.7**	**1037.5**	**632.5**
Cabernet Mitos	**2024**	37	25,4	59,6	69,1	27,6	15,2	939,8	569,8
			R+0.61	***R-0.75***	***R+0.19***	***R+0.77***	***R-0.97***		
	2025	29	26.1	54.6	84.8	27.9	8.2	758.2	468.2
			R+0.49	***R-0.47***	***R+0.02***	***R+0.49***	***R-0.99***		
	Avg.	**33**	**25.75**	**57.1**	**76.95**	**27.75**	**11.7**	**849**	**519**

Legend: R – correlation coefficient

Similar results for the delay of phenophases at lower soil moisture are reported by Falcão et al. (2021), according to which moderate water deficit can lead to slow cell growth and prolong the process.

The strong negative correlation (R=-0.97 and R=-0.99) confirms the leading role of soil moisture, as at high soil moisture, the duration of the period decreases.

Some studies (Vannozzi et al., 2023) suggest that at a moderate deficit, the vine develops adaptation mechanisms that can partially compensate for the effect on phenology.

According to the same authors, low soil moisture can affect the hormonal balance in the plant (an increase in abscisic acid) and slow down the transition between phases.

The beginning to the end of the veraison lasts for 17.5 days in KD and 19.5 days in KM (Table 6). No significant differences are noted in the years studied. It passes at a relatively uniform average daily air temperature. The accumulation of active temperature sum for the period is 322.25ºC for KD and 360.5ºC for KM; a difference is noted in the soil moisture at a depth of 50 cm, as in 2025 it is 70.4-72.1%, compared to 2024, 53.2 to 54.8%.

The strong positive relationship (R+0.88) confirms the extension of the phase in 2024, while in 2025, the very strong negative relationship (R=-0.93 and R=-0.97) indicates its shortening. Despite the lower soil moisture in 2024, the phase in both varieties passes at approximately the same active temperature sum and duration in both years, showing phenological stability and lack of change under moderate water stress. From the end of veraison to the onset of technological ripeness, the average daily temperature for KD is 26.3ºC and 26.1ºC for KM (Table 7). The accumulated active temperature is 267ºC for KD and 304.35ºC for KM. The duration of the period in 2024 for KD is 14 days, and 16 days for KM. In 2025, the interval is 5 days longer for KD and 6 days for KM.

Table 6. Start to end of veraison and related climatic indicators

Variety	Year	Period in days	Average daily air temperature, t^oC	Atmospheric humidity, %	Soil moisture at 50 cm depth, %	Soil temperature at a depth of 20 cm, t^oC	Precipitation, mm	Total Temperature Sum, $\sum t^oC$	Active Temperature Sum, $\sum t^o C$
Cabernet Dorsa	**2024**	18	28,8	50,1	54,8	30,9	18	519,9	338,1
			R-0.69	***R+0.52***	***R+0.34***	***R-0.72***	***R+0.88***		
	2025	17	28.02	55.8	70.4	30.6	15.8	476.4	306.4
			R-0.20	***R+0.37***	***R+0.31***	***R+0.17***	***R-0.93***		
	Avg.	**17.5**	**28.41**	**52.9**	**62.6**	**30.75**	**16.9**	**498.15**	**322.25**
Cabernet Mitos	**2024**	20	28,7	48,1	53,2	31,2	7,4	574	374
			R-0.69	***R+0.52***	***R+0.34***	***R-0.72***	***R+0.88***		
	2025	19	28.2	51.2	72.1	30.5	3	537.1	347
			R-0.31	***R+0.13***	***R-0.02***	***R+0,80***	***R-0.97***		
	Avg.	**19.5**	**28.45**	**49.6**	**62.7**	**30.85**	**5.2**	**555.55**	**360.5**

Legend: R – correlation coefficient

Table 7. End of veraison to technological ripeness and related climate indicators

Variety	Year	Period in days	Average daily air temperature, t^oC	Atmospheric humidity, %	Soil moisture at 50 cm depth, %	Soil temperature at a depth of 20 cm, t^oC	Precipitation, mm	Total Temperature Sum, $\sum t^oC$	Active Temperature Sum, $\sum t^o C$
Cabernet Dorsa	**2024**	14	27,2	45,5	59,1	29,3	3,6	381	241
			R+0.42	***R+0.57***	***R+0.30***	***R+0.08***	***R+0.65***		
	2025	19	25.4	58,4	66.6	27.4	9,8	483	293
			R-0.58	***R+0.37***	***R+0.31***	***R-0.49***	***R-0.89***		
	Avg.	**16.5**	**26.3**	**51.95**	**62.85**	**28.35**	**6.7**	**432**	**267**
Cabernet Mitos	**2024**	16	27	46,7	59	28,6	4,4	433	273
			R+0.42	***R+0.57***	***R+0.30***	***R+0.08***	***R+0.65***		
	2025	22	25.2	60,4	66.9	27.6	22,6	555,7	335,7
			R-0.31	***R-0.02***	***R-0.10***	***R-0.48***	***R-0.91***		
	Avg.	**19**	**26.1**	**53.55**	**62.95**	**28.1**	**13.5**	**494.35**	**304.35**

Legend: R – correlation coefficient

Table 8. Duration of the period from bud burst to technological ripeness and temperature sum

Variety	Year	Duration, days	Total Temperature Sum, ∑t°C	Active Temperature Sum, ∑t°C
Cabernet Dorsa	**2024**	157	3192.9	1831.1
	2025	144	3025	1655
	Avg.	**150.5**	**3108.95**	**1743.05**
Cabernet Mitos	**2024**	154	3132.2	1739.2
	2025	141	3007.5	1667.5
	Avg.	**147.5**	**3069.85**	**1703.35**

The period lenthg increasment in 2025 for both varieties is due to the joint influence of the factors low average air temperature (25.4ºC-KD and 25.2ºC for KM), combined with a negative correlation coefficient R-0.58 and R-0.31, higher soil moisture (66.6% for KD and 66.9% for KM) at R-0.89 and R-0.91 and lower soil temperature (27.4ºC for KD and 27.6ºC for KM) at R-0.49 and R-0.48, compared to 2024. A combination of these factors in 2025 helps to smoothly accumulate sugars and extend the ripening period until technological ripeness is reached. The total duration of the period from bud burst to technological ripeness is 150.5 days for KD and 147.5 days for KM (Table 8). Differences in duration are observed in 2024, which is 13 days longer for both varieties, mainly due to the amount of precipitation.

For KD, the active temperature sum from the beginning of bud burst to technological ripeness is 1743.05ºC, with a total temperature sum of 3108.95ºC. For KM, the active temperature sum is 1703.35ºC with a total of 3069.85ºC C.

The duration of phenological phases in the vine plant of a given terroir depends on the interaction between the temperature and moisture regimes. Correlation analysis shows the direction and strength of the relationship between the given factor and phase duration.

CONCLUSIONS

Cabernet Dorsa and Cabernet Mitos varieties react in a similar way to climatic changes during the period from bud burst to reaching technological ripeness. The phases occur in close time intervals, showing high physiological stability in a variable climate and emphasizing their good adaptive ability to diverse climatic conditions. Air and soil temperature have the strongest influence on the phenological duration, while hydrothermal factors are of secondary importance. The influence of moisture is more limited, which is a decisive factor with a two-way effect depending on the values and the dependence on the total water balance. The period from bud burst to technological ripeness is 141 to 157 days long. After entering full fruiting, due to the higher yield, this period may be extended. Technological ripeness occurs in the second decade of August, which limits the risk of autumn climatic anomalies that reduce the grapes quality. Varieties have low heat requirements; the active temperature sum required to reach technological ripeness is in the range between 1655°C and 1831.1°C. The results obtained have practical application in the selection of varieties depending on the production goals, in the planning of agrotechnical measures, and in the assessment of the risk of climatic anomalies, such as late spring frosts and drought.

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