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THE GRAPEVINE PHENOLOGY AND THE CLIMATE CHANGES IN TARNAVE VINEYARD

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Abstract

In the context of climate change, the paper presents an analysis of the evolution of grapevine phenophases, in the period 1991-2021, for four grapevine cultivars Selena, Blasius, Rubin and Radames, and two clones Sauvignon blanc 9 Bl, Feteasca alba 29 Bl homologated at SCDVV Blaj. The study is based on the climatic and phenological data from SCDVV Blaj. The climatic data have been processed into fourteen parameters and for the phenological periods the starting date was analyzed. Regarding the average annual temperature, during 2010-2021 there is an increase of 1.1 ºC compared to the multiannual average reference temperature (calculated as the annual average of the years 1975-2010), which means that in the studied area, during the period 2010-2021 there was a warming compared to reference years. The average duration of the vegetation period from 2010-2021 is shorter than the reference period by 3.2 days. In 2011 the annual aridity index denotes a semi-arid dry climate, and in 2012, 2015, 2017 and 2019 a moderately humid climate. The hydrothermal coefficient was higher in the studied period compared to the reference period, registering values between 1.0 (2011) and 2.8 (2016), which has a positive influence on grape production. The Huglin index for the studied period is between 2237.6 in 2021 and 2928.5 in 2012, with an average of 2542.6 which places Tarnave vineyard area in a warm climate zone. Concerning the precipitation, a slight increase of 34.7 mm/m^2 compared to the multiannual reference amount was monitored. In these conditions the warming of the climate induced an earlier budburst with an average of 8 days, correlated with an earlier maturation with 9-11 days in average. So far for the blooming and veraison phenophases starting date, no differences of the outrunning were clearly observed.

Key words: *grapevine phenophases, Tarnave vineyard, climatic parameters, climate change.*

INTRODUCTION

The culture of the grapevine in Transylvania has been known since the Iron Age, and there is sufficient evidence of this since the 1st century BC. to this day. Viticulture, entrenched in Transylvania, since antiquity, has been perpetuated during the migration of peoples, developing during the feudal period, both in terms of cultivation and preparation and preservation of wines. The colonization of the Saxons by the Arpadian kings (12th century) in the regions of Sibiu, Alba and Bistrita, led to the development of viticulture in the territory between Tarnave and Mures, an area that appeared on time maps under the name Weinland (Wine Country) (Iliescu et al. 2010; Calugar et al. 2018; Macici 1996).

The first clones of noble vine, of German origin, were brought to Transylvania in the 12th century in the Alba wine center, on the territory of the current localities Alba Iulia, Ighiu and Cricau. Until the invasion of phylloxera, the varieties Grasa, Iordană, Fetească alba, Bakator, Furmint, Pinot gris, Muscat Ottonel, Traminer roz, Riesling Italian were cultivated in Transylvania.

In 1950 a new phase started in the Romanian and also Transylvanian viticulture, by the establishment of effective technical measures for its restoration and development, by the elimination of direct producing hybrids, replanting and expansion of areas planted with noble cultivars, especially with valuable selections and new cultivars (Iliescu et al. 2010; https://www.scvblaj.ro/articole/istoricul-viticulturii-din-transilvania).

Tarnave vineyard is part of the viticultural zone 1 of Romania and is positioned at the intersection of the geographical coordinates of

46°-47° Northern latitude and 23°-24° Eastern longitude, on the Transylvanian Plateau (Iliescu et al., 2010; Calugar et al., 2018; Cudur et al., 2014; Donici et al., 2019; Chedea et al., 2021). The most significant viticultural area of Transylvania, the prestigious Tarnave vineyard, is known and appreciated for its quality wines with a specific flavor and a good sugar/acidity balance mainly from the cultivars Fetească albă, Fetească regală, Traminer roz, Pinot gris, Sauvignon blanc, Neuburger, Riesling Italian, Muscat Ottonel (Iliescu et al., 2010; Cudur et al., 2014; Donici et al., 2019). In Târnave vineyard, from the environmental point of view, there are appropriate conditions for grapevine growing (Cudur et al., 2014; Cotea, 2003). These condition might be unbalanced by the climate change (Santos et al., 2020; Fraga 2021; Chedea et al., 2021, Bălăceanu et al., 2021), the forecasting of the seasonal weather factors being difficult in this context (Sillmann et al., 2017; Cyr et al., 2010; Webb et al., 2010; Chedea et al. 2021, Bălăceanu et al., 2021). The environmental dynamic, with late spring freezes, flooding, heatwaves, droughts, area wildfires, early fall frosts, and pest infestations on the background of new and irregular temperature and humidity regimes, require its fast and appropriate mitigation from the viticulturists (Jones & Webb, 2010; Chedea et al., 2021). The final point of this process is the maintaining of the economic feasibility of grape, grape juice and wine production (Jones et al., 2011; Chedea et al., 2021).

In this context, the paper presents an analysis of the evolution of grapevine phenophases, in the period 1991-2021, for Selena, Blasius, Rubin and Radames, grapevine cultivars: and two clones homologated at SCDVV Blaj: Sauvignon blanc 9 Bl and Feteasca alba 29 Bl.

MATERIALS AND METHODS

Monitoring of climate factors with major impact (temperature and rainfall) on SCDVV Blaj vineyards was carried out by recording and processing the daily climate data. The following indices were calculated: the global thermal balance (∑tºg,ºC - sum of positive average daily temperatures), active thermal balance (∑tºa,ºC - sum of average daily temperatures >10°C), useful thermal balance (∑tºu,ºC - sum of differences between daily average temperature > 10°C and biological threshold for starting the vine vegetation (10ºC), annual average temperature ºC, average temperature during the vegetation period, ºC, absolute minimum temperature, ºC, absolute maximum temperature, ºC, the annual precipitation amount (∑ of the annual precipitations - mm), the precipitations amount during the vegetation period (∑ of the precipitations during the vegetation period - mm), precipitation coefficient (Pc), (∑ of precipitations/no. of days - the amount of precipitation related to the number of days in the growing season), the length of the vegetation period, (number of days), hydrothermal coefficient (HTC), (∑ annual precipitations/∑ precipitations during the vegetation period)*10 De Martonne's aridity index (Iar-DM) and Hughlin Index (Iliescu et al. 2019; Jarvis et al., 2017). De Martonne's aridity index (Iar-DM) (mm $°C^{-1}$) expresses the connection between climate and soil and is and is given by the relation Iar-DM = P/(Ta+10) where P is the annual amount of rainfall in mm and Ta is the mean value of the annual air temperature in ºC (De Martonne, 1926; Pellicone et al., 2019).

The Huglin Heliothermal Index (Huglin 1978) was developed in northern Europe and utilizes growing temperatures as well as including the maximum temperature. The combination of daily maximum temperature helps take into account also the warm afternoons from April 1st to September 30th (in Romania and northern hemisphere) (Jarvis et al., 2017).

Huglin index (HI)=$\Sigma([(Tdmed - 10) + (Tdmax - 10)]/2 \times k)$ from April 1st to September 30th where Tdmax is the daily maximal temperature, Tdmed is the daily average temperature and k is the latitude coefficient which for Tarnave vineyard is 1.05 (46º.2 lat N) (https://www.onvpv.ro/sites/default/files/20210429_huglin_index_21_apr_2021_ro.pdf).

For reporting the starting of the phenological phases: budburst, flowering, veraison (change of color of the grape berries) and ripening-maturation we have taken the data from the SCDVV Blaj database for the studied cultivars Selena, Blasius, Rubin, Radames, Sauvignon blanc 9 Bl, Feteasca alba 29 Bl (Figure 1).

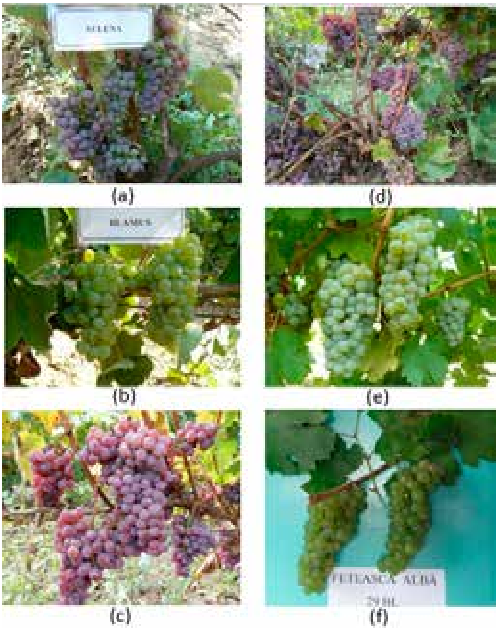

Figure 1. Grapevine cultivars Selena (a), Blasius (b), Rubin (c), Radames (d), Sauvignon blanc 9 Bl (e), Feteasca alba 29 Bl (f) homologated a SCDVV Blaj- grapes in the phenological phase of maturation

The period of time analyzed in this study was divided as follow: for the climatic data 2010-2021 with 1975-2009 taken as reference period, and for the phenological observations 1991-2021 with 1991-1999 considered as comparison reference period

RESULTS AND DISCUSSIONS

Tarnave vineyard is the largest vineyard of all the vineyards in Transylvania, with an area of approximately 2,250 km² and extends over a length of several tens of km, from Craciunelul de Jos (7 km west of Blaj) to the upper course of Tarnave rivers, reaching beyond Hartibaci, being located on the territory of 3 counties (Alba, Mureş, Sibiu) (Coros et al., 2019; Chedea et al., 2021). The vineyards are located on the southern slopes of the heights of this area, starting with the altitude of 250-270 m and up to 400-450 m, the slope of these lands being between 15-35%. The highest slopes are located on the river Tarnava Mare and decrease on Tarnava Mica, Murea and inland valleys (Iliescu et al., 2010; Calugar et al., 2018; Cudur et al., 2014; Donici et al., 2019).

The climate characteristics of the Transylvanian Plateau, under the influence of which are the Tarnave vineyard, is of the moderate temperate-continental type (Iliescu et al., 2019; Chedea et al., 2021). This climate is characterized by a lower level of heliothermal resources, accentuated by the location of the plateau inside the intra-Carpathian area, but it is very favorable for the cultivation of grapevines for wine grapes as the autumns are long, hot and sunny (Iliescu et al., 2010; Calugar et al., 2018; Donici et al., 2019; Chedea et al., 2021).

This allows the accumulation of sugars in grapes, while the acidity remains quite high, favoring a good balance for obtaining high quality wines (POD) (Iliescu et al., 2010; Calugar et al., 2018; Donici et al., 2019; Chedea et al., 2021). The viticultural area of Târnave vineyard is also characterized by the boreal climate, with cold and humid winters, but the grapevine development is not affected if the technological recommendation of partial mechanized protection of the vines at the base of the slope are followed (Iliescu et al., 2010).

Climate of the cultivation area, like the choice of an appropriate cultivar, is one of the most important elements influencing grape production as well as the type and quality of the wine produced (Koźmiński et al., 2020). The most essential climate parameter influencing grapevine growth and development is air temperature (Tonietto & Carbonneau, 2004; Coombe, 1987; Jones & Alves, 2012; Lisek, 2008; White et al., 2006; Santos et al., 2013; Koźmiński et al., 2020). The temperature determines when grapes ripen, which varies by cultivar (Jones & Davis, 2000; Malheiro et al. 2013; Karvonen, 2015; Koźmiński et al., 2020).

As Table 1 shows the most climatic parameters are presented and calculated based on the air temperature. For this study all the reference values were calculated for the period 1975-2009 and the comparison of the parameters of the period 2010-2021 was done with the above reference period. The average monthly temperatures show an increase compared to the reference value in all the months of the studied period. The highest increase was recorded in February with a positive deviation of 2°C compared to the multiannual average temperature (Table 1). Regarding the average annual temperature, for the period 2010-2021 there is an average increase of 1.1°C compared to the average multiannual reference temperature (calculated as the annual average of the years 1975-2009), which means that in the studied area, during the period 2010-2021 there was a warming of the air temperature compared to previous years (1975-2009).

Every year there have been increases in the multiannual temperature, the highest value being 11.9°C (in 2019), and the lowest being 9.7°C (in 2011), a value identical to the reference temperature (Table 1).

Regarding the global thermal balance and the active thermal balance, no differences were found compared to the reference values. The lowest value of the global thermal balance was recorded in 2021 (3027.1°C), the highest being recorded in 2015 (3682.5°C). The lowest value of the active thermal balance was recorded in 2010 (2950.0°C) and the highest being recorded in 2012 (3473.3°C) (Table 1).

Santos et al. (2013), Jones et al. (2005), Keller (2016), Clingeleffer (2010), and Koźmiński et al. (2020) stated that the air temperature during the vegetative part of the culture year expressed as active thermal balance has a higher impact on a specific wine vintage (grape composition, wine quality) than cultivation technology. When it comes to thermal resources, it should be noted that excessive heat during the vegetative period can cause grapes to mature earlier, have higher sugar content, and have lower acidity (De Orduna, 2010; Koźmiński et al., 2020). In contrast, insufficient active heat may result in delayed or limited maturation, and as a result, the produced wine will have a low alcohol concentration and a poor palatability (Jackson & Lombard, 1993; Koźmiński et al., 2020).

The useful thermal balance, in the studied period (2010-2021), on average, had an increase of 80.8°C compared to the reference value (1975-2009) (Table 1). The maximum value is observed in 2012 (1733.3°C), and the minimum value in 2010 (1320.0°C) (Table 1).

In the period 2010-2021, the average temperature during the vegetation of the vine is 17.8°C, thus registering a positive deviation from the reference value of 0.6°C (Table 1).

The absolute minimum temperature was recorded in 2017 (-24.7°C), a lower value than the absolute minimum reference (-24.0°C). The absolute minimum temperatures with the highest values are 2019 and 2020 (-12.5°C and -12.9°C) (Table 1). The absolute maximum temperature was recorded in 2012 (41.6°C), a much higher value than the absolute maximum reference (38.0°C). The absolute maximum temperatures with the highest values are 41.6°C for the year 2012 and 38.8°C for 2013 and 2015 (Table 1).

The precipitations are also an important climatic factor for grapevine cultivation. In this study, a slight increase of 34.7 mm of the annual precipitation amount was observed compared to the multiannual reference amount. The highest amount of precipitation was recorded in 2016 (1006.6 mm). The lowest amount of precipitation was recorded in 2011 (mm). The amount of precipitation during the vegetation period of the vine, during the studied period follows the same trend, registering a slight increase (by 15.3 mm) compared to the reference value, which is also found in the increase observed for the precipitation coefficient.

During the studied period, the number of days in the vegetation period varied from 200 days in 2012 (the warmest and driest year) to 160 in 2021. The average duration of the vegetation period in 2010-2021 is shorter than the reference period with 3.2 days.

The hydrothermal coefficient was higher in the studied period compared to the reference period, registering values between 1.0 (2011) and 3.1 (2016), which has a positive influence on the grape production. The average value (31) of the annual De Martonne's aridity index places the studied period in the lower limit of the humid climate category, similar and in the same climate as the reference period (Iar-DM = 31.1) . However, in 2011 the annual aridity index denotes a semi-arid dry climate, and in 2012, 2015, 2017 and 2019 a moderately humid climate (De Martonne, 1926; Pellicone et al., 2019).

The Huglin index for the studied period ranges between 2237.6 in 2021 and 2928.5 in 2012, with an average of 2542.6 which places the Tarnave vineyard in an area with a warm climate (Jones et al., 2010; ONPV, 2021 https: //www.onvpv.ro/sites/default/files/20210429_huglin_index_21_apr_2021_en.pdf)

Table 1. Climatic parameters for Tarnave vineyard as measured in Blaj wine center for the period 2010-2021 with references values calculated for the period 1975-2009.

	Reference value (1975-2009)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average 2010-2021
January	-2.0	-2.5	-3.4	-2.0	-1.2	0.8	-0.4	-1.8	-6.9	0.9	-0.3	-2.2	0.1	-1.6
February	-0.4	1.8	-2.1	-6.8	3.4	3.5	1.3	6.3	1.7	2.0	2.2	3.7	2.7	1.6
March	5.0	4.9	5.6	4.7	5.1	9.1	6.3	6.9	9.0	5.2	8.0	6.9	3.7	6.3
April	10.5	10.6	11.3	12.1	12.6	12.2	10.1	13.5	10.4	16.7	12.2	11.2	8.1	11.8
May	15.6	15.8	15.6	16.1	17.7	15.8	16.5	14.8	15.7	19.5	14.1	13.8	14.5	15.8
June	18.8	19.2	19.5	21.1	20.1	19.1	19.5	20.2	20.2	20.0	21.0	18.8	19.5	19.9
July	20.4	21.1	21.2	25.2	21.5	21.6	22.5	21.5	20.7	19.7	20.3	20.1	22.6	21.5
August	19.8	21.1	21.0	22.4	22.8	21.3	22.4	20.3	22.2	21.8	22.3	21.2	20.3	21.6
September	15.5	14.6	18.6	18.6	14.7	17.4	18.4	16.9	16.1	16.9	17.7	18.2	15.0	16.9
October	9.9	7.1	8.1	11.5	11.1	12.0	11.0	9.1	10.5	12.1	12.9	11.8	8.9	10.5
November	3.9	5.5	-0.3	4.6	7.6	5.5	5.4	2.8	5.2	5.7	10.0	3.1	4.8	5.0
December	-0.7	-1.6	1.1	-1.9	-1.8	2.6	1.2	-2.1	1.8	0.5	1.8	3.7	2.1	0.6
Annual average temperature, °C	9.7	9.8	9.7	10.5	11.1	11.7	11.2	10.7	10.6	11.8	11.9	10.9	10.2	10.8
Global thermal balance, ∑t°g, °C	3366.4	3127.7	3274.6	3534.0	3302.0	3551.1	3682.5	3273.0	3197.3	3482.4	3293.3	3418.3	3027.1	3346.9
Active thermal balance, ∑t°a, °C	3249.2	2950.0	3167.7	3473.3	3302.0	3440.6	3412.9	3220.5	3017.2	3441.7	3214.9	3329.2	3016.9	3248.9
Useful thermal balance, ∑t°u, °C	1410.7	1320.0	1477.7	1733.3	1522.0	1470.6	1592.9	1450.5	1429.2	1670.7	1474.9	1429.2	1326.9	1491.5
Average temperature during the vegetation period, °C	17.2	17.1	17.9	19.3	18.2	17.4	18.1	15.2	17.6	19.5	17.9	17.2	15.57	17.8
Absolute minimum temperature, °C	-24.0	-17.4	-17.6	-21.6	-13.7	-21.7	-23.5	-18.4	-24.7	-17.6	-12.5	-12.9	-13.1	-24.7
Absolute maximum temperature, °C	38.0	32.5	35.4	41.6	38.8	37.3	38.8	37.3	37.9	34.9	35.1	33.5	35.7	41.6
∑ annual precipitations (mm/ m^2)	611.8	698.0	303.9	519.8	677.0	668.0	598.6	1006.6	583.4	832.4	500.6	699.4	670.2	637.0
∑ precipitations during the vegetation period (mm/ m^2)	435.9	487.2	201.8	335.8	441.2	464.2	427.4	647.0	401.2	577.0	328.0	568.2	535.4	451.2
Precipitation coefficient, Pc	3.3	3.8	1.8	2.6	4.1	3.5	3.2	4.7	3.1	4.5	2.7	3.5	4.2	3.5
The length of the vegetation period (number of days)	187.0	182.0	173.0	200.0	166.0	192.0	188.0	190.0	190.0	183.0	183.0	199.0	160.0	183.8
Hydrothermal coefficient, HTC	1.9	2.4	1.0	1.5	2.1	1.9	1.8	3.1	1.9	2.4	1.6	2.1	2.2	2.0
De Martonne's aridity index Iar-DM	31.1	35.1	15.4	25.4	32.1	30.8	28.2	48.6	28.4	38.2	22.9	33.5	33.2	31
Huglin Index		2352.5	2280.2	2928.5	2802.7	2556.8	2653.6	2597.9	2429.3	2883.6	2520.6	2268.4	2237.6	2542.6

According to Table 2, the budburst phenophase, in the Tarnave vineyard, takes place between April 12 and May 10. Most of the studied cultivars buddbursted most frequently between April 14 and 20 (Table 2). Late budding, can be seen mainly between

1990 and 1998 (April 24-May 10) (Table 2). Selena, in most years, budbursted on April 16-17th (Table 2). Blasius, in most years, budbursted on April 18, the earliest buddburst being on April 12 (2018), and the latest on May 10 (2005) (Table 2). Rubin, in most years, budbursted on April 19, the earliest on April 16 (2018, 2019), and at the latest on April 22 (2013) (Table 2). Radames, in most years, budbursted on April 19, the earliest on April 14 (2001, 2003 and 2019), and at the latest on May 9 (1997 and 1998) (Table 2). Sauvignon blanc 9 Bl, in most years it budbursted on April 20, the earliest on April 15 (2003), and at the latest on May 10 (2005) (Table 2). Feteasca alba 29 Bl, in most years budbursted on April 15-16, the earliest on April 12 (2018), and at the latest on April 19 (2013) (Table 2).

Table 2. Budburst phenophase for the studied Tarnave vineyard cultivars for the period 1991-2021

Budburst Date	Cultivars – homologation year					
	Selena - 1995	Blasius - 1994	Rubin - 2007	Radames - 1993	Sauvignon blanc 9 Bl - 1975	Feteasca alba 29 Bl - 2006
12.04	2001; 2003; 2019	2018				2018
13.04	2016					2016
14.04	2018	2003		2001; 2003; 2019		2019
15.04	0	2016			2003	2006; 2009; 2010; 2011
16.04	2000; 2004; 2008; 2009; 2010	2001; 2019	2018; 2019	2018		2012; 2015; 2017
17.04	2006; 2014; 2015; 2017	2009	2016	2016	2018; 2019	2014
18.04	2007; 2011	1994; 2008; 2014; 2015; 2017	2008; 2014	2000; 2006; 2008	1994; 2016	2007; 2008
19.04	2012	2000; 2004; 2012	2007; 2010; 2011; 2012; 2015; 2017	2004; 2007; 2010; 2011; 2012; 2014	2012; 2014; 2015	2013
20.04		2006; 2007; 2010	2009	2009; 2015; 2017	2000; 2004; 2007; 2009; 2017	
21.04	2013	2011		1994	2006	
22.04			2013		2010; 2011	
23.04		2013		2013	2013	
24.04	1996				2008	
25.04	1995	1995			1991; 1995	
26.04		1996			1996	
28.04				1995		
30.04				1996		
1.05					1993	
2.05	2002					
3.05					2002	
4.05	2005			1993; 2005		
5.05		1997; 1998; 2002			1997; 1998	
6.05				2002		
7.05	1997; 1998					
9.05				1997; 1998		
10.05		2005			2005	

As Table 3 shows, the flowering phenophase, in the Tarnave vineyard, takes place between May 26 and June 23. In most years, the studied cultivars bloomed between June 5 and 10 (Table 3). Due to the climatic conditions manifested in June (capricious and rainy month) the flowering phenophase includes a fairly wide range of dates in which it takes place, therefore notable differences between the studied period and the reference period were not observed.

Selena cultivar, in most years, bloomed on June 8, the earliest on May 26 (2000, 2019), and the latest on June 17 (1997, 1998 and 2005) (Table 3). Blasius, in most years, bloomed on June 10, the earliest on May 26 (2019), and the latest on June 23 (2005) (Table 3). The Rubin cultivar bloomed between May 27 and June 22 and Radames between May 27 and June 21 (Table 3). Sauvignon blanc 9 Bl, in most years it bloomed on June 10-11, the earliest on May 28 (the years 2000 and 2019), and at the latest on June 22 (the years 2005 and 2006) (Table 3). Feteasca alba 29 Bl, in most years it bloomed on June 5-6, the earliest on May 26 (2000 and 2019), and at the latest on June 19 (2006) (Table 3).

Table 3. Flowering phenophase for the studied Tarnave vineyard cultivars for the period 1991-2021

Flowering Date	Cultivars – homologation year					
	Selena - 1995	Blasius - 1994	Rubin - 2007	Radames - 1993	Sauvignon blanc 9 Bl - 1975	Feteasca alba 29 Bl - 2006
26.05	2000; 2019	2019				2000; 2019
27.05			2000; 2019	2000; 2020		2013
28.05					2000; 2019	2000
29.05		2000				
30.05	2013		2013	2013	2013	
1.06	2018	2018				2018
2.06	2002	2002; 2013	2002	2002	2002	
4.06	2012;	2012;				2012
5.06	2015; 2017		2018	2018	2018	2008; 2011; 2015; 2017
6.06	2016	2015; 2016; 2017	2001	2001	2015; 2016	2001; 2003; 2016
7.06			2016	2016		2009; 2010
8.06	2001; 2003; 2009; 0210; 2011	2001	2015; 2017	2015; 2017	2017	
9.06		2011	2009; 2011	2009; 2011; 2012	2011; 2013	2004
10.06	1996	1996; 2003; 2009; 2010	2010	2010	1991; 1993; 1996; 2009	
11.06				1993	2001; 2003; 2010	
12.06	2014					2014
13.06		2014	2014	1996; 2014	2008; 2014	
14.06	1995; 2004	1995			1995	
15.06		1997; 1998		1995	1997; 1998	
16.06	2006; 2007; 2008	2008	2003	2003	2004	
17.06	1997; 1998; 2005		2018	1997; 1998		2005
18.06		2004	2004	2004		2007
19.06			2007			2006
20.06		1994; 2007	2005	1994; 2005; 2007	1994; 2007	
21.06		2006		2006		
22.06			2006		2005; 2006	
23.06		2005				

According to the analyzed data, the grapevine phenophase of veraison (change of color of the grape berries), in Tarnave viticultural area, takes place between July 25 and August 27 (Table 4). In most years, the varieties studied started to change the color of the grapes between August 14 and 20 (Table 4). Selena, in most years, entered veraison on August 14-16, the earliest veraison phenophase was on July 25 (2002), and at the latest on August 22 (2014) (Table 4). Blasius, in most years, started the veraison phenophase on August 18, the earliest on July 28 (2002), and at the latest on August 23 (2005) (Table 4). Rubin, in most years, started the veraison on August 20, the earliest date of veraison was observed on

August 8 (2012), and at the latest on August 22 (2014) (Table 4). Radames, in most years, started the veraison phenophase on August 16 and 20, the earliest on July 31 (2002), and at the latest on August 27 (1997 and 1998) (Table 4). Sauvignon blanc, in most years, started the veraison on August 20, the earliest veraison was on July 30 (2002), and at the latest on August 25 (1991) (Table 4). For the Feteasca alba 29 Bl cultivar, no consistency was observed in terms of veraison phenophase, which took place between July 29 and August 20 (Table 4).

It is noticeable that during the years 1991-2000, the veraison phenophase took place mainly in the second half of August and the period 2000-2010 stands out with an early entry into this phenophase compared to the rest of the studied years.

Table 4. Veraison (change of color of the grape berries) phenophase for the studied Tarnave vineyard cultivars for the period 1991-2021

Veraison Date	Cultivars – homologation year					
	Selena - 1995	Blasius - 1994	Rubin - 2007	Radames - 1993	Sauvignon blanc 9 Bl - 1975	Feteasca alba 29 Bl - 2006
25.07	2002					
28.07		2002				
29.07						2009
30.07					2002	
31.07				2002		
1.08	2000; 2012					
3.08		2009				2010; 2012
4.08		2000				2008; 2011
5.08		2008; 2012				
7.08	2008				2009	
8.08	2009; 2011	2011	2012	2012	2012	
9.08	2010	2010	2008	2008		2007
10.08	2007	2007	2007; 2009	2009	2000	
11.08				2000; 2007	2008; 2011	
12.08			2010		2010	
13.08			2011	2010; 2011	2007	
14.08	1995; 2001; 2003; 2016; 2019	1995		1995	1995	2016; 2019
15.08		2016				2015; 2017
16.08	1996; 2015; 2017; 2018	1996; 2001; 2019	2016	2001; 2016; 2019	1996	
17.08	2006		2019	2004		
18.08	2004; 2005	1994; 2003; 2006;2015; 2018			1994; 2016	2013; 2018
19.08		2004		1996; 2005	2004	2006
20.08	1997; 1998	1997;1998; 2013	2013; 2015; 2017; 2018	2003; 2006; 2013	1993; 2001; 2003; 2013; 2015; 2019	2014
21.08	2013			2015; 2017	2017	
22.08	2014	2014	2014	2018	1997; 1998; 2018	
23.08		2005		2014	2014	
24.08				1993; 1994	2005; 2006	
25.08					1991	
27.08				1997; 1998		

Table 5 presents the ripening-maturation starting date for all the studied cultivars According to it, the phenophase of grape ripening, in the Tarnave vineyard, takes place between September 2 and October 1 (Table 5). In most years, the varieties studied reached maturity between September 10-18 (Table 5).

Selena, in most years, entered the grape ripening phenophase on September 10-16, the earliest ripening was observed on September 2 (year 2002), and at the latest on September 30 (the year 2014) (Table 5). Blasius, in most years, entered the grape ripening phenophase on September 10-16, the earliest start was on September 3 (2002), and at the latest on September 30 (the year 2014) (Table 5). Rubin, in most years, entered the grape ripening phenophase on September 16-18, the earliest maturation was on September 10 (2002), and the latest on September 30 (the year 2014) (Table 5). Radames, in most years, started to ripe on September 15-18, the earliest maturation was observed on September 10 (2002), and the latest on October 1 (the years 1997; 1998) (Table 5). Sauvignon blanc, in most years, entered the grape ripening phenophase on September 16-18, the earliest ripening date was observed on September 10 (2002), and the latest on October 1 (year 1991) (Table 5). Feteasca alba, in most years, started the grape ripening phenophase on September 5, the earliest maturation date was observed on September 2 (2002), and the latest on September 24 (2013) (Table 5).

It can be easily observed that during the years 1991-1999, the ripening phenophase of the grapes took place mainly at the end of September (after September 20).

Table 5. Ripening-maturation phenophase for the studied Tarnave vineyard cultivars for the period 1991-2021

Harvest Date	Cultivars – homologation year					
	Selena - 1995	Blasius - 1994	Rubin - 2007	Radames - 1993	Sauvignon blanc 9 Bl - 1975	Feteasca alba 29 Bl - 2006
2.09	2002					2002
3.09		2002				
5.09		2000				2000; 2001; 2003; 2004; 2019
6.09	2000					2010
8.09						2009; 2012
10.09	2001; 2003; 2012; 2019	2001; 2009; 2012; 2019	2002	2002	2002	2006; 2008; 2011
11.09	2010					
12.09	2004; 2009; 2018	2003; 2008; 2010	2001; 2019	2001; 2019	2001; 2003; 2019	
13.09	2015					2015; 2017
14.09	2008; 2011	2006		2003		
15.09	2016; 2017	2004; 2011; 2015; 2018	2000; 2012	2000; 2004; 2012	2000; 2012; 2016	2016; 2018
16.09	2005; 2006; 2007	2005; 2007; 2016	2003; 2004; 2008; 2009; 2010	2008; 2009; 2010; 2011	2004; 2008; 2009; 2010; 2011	2005; 2007
17.09			2011			
18.09		2017	2005; 2006; 2007; 2016; 2018	2005; 2006; 2007; 2016; 2018	2005; 2006; 2007; 2016; 2018	2014
20.09	1995	1995	2017	2017	1995	
22.09	1996	1996		1995	1996	
24.09		2013				2013
25.09			2015	1996; 2015	2015; 2017	
26.09	2013	1994			1994	
28.09	1997; 1998	1997; 1998	2013	1994; 2013	1993; 2013	
29.09					1997; 1998	
30.09	2014	2014	2014	1993; 2014	2014	
1.10				1997; 1998	1991	

CONCLUSIONS

The climatic data for Tarnave vineyard as collected at SCDVV Blaj have been processed into fourteen parameters, and for the phenological periods the starting date was analyzed. The average annual temperature, during 2010-2021 shows a warming with 1.1 ºC compared to the multiannual average reference temperature. The average duration of the vegetation period from 2010-2021 is shorter than the reference period by 3.2 days.

Acording to the climate indexes observations, our study places Tarnave vineyard, during the years 2010-2021, in a humid (given by the Martonne aridity index), warm climate (given by the Hughlin Index) with an increase of precipitations (given by the sum of annual precipitations and also the precipitation coefficient).

In the conditions above presented, most of the studied varieties budbursted frequently between April 14 and 20, bloomed between 5 and 10 June, started the veraison phenophase between August 14 and 20 and reached maturity between September 10-18.

In conclusion the warming of the climate induced an earlier budburst with an average of eight days and an advance regarding the maturation phenophase with an average of 9-11 days. So far for the blooming and veraison phenophases starting dates, the outrunning was not clearly observed.

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