Growing Season Climate Variability and its Influence on Sauvignon Blanc and Pinot Gris Berries and Wine Quality: Study Case in Romania (2005-2015)

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The purpose of our research was to find out what influence climatic variability in the growing season has on the berry and wine composition in two white grape varieties grown in the vineyard of Banat University of Agricultural Sciences and Veterinary Medicine from Timisoara, located in the western area of Romania. The quality and characteristics of the wines produced in a limited area is essentially due to the environment, including natural and human factors. Two white cool-intermediate climate grape varieties - Sauvignon Blanc and Pinot Gris were chosen to study the impact of climate change on the main characteristics of juice and wine. A number of 40 berries from each variety was chosen for phenol extraction, total soluble solids (sugar content), titratable acidity and pH determinations. Wine samples were analysed after one year of ageing in the bottle. Alcohol concentration was not majorly influenced by temperature and rainfall over the years. Some experimental years with hot weather were favourable for sugar accumulation in berries and wine respectively;therefore, potential alcohol also increased. In the last decade, annual and monthly variability of rainfall and temperature influenced the phenological cycle of grapevines most, delaying or accelerating the developing of foliar area, as well as the ripening and harvesting time, which has a direct influence on grapes and wine products.

INTRODUCTION

Recent climate variability including major temperature differences from summer to winter, alternating hot, dry days and cold, rainy days negatively influenced the grape yield and quality. This is not only the case in Romania, but all over the world (Nesbitt *et al.,* 2016). The World Meteorological Organization (WMO) reported that Europe experienced its second hottest year in 2015, behind only the record set in 2014. The rising temperatures associated with climate change are already reshaping the wine industry; therefore, viticulturalists match the varietal with the environmental factors of a region (Jones *et al.,* 2012). There is a clear correlation between grapevines and climate change. As a result of phenological stage changes, harvest time has shifted from late October to early September over the last 25 years in many vineyards located in France, Italy and Germany (McQuaid, 2011& Daux *et al.,* 2011). Climate variability in Romania generates beneficial and adverse consequences. The area of vineyards was expanded in terms of climate suitability for better wine production by 2.4 million hectares. Red wine grape varieties were introduced in northern regions, while grape composition was influenced by excessive sugar levels and lower acidity in southern regions (Irimia *et al.,* 2017). Despite climate variability that has occurred throughout history, vine cultivation and wine making have survived through continuous adjustment (Ashenfelter & Storchmann, 2014).However, these adjustments seem to be slower for vines that have a productive lifetime of over 25 years than for annual crops (Cooper *et al.,* 2012). Grape yield and wine quality, and therefore prices and revenues, are directly influenced by weather, both during the season and at harvest (Lorenzo *et al.,* 2012). Temperature, humidity and solar radiation have great influence on grapevine growth, fruit set, grape yield and wine quality, as Bora *et al.* (2016) reported in their research concerning the wine quality from several Romanian and worldwide vintages, including Sauvignon Blanc, Italian Riesling and Muscat Ottonel. Yield and grape quality from the same plot can vary from year to year depending on climate (Ashenfelter *et al.,* 1995). Berry composition is influenced by climate, viticultural practices and topography (Jackson, 2000). During ripening, phenols and especially tannins are developed in the skins and seeds of the grape, and can affect the wine flavours and

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aromas (Weston, 2000). Temperature has a deep impact throughout grape growing season. After veraison starts, sugars build up (fructose and glucose accumulate) and pH (acids) begins to fall (Robinson & Harding, 2015). The heat hastens ripening, producing grapes with more sugar, stronger flavors, and wine with more alcohol.However, over 33°C photosynthesis and, in consequence, berry ripening is slowing down (Jones & Davis, 2000). Some researchers state that high day temperatures combined with low temperatures overnight stimulates phenolic compounds with positive results for wine quality (Jones & Alves, 2012). In relatively closed locations, the same grape wine variety can offer special traits with its own typicity and strong footprint (Dobrei *et al.,* 2015).

Research was carried out with the aim to assess the influence of climate variability, temperature and precipitation on grape berries and wine quality in Sauvignon Blanc and Pinot Gris varieties grown in the vineyard of Banat University of Agricultural Sciences and Veterinary Medicine from Timisoara, during 2005-2015. Research is important for winemakers to be able to evaluate the opportunities and risks, including those from the well-known vineyards Recas, Minis and Buzias-Silagiu in western Romania in order to adapt the growing practices according to the region climate to preserve the typicity of white wines in the region, knowing the harsh competition in the wine industry.

MATERIALS AND METHODS
The trial was conducted at the Banat University of Agricultural Sciences and Veterinary Medicine from Timisoara, located in the west of Romania, 45°78'83.84"N, 21°22'60.11"E, latitude and longitude coordinates (Fig. 1), during 2005-2015.

Climate in the region is moderate continental with slight Mediterranean influences. The average annual temperature is 10.9°C (1961 - 2015), with a maximum of 41°C registered on 16-08-1952 and a minimum of -35.3°C on 29-01-1963. Two white cool-intermediate climate varieties - Sauvignon Blanc and Pinot Gris - grown in the same vineyard of 22 years old were used in the study. The vines were planted on rows oriented west to east, at 1.2 m between vines and 2 m mid-row (4166 vines/ha). Vines training on trellis were Cordon de Cazenave and pruned at 30 buds per vine (two buds/spur). The vineyard is located on a flat field on a fertile cambic chernozem (silty clay, fine loess deposits) in the upper50 cm. Temperature was measured by sensors installed at 1.5 m above the ground, year-round at each third hour to create daily maximum measurements by using a WMS-25 Modular Weather Station with standard SD card with 2 GB for data storage, placed in the vineyard at 35 m away from paved surfaces to avoid the retained heat. WMS-25 is equipped with 6 standard weather parameters: wind speed and direction, temperature, relative humidity, barometric pressure and precipitation. Data from the SD card were transferred to a computer in Microsoft Excel for graph and data analysis.

Using our own protocol, clusters for the experiment were selected on shoots of similar vigour on vines. Each year, berry samples were collected at harvest from different places within the cluster, placed in plastic bags and stored in cooler box. Samples were taken to the laboratory and was separated in sub-samples, put in sealed plastic bags and stored at -18°C until analysed. A number of 40 berries from each variety for phenol extraction and other components analyses was chosen. Berries were manually crushed for juice extraction. For total phenolic determination 10 berries were used; the

FIGURE 1
Research location (Timisoara) in western Romania (45°78'83.84"N, 21°22'60.11"E)
(http://street-map.us/gps/)

remaining berries were reserved for determining total soluble solids (sugar content), titratable acidity and pH. Soluble solids were determined using a handheld refractometer, pH and titratable acidity (TA) was determined with a pH meter. TA was determined by titration with 0.1 NaOH ((TA = (no.ml NaOH/ no.ml juice) x 0.75)) and results are expressed as tartaric acid equivalents per litre of juice (g/L). Determination of the total phenol content was done by using the Folin-Ciocalteu method adapted from Singleton and Rossi (1965), and expressed as gallic acid equivalent (GAE) (mg/100g dry weight basis). All wines were produced under the same conditions in the BUAS winery. The wine samples from 2005 until 2015 vintages were analysed after one year of ageing in the bottle. Wine bottles were stored at 10°C prior to analysis. Ien the statistical analysis,data were subjected to Microsoft Excel 2013 and Statistica 7.1 (Dell Statistica, Tulsa, Oklahoma, USA) at a 0.05 level of significance. In all experiments, data were subjected to a coefficient of determination and graphical representations using Excel 2013 (Microsoft Corporation, Redmond, Washington, USA). The average monthly temperature and monthly total precipitations were calculated for the period 2005-2015 (Fig. 2 and 3) and registered data in the research region for 1961-2015 (Fig. 4). Resulted values for grapes and wines were subjected to ANOVA for both varieties. Five traits (alcohol, sugars, titratable acidity, and pH (for grape juice and wine)) were tested for the influence of two main weather effects (temperature and precipitations). A separate analysis was performed for each variety, and tables and graphs were produced. Predictions for sugar content in Sauvignon Blanc and Pinot Gris, depending on average monthly rainfall (2005 - 2015), were subjected to a polynomial regression model calculated with Microsoft Excel 2013, and corresponding

R^2 values resulted. For veraison months (June and August), predictions of sugar content influenced by average monthly temperature (2005-2015) were made. A principal component analysis (PCA) was developed for analysing Sauvignon Blanc and Pinot Gris varieties' main parameters from grape juice and wine, related to the temperature and rainfall variability during 2005-2015 (XLSTAT, 2014).

RESULTS
Climatic conditions
Thermal and rainfall variability over growing season (Fig. 2 and 3) influenced the vegetation start and phenology of grape vines with significant differences in crop yield and quality, including influences on premium quality wine (Malheiro *et al*., 2013). Between 2005 and 2015, in March, the average monthly temperatures were within normal limits for budburst time, except in 2005 and 2006 when there was colder weather. In March in the Timisoara region, when bud break stage is starting at over 10°C, the mean temperature was highly variable, from 1.36°C to 12°C. There were days in both 2005 and 2006 when variability ranged from a minimum of -15°C to 20°C; buds were vulnerable due to high temperature amplitude and young shoots were damaged by spring frost. Flowering began about 52 days after bud break in 2012, for the shortest period (a warm and wet year), and about 73 days after bud break in the longest interval, which was in 2005 (cold with low rainfall from May to August).

In 2008, 2010 and 2013, flowering time and fruit set were both negatively influenced by rain, because many flowers were not fertilised, and crop yield declined. Limited water stress and canopy management from years 2008, 2009, 2012 and 2015 lead to early veraison and high quality wine. During ripening time (September-October), the highest
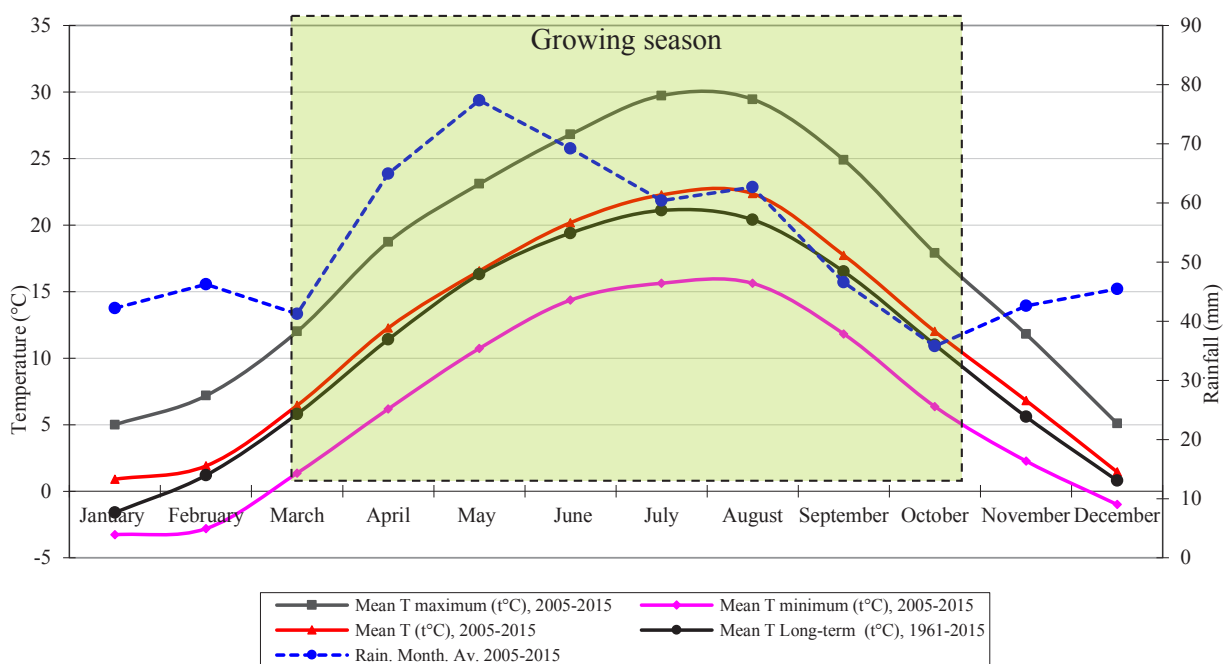

FIGURE 2
Temperature and rainfall monthly average during 2005-2015, and long term average temperature (1961-2015) in Timisoara region, Romania

monthly average temperature was recorded in 2011 (22°C) and the lowest monthly average temperature in 2010 (9.5°C). High temperatures in winter months influenced the grapevine phenology, disturbed its development and shortened its vegetation. In all the years of research, the average monthly temperature in December was above 1°C, which is quite warm for a winter month, except in 2009, 2012 and 2014 when the average monthly temperature was below 0°C. Similar observations were made for February.

During the growing season (April – September), in May, June and July were registered the most variable total average rainfall, especially during the last five years of research (2010-

2015). During 2005-2015 growing seasons, 2014/2015 could be classified as the driest (372 mm rainfall) and 2013/2014 as the wettest (738.4 mm rainfall). In the long term, rainier periods during growing season were observed in the years 1974-1975 (Fig. 4). The influence of this climate variability over 11 years (2005-2015) was studied for Sauvignon Blanc and Pinot Gris varieties in the west of Romania.

Sauvignon Blanc and Pinot Gris juice and wine traits during 2005-2015
Sauvignon Blanc originates from the regions of Loire Valley and Bordeaux in France. This variety performs well in a cool
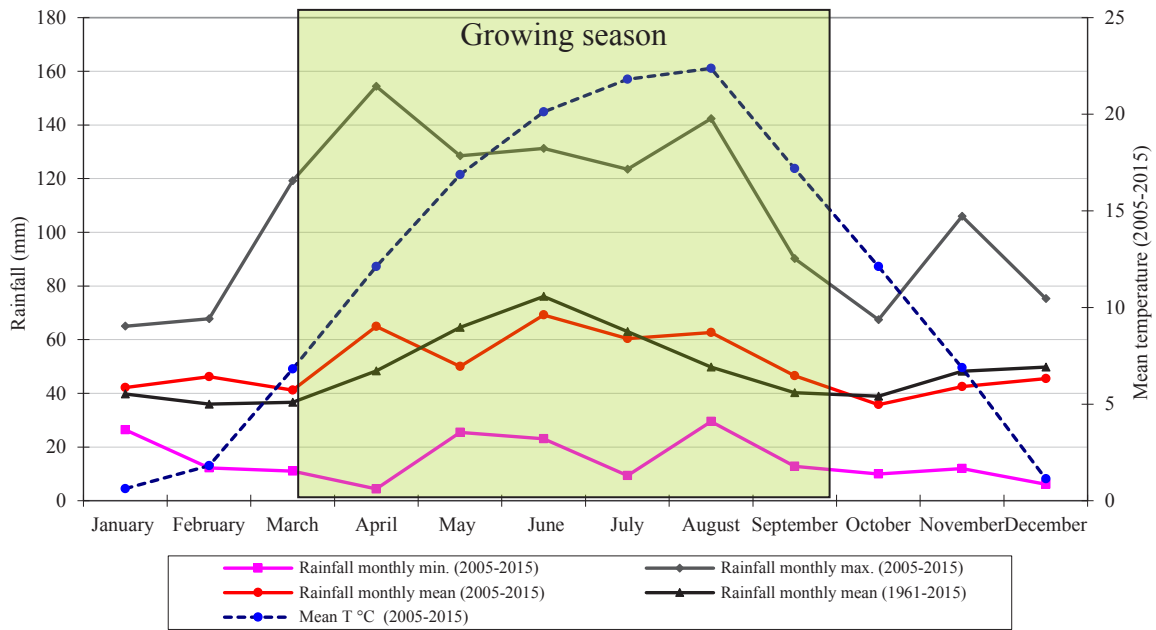

FIGURE 3
Rainfall and mean temperature during 2005-2015, and long term average monthly rainfall (1961-2015) in Timisoara region, Romania
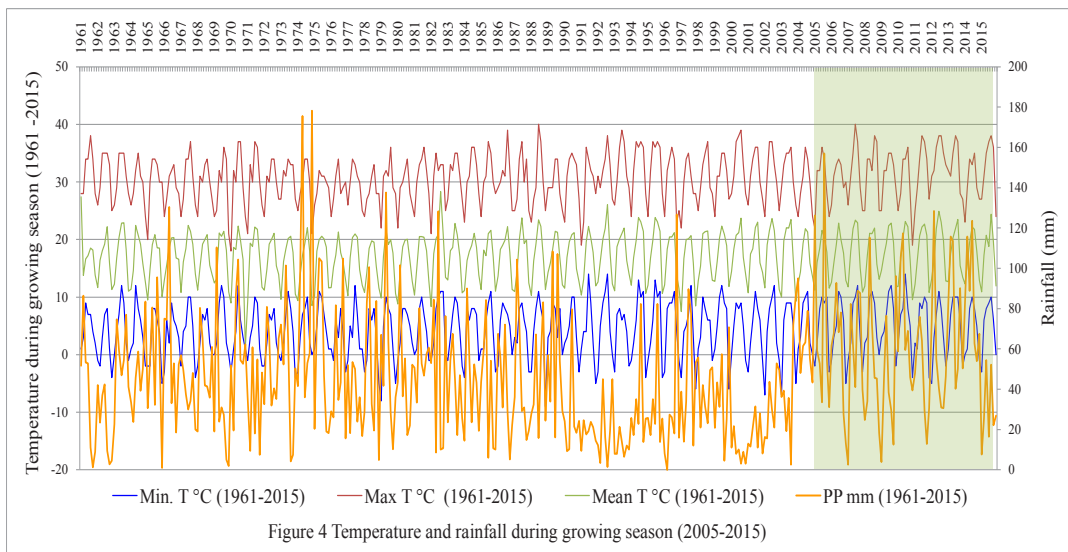

Figure 4 Temperature and rainfall during growing season (2005-2015)

FIGURE 4
Temperature and rainfall during growing season (2005 – 2015)

climate (Clarke *et al.*, 2001), and depending on the climate it can offer a large range of wine styles (Coetzee & du Toit, 2015). Pinot Gris is well known from the Middle Ages in the Burgundy region, from where it spread to many countries of the world (Robinson, 1986). According to Jones *et al.* (2009), varieties suited for cool climates perform well at 13-15°C (Pinot Gris) and 15-17°C (Sauvignon Blanc) in the growing season, with cooler summer days and a short period of veraison.

Sugar accumulation and alcohol level

During our research (2005-2015), grape juice sugar levels in Sauvignon Blanc oscillate from lower, 204 g L^{-1} in 2005, to the highest, 249 g L^{-1} in 2015 (Table 1). In Pinot Gris, the highest sugar content in grape juice was recorded in 2015 (260 g L^{-1}), followed by 2012 (254 g L^{-1}), with the lowest value of 219 g L^{-1} observed in 2005 (Table 2). The year 2015 ranked amongst the 10 warmest years on record, especially in South East Europe (Christidis *et al.*, 2015), and was favourable for sugar accumulation compared to other experimental years. Drought associated with low temperature during ripening had a positive effect on sugar concentration in berries (Gerós *et al.*, 2012). Therefore, alcohol levels in wine also increased. Fruit composition is highly influenced by temperature, and sugar concentration increased significantly above 30°C (de Beer *et al.*, 2005). Between 2005 and 2015, berries' sugar concentration was highly correlated with temperature and rainfall in both varieties (Sauvignon Blanc and Pinot Gris). 2005 was the coldest and one of the wettest years during research (2005-

TABLE 1
Sauvignon Blanc (SB) quality parameters in grape juice and wine, during 2005-2015.

Year	SB Sugars	SB Alch.%	Juice SB TA g L^{-1}	Juice SB pH	Wine SB pH
2005	204	12.08	8.14	3.13	3.1
2006	211	12.09	7.82	3.17	3.13
2007	216	12.37	7.39	3.24	3.19
2008	227	12.41	7.69	3.18	3.16
2009	218	12.46	7.26	3.25	3.20
2010	212	12.49	7.90	3.14	3.12
2011	224	12.56	7.50	3.23	3.19
2012	233	12.99	7.11	3.34	3.27
2013	226	12.52	7.65	3.20	3.17
2014	223	12.53	7.41	3.22	3.18
2015	249	12.96	7.01	3.47	3.41

SB - Sauvignon Blanc; Alch. – alcohol; TA – titratable acidity

TABLE 2
Pinot Gris (PG) parameters in grape juice and wine, during 2005-2015.

Year	PG Sugars	PG Alch.%	Juice PG TA g L^{-1}	Juice PG pH	Wine PG pH
2005	219	12.32	7.99	3.31	3.19
2006	231	12.56	7.69	3.42	3.21
2007	242	12.67	7.45	3.46	3.27
2008	240	12.66	7.54	3.42	3.24
2009	249	12.70	7.20	3.48	3.29
2010	239	12.67	7.79	3.39	3.20
2011	251	12.69	7.46	3.46	3.26
2012	254	13.07	7.17	3.50	3.32
2013	247	12.71	7.49	3.43	3.24
2014	246	12.70	7.47	3.44	3.25
2015	260	13.18	7.01	3.52	3.36

PG – Pinot gris; Alch. – alcohol; TA – titratable acidity

2015), and sugar concentration was negatively influenced hereby. In 2012 and 2015, high temperatures above 18°C favoured sugar accumulation in Pinot Gris juice (Table 2). In both varieties, alcohol concentration was not majorly influenced by temperature and rainfall over the years. In wet years (2005, 2010, 2013 and 2014), Sauvignon Blanc which has tight clusters, was damaged by rot more than Pinot Gris. Viticultural practices and dryness decreases the sugars in 2014, close to the level of concentration in 2010.

pH level

Over-ripe due to the higher temperatures alters the wine flavours and acidity (Dobrei *et al.*, 2015). The largest increase of pH in the Sauvignon Blanc variety was recorded in 2013, which was caused by reduced photosynthetic activity and high potassium concentration in berries. Although 2010 and 2015 were different in terms of climate, the juice and wine from the Sauvignon Blanc and Pinot Gris varieties had overall relatively close and moderate pH values, below 3.6 respectively (Table 1 and 2), which is favourable for stable wines.

Titratable acidity

The concentration of titratable acidity (TA L^{-1}) of Sauvignon Blanc juice is over 7, which is the lowest desired for this variety, even though the acid profile is somewhat higher than in other wine varieties (Clarke, & Bakker, 2004). In both varieties, TA of both juice and wine was the lowest in 2012, due to the warm weather and dilution with water in berries. The highest TA concentration was registered in 2014 because of the late harvesting, which correlated with water stress. For specific high acidity wines, the Sauvignon Blanc variety needs low temperatures (Jones *et al.,* 2009). Results for TA in juice of white varieties, except in 2010, are in agreement with the observations of Myburgh (2006) in Sauvignon Blanc from South Africa (8.3-9.1 TA g L^{-1}). The pH value of Sauvignon Blanc juice below 3.5 improved the colour stability and clarity of the wine. High temperatures and water stress in 2013 and 2014 resulted in grapes with low acidity/high pH for both Sauvignon Blanc and Pinot Gris. The higher TA in the Pinot Gris variety was found in juice from berries harvested in 2014, when temperature in ripening time (October) was low (12°C).

Prediction for sugar content in Sauvignon Blanc and Pinot Gris varieties

Sugar concentration influenced by temperature

Since the accumulation of sugars influences the other components in berries and wine, regression analysis was done only for this parameter. Regression data analysis confirmed the prediction of Sauvignon Blanc and Pinot Gris sugar content based on the temperatures in the research area. Prediction of sugar content in Sauvignon Blanc and Pinot Gris varieties according to temperature (2005 - 2015) was statistically significant ($R^2 = 0.545$; $p < 0.005$), according to equation 1, and ($R^2 = 0.783$; $p < 0.001$) equation 2 for Sauvignon Blanc. Equations 3 ($R^2 = 0.519$; $p < 0.003$) and 4 ($R^2 = 0.888$; $p < 0.005$) are available for Pinot Gris (Table 3). The particular distribution of values is shown in Figure 5 (a - d).

Sugar concentration influenced by rainfall

Correlated with temperature, precipitations are the second most important factor that influenced the grapevine growth, and consequently berry and wine quality (Chevet *et al.*, 2011). Prediction of sugar content in both varieties according to monthly total rainfalls (2005 - 2015) was statistically significant ($R^2 = 0.677$; $p < 0.001$), according to equation 5 for both Sauvignon Blanc and for Pinot Gris ($R^2 = 0.865$; $p < 0.001$; equation 6) (Table 4). The particular distribution of values is shown in Figure 6 (a - d).

According to R^2 results from Table 3 and 4, in both varieties temperature and rainfall from August influenced the sugar content in berries most. Water deficits in summer reduced shoot vigour and favoured the partitioning of carbohydrates through the clusters. Low levels of humidity and the favourable solar radiation in this period of veraison when colour of grapes is changing, lead to sugar level increase (Carey *et al.*, 2009). Mirás-Avalos and Intrigliolo (2017) found in their research concerning the grape composition under water stress in a Mediterranean climate that this climate has a strong effect on the cultivar, since the weight of the Sauvignon Blanc and Riesling berries were strongly reduced. They found a correlation of -0.236 and 0.024 between grape sugars and vine water status.

The difference in vigour between varieties and berry development as a response to water limitation has a major

TABLE 3
Predictions for sugar content in grape juice of Sauvignon Blanc and Pinot Gris varieties, according to average monthly temperatures (2005 - 2015).

	Parameter	Sauvignon Blanc		R^2	Pinot Gris		R^2
May		$y = -9.3413x^2 + 318.13x - 2480.2$		0.183	$y = -8.0925x^2 + 276.1x - 2106$		0.163
June		$y = -2.4975x^2 + 106.65x - 909.49$ $p < 0.005$	[1]	0.545*	$y = -2.3504x^2 + 100.35x - 821.13$ $p < 0.003$	[3]	0.519*
July	Sugar/ Temp.	$y = -0.083x^2 + 8.5737x + 72.364$		0.146	$y = 5.2111x + 127.39$		0.182
Aug		$y = 0.1396x^2 + 0.8938x + 132.052106$ $p < 0.001$	[2]	0.783*	$y = 0.1624x^2 + 0.0538x + 160.74$ $p < 0.005$	[4]	0.888*
Sept		$y = 1.0834x^2 - 36.738x + 528.95$		0.199	$y = 1.1648x^2 - 39.425x + 572.05$		0.258
Oct		$y = -0.27x^2 + 9.5363x + 147.02$		0.168	$y = 1.8x + 221.85$		0.053

*statistically significant

impact on sugar accumulation, especially before veraison, according to Keller *et al.* (2006). The influence of water stress on grape quality was confirmed by Balint and Reynolds (2013) in Sauvignon Blanc from the Ontario region, where irrigation in the hot season improved grape composition and wine aroma.

Principal component analysis (PCA) was applied to Sauvignon Blanc and Pinot Gris varieties for grape juice and wine on the basis of sugars, alcohol content, titratable acidity and pH over the 11 years (2005-2015). The PCA plot gives the overview of how analysed parameters were influenced by variety and by years. The first two main components (PC1
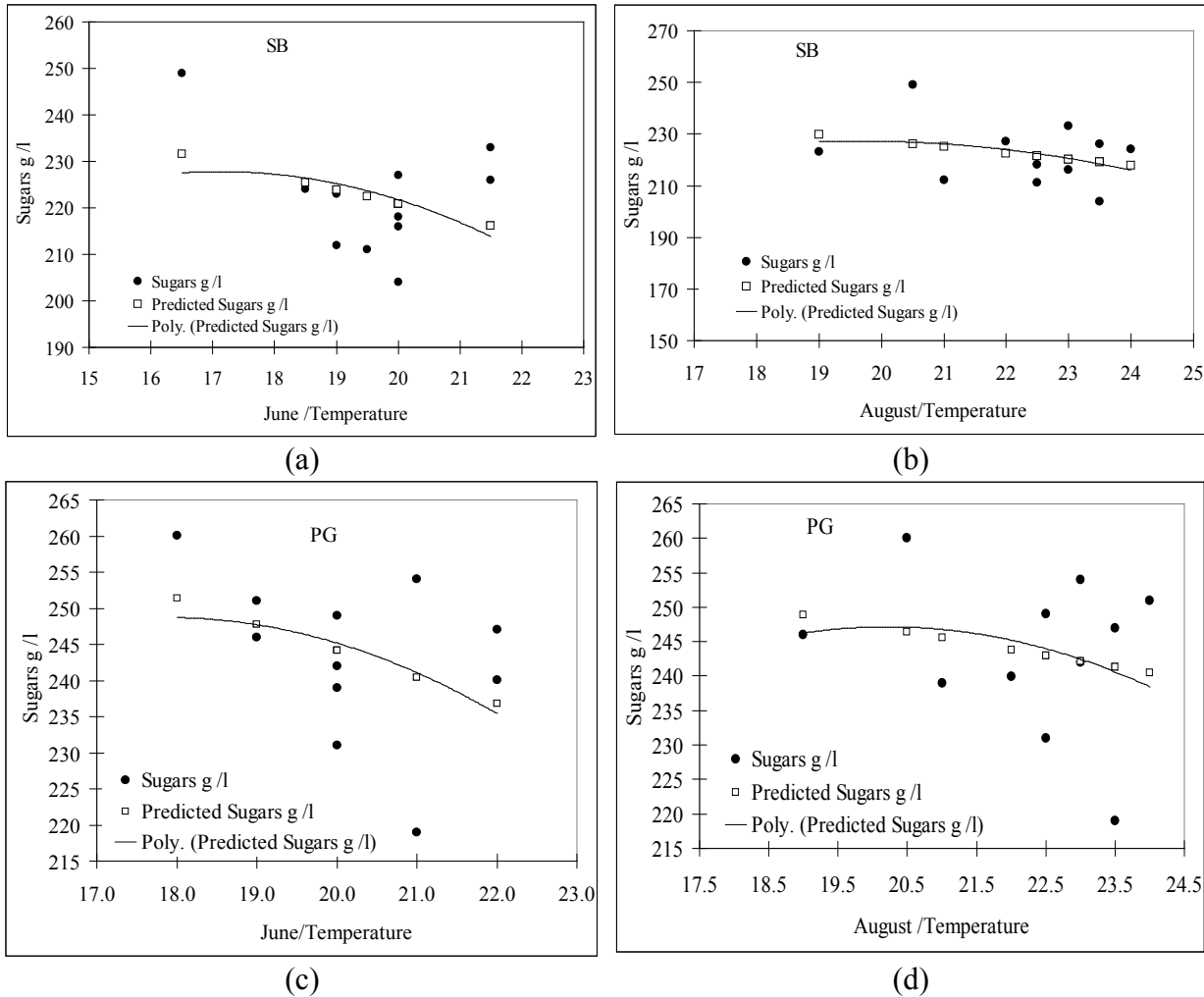

(a)   (b)

(c)   (d)

FIGURE 5

Predictions of sugar content in grape juice of Sauvignon Blanc (SB) and Pinot Gris (PG) grape varieties according monthly average temperatures in June and August (2005-2015)

TABLE 4

Predictions for sugar content in grape juice of Sauvignon Blanc and Pinot Gris varieties, according to total monthly rainfall (2005 - 2015).

|	Parameter	Sauvignon Blanc	R^2	Pinot Gris		R^2
May		$y = -0.0063x^2 + 0.9577x + 192.97$	0.244	$y = -0.0094x^2 + 1.4936x + 195.58$		0.565
June		$y = 0.0022x^2 - 0.5414x + 246.52$	0.379	$y = 0.0031x^2 - 0.5954x + 266.22$		0.236
July		$y = 0.0029x^2 + 0.5242x + 206.08$	0.190	$y = -0.0032x^2 + 0.615x + 223.38$		0.316
Aug	Sugar/ Rainfall	$y = 0.0004x^2 - 0.3105x + 239.59$ $p < 0.001$	[5] 0.677*	$y = -0.0922x^2 + 10.534x$ $p < 0.001$	[6]	0.865*
Sept		$y = -0.0003x^2 - 0.1107x + 227.99$	0.128	$y = -0.0018x^2 - 0.0205x + 249.4$		0.288
Oct		$y = -0.0044x^2 - 0.1218x + 224.51$	0.101	$y = -0.0019x^2 - 0.1073x + 250.17$		0.145

*statistically significant
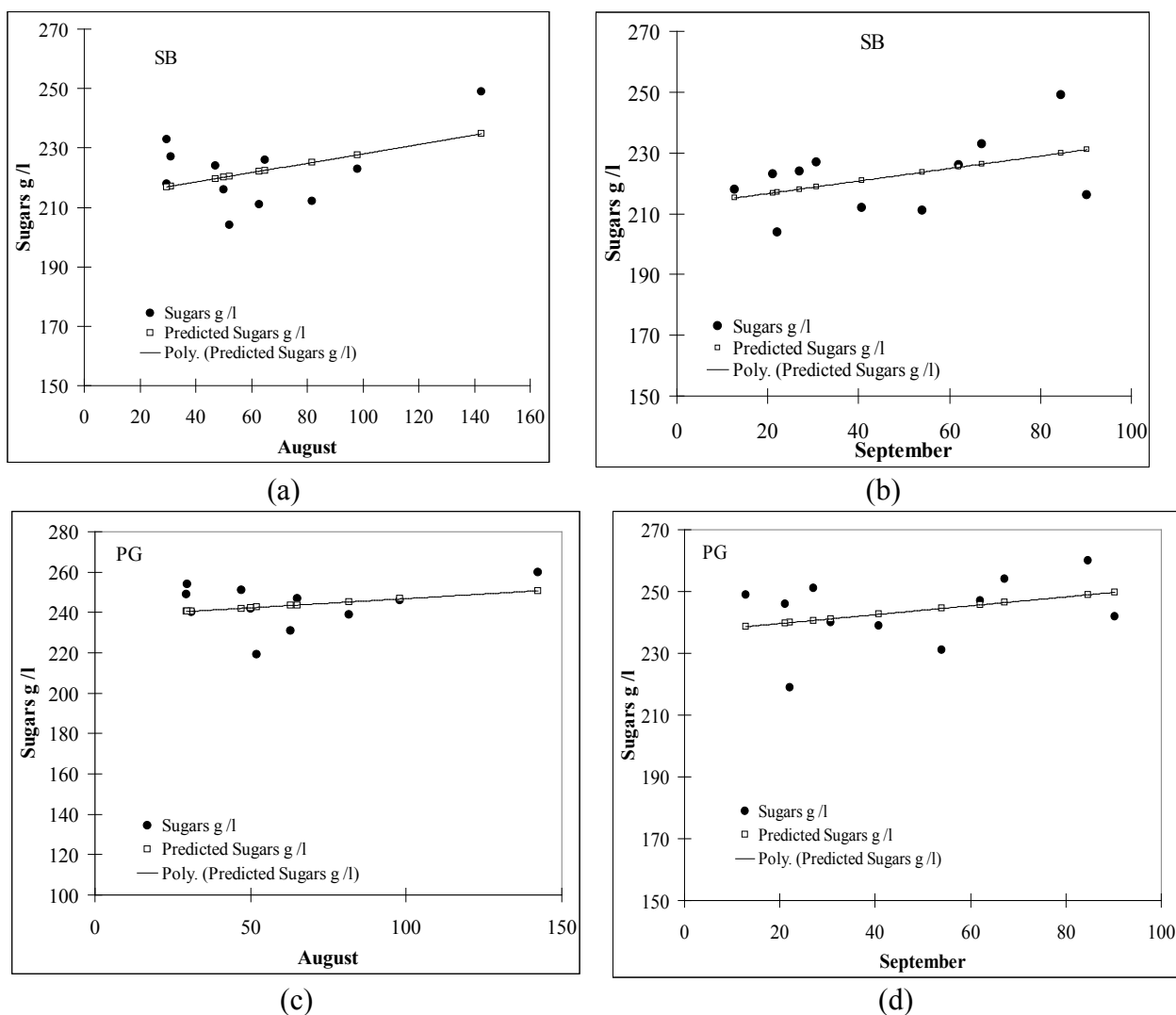
FIGURE 6

Predictions of sugar content in grape juice of Sauvignon Blanc (SB) and Pinot Gris (PG) grape varieties according monthly average rainfall in August and September (2005-2015).

and PC2) explains 94.44% of the experimental variance for those five traits studied for the Sauvignon Blanc variety, where PC1 explained 89.79% and PC2 explained 4.65% (Fig. 7). Factorial analysis revealed that alcohol content and sugar levels in the Sauvignon Blanc variety were higher over the years such as the balanced year of 2012 when the weather was warm and moderately wet, correlated with below average titratable acidity and grape juice or wine pH respectively.

In the Pinot Gris variety, multivariate analysis (Fig. 8) based on the first two main components explained 95.91% of the variability for the five parameters analysed. The sugars in the Pinot Gris grape juice was moderately influenced by the climatic conditions of the warmer and drier years (2012 and 2015), while the alcohol content was much higher than the average. In the moderate but warmer years (2010 and 2013), the titratable acidity was higher, while the pH of grape juice and wine was relatively low, especially in the warm and dry year of 2009.

DISCUSSION

Sugar accumulation and alcohol content

High temperatures during ripening (average 20°C) increased the sugar accumulation in both Sauvignon Blanc and Pinot Gris varieties, which is in accordance with the results of Coombe (1987). High levels of sugar concentration in juice are also due to dehydration of berries. In many research, results confirm that the optimum ripening temperature ranges between 20°C and 22°C (Gladstones, 2011). High sugar concentration and alcohol levels, correlated with low acidity, result in relatively unbalanced wine (Jackson, 2000). One of the issues generated by high alcohol content is that these wines will not age well and long, like those with moderate alcohol content do (Ashenfelter *et al.,* 1995). Caliari *et al.* (2014), found in the Brazilian Santa Catarina region for the Sauvignon Blanc variety an alcohol content of 12.9 ± 0.2%, closely related to our values from 2015; while for Pinot Gris, value recorded was 10.5 ± 0.2%, much lower compared to the Pinot Gris alcohol content from the Timisoara region.
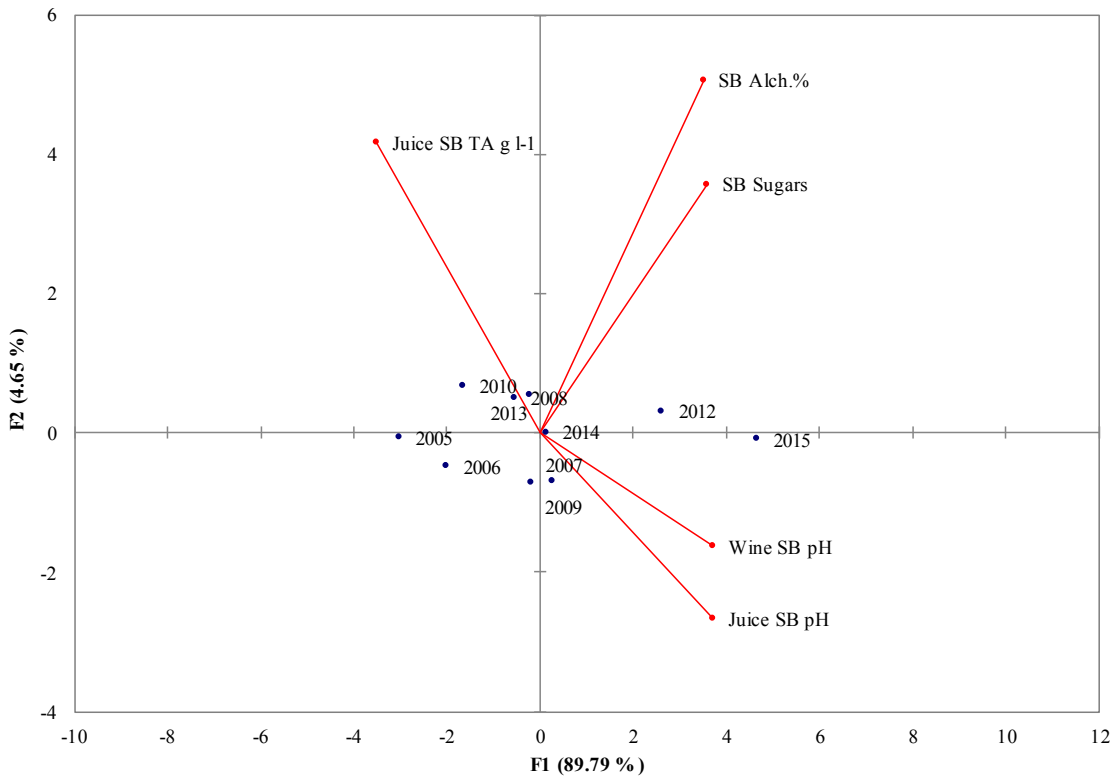
FIGURE 7

Principal component analysis of Sauvignon Blanc grape juice and wine and their characteristics (axes F1 and F2: 94.44 %)
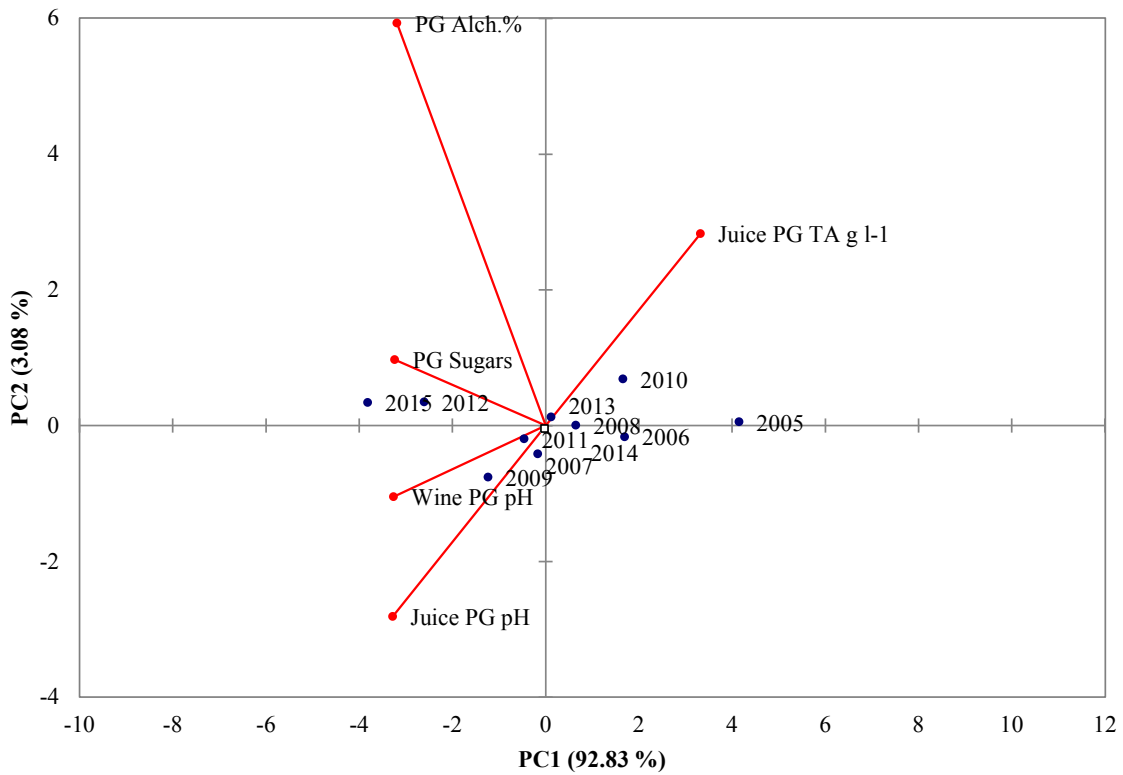

FIGURE 8

Principal component analysis of Pinot Gris grape juice and wine and their characteristics (axes PC1 and PC2: 95.91 %)

pH level

Conradie *et al*. (2002) found quite similar results for must pH in Sauvignon Blanc from South African vineyards (3.19 -3.30), with those from Sauvignon Blanc must from Romania (3.13 -3.47). Evaluating the leaf removal effect on berry composition in a Sauvignon Blanc vineyard from Italy, Mosetti *et al*. (2016) found (in control plot) a pH of 3.51, associated with a TA of 4.88 (g L^{-1}). Wine alcohol concentration ranged in the same limits or was lower than those obtained by Ford (2007) in his research on Sauvignon Blanc wine in New Zealand (12.7 -13.5%). In the research of Tosi *et al.* (2008), Pinot Gris wine alcohol concentration ranged from 10.75 to 12.34%, pH by 3.09 to 3.36 and phenols between 255 and 397 mg L^{-1}. Shange and Conradie (2012) found the same influence of Botrytis cinerea on sugar accumulation for the Sauvignon Blanc variety grown in the Helderberg area of the Western Cape in South Africa. The pH value found in grape juice of Pinot Gris by Steiner *et al.* (2005) during 2001-2004 in Ohio State University vineyards, was between 3.12 and 3.24 (free run) in grape juice and between 2.96 and 3.22 in wine.

Titratable acidity

The influence of high temperature associated with water stress on TA/pH, was observed by Conradie *et al.* (2002) in several vineyards of Sauvignon Blanc from South Africa. Freeman *et al.* (1982) mentioned that for vineyards from Salinas Valley, among other factors, water stress reduces the photosynthetic activity in leaves, which leads to higher potassium accumulation in berries and increased must pH values. Bora *et al.* (2016) found a higher alcohol level of $14.35 \pm 0.25\%$, and a lower TA (5.20 ± 0.07 g l^{-1}) level in the eastern region of Romania (Dealu Bujorului from the Galati County located at 45°52′10″ North, 27°55′8″ East), in wine of the Sauvignon Blanc variety. In the same research, they found a higher pH level in the wine (3.54 ± 0.17). Grigorica *et al.* (2017) found in their research in the Sauvignon Blanc variety grown on sandy soils of the Oltenia region in the south of Romania during 2013-2015, the following values for wine parameters: alcohol level between 11.8% (in 2014) and 13.6% (in 2015), TA between 5.9 g L^{-1} (in 2013) and 6.7 g L^{-1} (in 2015) and pH between 3.11 (in 2015) and 3.35 (in 2013). For the Pinot Gris variety grown in similar conditions, their results were: alcohol level from 12.9% (in 2014) to 13.8% (in 2015), TA from 5.8 g L^{-1} (in 2013) to 6.2 g L^{-1} (in 2015) and pH from 3.27 (in 2014) to 3.49 (in 2015). Their conclusion was that even in the years that are not very favourable for high quality white wines, good quality wines could be produced by adapted winemaking and biotechnological solutions. In their research from Stellenbosch in South Africa, Corey *et al.* (2009) found that must composition (sugars, pH and TA) of Sauvignon Blanc was not significantly influenced by climate variability. Wine aroma and acidity (pH 3.6) were determined by viticultural terroir.

Results obtained for TA in the Pinot Gris variety are closely related to those found by Tosi *et al.* (2008). By studying nine clones of Pinot Gris in the Verona region for three years (2002-2004), they found in the juice a TA between 6.75 and 10.45 g L^{-1} (harvested in the last decade of August),

while pH ranged from 3.09 to 3.71. Chemical analyses of juice done by Olejar *et al.* (2015) in New Zealand revealed higher TA (10.1 g L^{-1}) and pH (3.4) because of cryogenic maceration. In the dry summers and higher temperatures of 2012 and 2015, grapes matured earlier and therefore have a lower TA value in both varieties. In traditional Cencibel vineyards from Spain, Ortiz-Villajos *et al.* (2010) found that TA is decreasing from the end of July until the ripening time in September, from 13.5 g L^{-1} to 4.4 g L^{-1} in 2008 (a mild, fresh year in Spain), and from 9.5 g L^{-1} to 4 g L^{-1} in 2009 (a warm and dry year in Spain), respectively.

CONCLUSIONS

High sugar concentration in juice leads to undesirable fermentation products, suchas acetic acid. Among the white varieties, Sauvignon Blanc alcohol concentration fluctuated little over the years, and was found to be moderately low or medium alcohol concentrated wines. The temperature and rainfall study during April – October on grapevine vegetation is useful for prediction and adjustments in pruning and management technologies of main quality parameters in juice and wine. Rainfall and temperatures had very large amplitudes in the years and months of research, but in the research area, June and July influenced the vegetative cycle of the grapevine most, delaying or accelerating the development of the foliar area or the ripening and harvesting time, which has a direct influence on wine products. Knowing the behavior of the vineyard in reaction to climate change is helpful in order to be able to coordinate the grapevine management and pruning throughout the year, and to finally get the best juice and wine. At higher temperatures the grapevine phenology cycles start earlier, which means that sugars and tannins are fully developed before harvest. Hot weather induces faster sugar maturation without flavour fulfillment. If the harvest waits for flavour development, the acidity is sacrificed, resulting in high alcohol wine with low acidity. In ideal climates, sugar accumulation happens steadily, acidity level is regulated and the final result is the flavour palate of the wine. Understanding the relationship between grapevine phenology and temperature helps viticulturists with future vineyard management planning and to find suitable solutions. Results of the research offer new information for winemakers concerning the quality traits of juice and wine of Sauvignon Blanc and Pinot Gris varieties, which could be useful for their marketing and promotion.

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