EFFECT OF CLIMATE AND SOIL ON PHENOLOGY AND RIPENING OF *VITIS VINIFERA* CV TOURIGA NACIONAL IN THE DÃO REGION

Authors:PedroRODRIGUES[1,2,3], Vanda PEDROSO[4], Alexandre PINA[1], Gonçalo LOURENÇO[1], António CAMPOS[1], Sérgio SANTOS[1], Tiago SANTOS[1], Sílvia LOPES [1], João GOUVEIA[1], Carla HENRIQUES[1,2], Ana MATOS[1,2], Cristina AMARO DA COSTA[1,2]; Fernando GONÇALVES[1,2,3].

[1] *Instituto Politécnico de Viseu, Campus Politécnico, Viseu, Portugal*
[2] *Centro de Estudos em Educação, Tecnologia e Saúde, Instituto Politécnico de Viseu, Viseu, Portugal*
[3] *CERNAS, Centro de Estudos de Recursos Naturais, Ambiente e Sociedade, Instituto Politécnico de Viseu, Campus Politécnico, Viseu, Portugal*
[4] *Centro Estudos Vitivinícola do Dão. Direção Regional de Agricultura e Pescas do Centro, Nelas, Portugal*

*Corresponding author: prodrigues@sc.ipv.pt

Abstract:

Context and purpose of the study - "Terroir" has been acknowledged as an important factor in wine quality and style. It can be defined as an interaction between climate, soil, vine (cultivar, rootstock) and human factors such as viticultural and enological techniques. Soil and climate are the two components of the "Terroir" with an important role on the vine development and berries ripening. The present study is focused on the effects of the weather conditions and the soil characteristics on the phenological and berries ripening dynamics of the "Touriga Nacional" in Dão region.

Material and methods - This assay was carried out during 2017 and 2018 in four commercial vineyards at different places at Dão Region, centre of Portugal, with red grapevine variety Touriga Nacional. For each field were defined 3 plots were defined, and the observations were carried out in 10 plants per plot. Meteorological data was recorded at automatic stations localized next each vineyard. For the soil characterization, soil samples were taken in three layers until the 200 cm depths. Between budburst and veraison, the phenological stages were monitored using the E-L modify scale. During the ripening period, weekly, samples with 200 berries per plot were taken, determined their weights and juice volumes, and analysed their sugar contents, total acidity and pH. The anthocyanins accumulation was indirectly monitored, using the fluorescence optical sensor Multiplex, on six clusters per plot.

Results - The results showed similar characteristics of soils at the different vineyard, but different weather condition between places and years. The lag of the chronological evolution of the phenology and ripening between places and years was mainly due to the different thermal conditions of each place in each year.

Keywords: Soil, Climate, phenology, ripening, Touriga Nacional

1. Introduction.

Effect of Climate and soil on phenology and ripening of *Vitis Vinifera* cv Touriga Nacional in the Dão Region

Pedro RODRIGUES[1,2,3*], Vanda PEDROSO[4], Alexandre PINA[1], Gonçalo LOURENÇO[1], António CAMPOS[1], Sérgio SANTOS[4], Tiago SANTOS[1], Sílvia LOPES[1], João GOUVEIA[1], Carla HENRIQUES[1,2], Ana MATOS[1,2], Cristina AMARO DA COSTA[1,2]; Fernando GONÇALVES[1,2,3]

[1] Instituto Politécnico de Viseu, Campus Politecnico, Viseu, Portugal
[2] Centro de Estudos em Educação, Tecnologia e Saúde, Instituto Politécnico de Viseu, Viseu, Portugal
[3] CERNAS, Centro de Estudos de Recursos Naturais, Ambiente e Sociedade, Instituto Politécnico de Viseu, Campus Politécnico, Viseu, Portugal
[4] Centro Estudos Vitivinícola do Dão. Direção Regional de Agricultura e Pescas do Centro, Nelas, Portugal
*Corresponding author: prodrigues@sc.ipv.pt

Context and purpose of the study

- "Terroir" has been acknowledged as an important factor in wine quality and style. It can be defined as an interaction between climate, soil, vine (cultivar, rootstock) and human factors such as viticultural and enological techniques.
- Soil and climate are the two components of the "Terroir" with an important role on the vine development and berries ripening.
- The present study is focused on the effects of the weather conditions and the soil characteristics on the phenological and berries ripening dynamics of the "Touriga Nacional" in Dão region.

Material and methods

- The assay was carried out during 2017 and 2018 in four commercial vineyards at different places at Dão Region, centre of Portugal, with red grapevine variety "Touriga Nacional" (Figure 1).
- For each field were defined 3 plots were defined, and the observations were carried out in 10 plants per plot.
- Meteorological data was recorded at automatic stations localized next each vineyard.
- For the soil characterization, soil samples were taken in three layers until the 200 cm depths.
- Between budbreak and veraison, the phenological stages were monitored using the E-L modify scale.
- During the ripening period, weekly samples with 200 berries per plot were taken, determined their weights and juice volumes, and analysed their sugar contents, total acidity and pH.
- The anthocyanins accumulation was indirectly monitored, using the fluorescence optical sensor Multiplex on six clusters per plot

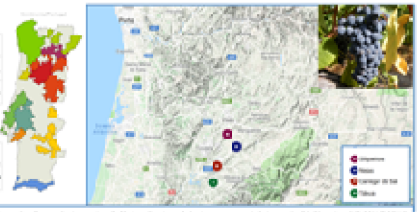

Figure 1 – Portugal wine region (left). Localization of the four commercial vineyards, P1-Silgueiros (40,39N;7,92W), P3-Nelas (40,52N ; 7,85W), P5-Carregal do Sal (40,42N ; 7,99W) and P7-Tábua (40,36N ; 8,02W). Touriga Nacional (low right).

Results

Soil

The analytical data present in Table 1 show similar characteristics of soils at the different vineyard. In all fields of this trial the soils are classified as Sand Loam, acids (P3) or very acids (P1, P5 and P7), with low (P3 and P7) or very low (P1 and P5) organic matter content and low water holding capacity.

Table 1 – Physical and chemical characteristics of soils

Vineyard		Depth (cm)	Clay	Silt	Sand	Textural Class (NRCS/USDA)	Moisture a pF0 (%)	Moisture a pF1,7 (%)	Moisture a pF4,2 (%)	Water holding capacity (% v/v)
P1	Silgueiros	0-60	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
		60-120	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
		120-200	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
P3	Nelas	0-60	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
		60-120	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
		120-160	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
P5	Carregal do Sal	0-60	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
		60-120	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
		120-160	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
P7	Tábua	0-60	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
		60-120	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]
		120-200	[illegible]	[illegible]	[illegible]	Sandy loam	[illegible]	[illegible]	[illegible]	[illegible]

Vineyard		Depth (cm)	Organic matter (%)	pH	P_2O_5 (mg/kg)	K_2O (mg/kg)	CEC (cmol kg^{-1})	Base Saturation
P1	Silgueiros	0-60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P3	Nelas	0-60	1,0	4,8	17,16	150	5,1	98,1
P5	Carregal do Sal	0-60	0,5	4,1	15,42	318	7,9	98,1
P7	Tábua	0-60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Climate

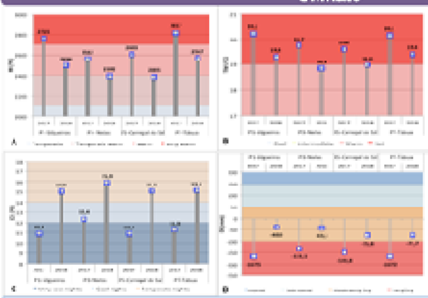

Figure 2 – (A) Huglin Index (base 10ºC, Apr-Sep); (B) Average Growing Season Temperature (Apr-Oct); (C) Cool Nights Index and (D) – Dryness Index (Apr-Sep) at P1, P3, P5 and P7 for the growing season 2017 and 2018 and class limits.

The results showed different weather condition between places and years.

- In all commercial vineyard, the average growing season temperature (TM) and Huglin Index (HI) were higher in 2017. At both years, these two viticulture climate indexes were lower at P3-Nelas and P5- Carregal do Sal (Figure 2 and Figure 3).
- The Cool Nights Index (CI), at all places, were higher in 2018 and in both year, at the vineyard P3-Nelas (Figure 4).
- At all places, the Dryness Index (DI) were lower in 2017. In both years, the vineyard P7-Tábua was the dryer place (figure 5).

Phenology

Although the seasonal evolution of phenological stages shows a large lag between years, and in each year, between sites (Figure 2), its relation with $GDD_{(1 Jan, 10º)}$ (R^2 = 0,93 p<0,001) reveals its strong dependence on temperature conditions (Figure 3).

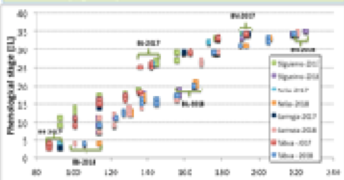

Figure 2 – Phenological stages evolution at different vineyards, during growing season 2017 and 2018 (BB – EL 4; BL – EL 19 to EL 23 and BP – EL 35).

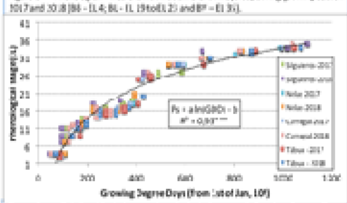

Figure 3 – Relationship between phenological stages and Growing Degree Days, calculated from the 1st january with base temperature of 10ºC.

Ripening

Figure 4 – (A) Sugar content (Brix) and (B) Total acidity (g of acid tartaric/L) of berries sampled from the different vineyards, at different dates during the ripening period of 2018. Means within bars followed by different letters differ significantly by statistical test at 5% probability.

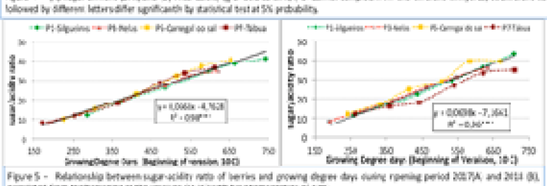

Figure 5 – Relationship between sugar-acidity ratio of berries and growing degree days during ripening period 2017(A) and 2018 (B), calculated from the beginning of the veraison (EL35) with base temperature of 10ºC.

In both years, the results show a strong dependence of the sugar-acidity ratio of $GDD_{(EL35,10ºC)}$ (2017 - R^2=0,98 p<0,001; 2018 - R^2=0,96 p<0,001) calculated from the beginning of veraison (EL35), with 10ºC (Figure 5). The ripening speed was similar in both years (0,067 in 2017 and 0,07 in 2018).

The evolution of the FERARI index during the ripening period (Figure 6A) shows that the maximum of anthocyanins accumulation occurs earlier at P1-Silgueiros. When we report this index to the thermal time (Figure 6B) its possible verify that the maximum accumulation, at all vineyards, was get when GDD reached to 350ºC.day.

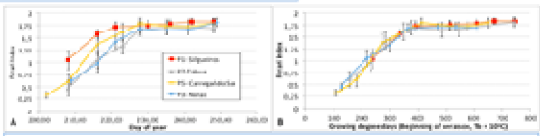

Figure 6 – (A) Evolution of FERARI index (FERARI=log(1/FRF_R), an indirect anthocyanins content indicator determined by measurements with fluorescence optical sensor MULTIPLEX, during ripening period 2017; (B) Relationship between FERARI index and growing degree days, calculated from the beginning of the veraison (EL35) with base temperature of 10ºC.

Conclusion

The results showed similar characteristics of soils at the different vineyard, but different weather condition between places and years. The lag of the chronological evolution of the phenology and ripening between places and years was mainly due to the different thermal conditions of each place in each year.

References

Fernández-González, M., Rodríguez-Rajo, F., Escuredo, O. and Aira, M. (2013). Influence of thermal requirement in the aerobiological and phenological behavior of two grapevine varieties. Aerobiologia 29:523-535.
Jones, G., Duff, A., Hall, A. and Myers, J. (2010). Spatial Analysis of Climate in Winegrape Growing Regions in the Western United States. Am. J. Enol. Vitic. 61(3): 313-326.
Santibanez, F., Sierra, H. and Santibanez, P. (2014). Degree Day Model of Table Grape Phenology in Mediterranean Temperate Climates. Int. J. of Science, Environment and Technology 3(1):10-22.
Tonietto, J. and Carbonneau (2004). A multicriteria Climatic Classification System for grape-growing regions worldwide. Agric. Forest Meteorol. 124:81-97.
Van Leeuwen, C., Friant, P., Chone, X., Tregoat, O., Koundouras, S. and Dubourdieu, D. (2004). Influence of Climate, Soil and Cultivar on Terroir. Am. J. Enol. Vitic. 55(3): 207-217.

Acknowledgements

This study was financed by CENTRO-04-3928-FEDER-000xx - Strategic Project to support the wine sector in the Central Region research activity Comparative Study of Autochthonous Varieties in the Dão region, sponsored by CENTRO2020.