TERROIR INFLUENCE ON GROWTH, GRAPES AND GRENACHE WINES IN THE AOC PRIORAT, NORTHEAST SPAIN

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Abstract

The Mediterranean climate of The Priorat AOC, situated behind the coastal mountain range of Tarragona, tends towards continentality with very little precipitation during the vegetation cycle. The soil is poor, dry and rocky, largely composed of slate schist, known as "llicorella". Vines primarily grow on steep slopes and terraces. To evaluate how the Priorat unique terroir influences the quality of its wines, two plots of Grenache were chosen, both grafted onto R110. In the study those two sites are referred to as: LO (in the township of Lloar) and EM (in the township of Molar), distinct topographic locations within the AOC. Grenache vines in LO are 14 years old growing in east-south facing terraces. Grenache vines in EM are 16 years old, and south-facing. Both vineyards feature VSP trellising with 2 wires (70cm height). The vines are pruned as bilateral cordon. During 2010 and 2011, leaf area (LA) at the phenological stages of pea size (PS), veraison (V), final ripening (RP) and post-harvest (PH) was measured. Berry phenolic maturity was monitored and the chemical analyses of the wine were carefully evaluated. The 2010 vintage was characterized by a heterogenic distribution of rainfall and a lower vapor deficit pressure than 2011. Total leaf area (TLA) within parcels did not differ significantly in the temperate year. In the drier vintage, however, vines from LO developed more leaf area than those growing in the south-facing terraces at EM. Nevertheless, the total leaf area before harvest was similar. The heterogeneity in the soil profile at the LO location could likely induce a variation in the drainage capacity, affecting the vine growth (TLA). Small berries from EM produced the highest levels of anthocyanins. EM always has the highest content in ANT T, ANT E, IPT and DMACA in both years. Concerning the wines, the highest concentration of anthocyanin were found in the EM treatment, with greater differences that LO in 2010. Grenache vines growing under warm climate conditions (Priorat AOC), in heterogeneous-stony soils, showed notably variability in the wine composition in front of climate change.

Key words: Priorat, Grenache, vapor pressure deficit, stony soil, schist, phenolics

1 INTRODUCTION

A vineyard reflects its immediate growing area, including the soils and climatic conditions that influence production [1, 2]. Variations resulting from the current climate change, especially in regions like the Mediterranean basin, should be carefully analyzed and characterized for greater understanding. Such climatic changes quickly effect growing regions featuring poor, coarse-textured soils with low fertility [3], especially those located in areas with low and irregular precipitation [4, 5], and also subjected to erosive phenomena [6]. Water stress, resulting from high evapotranspiration, lack of summer rainfall, and well-drained soils with low retention capacity, has a significant effect on such vineyards. An understanding of vegetative growth, and how this affects the final composition of the grapes, is a formula essential to determining optimal harvest dates for high quality wines.

This study evaluates the effect of climate variability on two different plots in the same growing area of the Priorat AOC (Catalonia, NE Spain), focusing on the grape varietal *V. vinifera* 'Grenache', in two climatically differentiated vintages. The availability of data to characterize the climatic variation between small plots is an essential tool for improving crop management under such extreme conditions.

2 MATERIALS AND METHODS

The Mediterranean climate of the Priorat AOC (Tarragona, Spain), situated behind the coastal mountain range of Tarragona, tends towards continentality with minimal precipitation during the vegetation cycle. Two Grenache vineyards are analyzed here, both grafted onto R110. The plots are located in the townships of El Molar (EM) (41° 9' 21.10" N, 0° 43' 4.08" E, altitude 210m) and El Lloar (LO) (41° 10' 5.64 "N, 0° 43' 17.18" E, altitude 240m), and studied during two distinctly different vintages: 2010 and 2011. Soils in both are typical of the region, characterized by poor, dry, and pebbly schist. The USDA classification for EM is sandy loam and silty loam for LO, both are of a co-alluvial origin formation.

The terraces are naturally located at progressive topographic heights. Grenache vines in LO are 14 years old, and are growing in east-south facing terraces; EM vines are 16 years old and south-facing. Vine spacing is 1.2m and the inter-row distance is 2.5m. VSP trellising (70cm high) and bilateral cordon pruning characterize both vineyards.

Weather stations (DECAGONmodel) located in each vineyard recorded climate data (temperature (ºC), humidity (%), rainfall (mm) and radiation ($W \cdot m^{-2}$). Vapor pressure deficit (VPD) was calculated for this study. Measurements were taken of leaf areas (primary and secondary leaf area, PLA and SLA respectively) during 2010 and 2011 at the phenological stages of pea size (PS), veraison (V), ripening (RP) and post-harvest (PH). Berry ripening was carefully monitored and the chemical analyses of the resulting wines were evaluated. During harvest, weekly samples of 400 berries were randomly harvested, and then analyzed. Sugars (Brix), ATT (g/L tartaric acid) and the pH of the grape juice were determined. After crushing the whole berries, extraction of phenolic compounds was performed according to the method of Glories modified [7] to determine the total and extractable anthocyanins (ANT T and ANT E), % EA % MP, and IPT (total polyphenol index) was also measured. Alcohol by volume (ABV), ATT, pH, anthocyanins, DMACA (flavan-3-ol), and total tannins were also analyzed in the wine [8]. (ANOVA) was performed using the General Linear Model procedure. The *Tukey* test was applied for *post-hoc* analysis (SPSS statistical package, version 17.0) between plots.

3 RESULTS AND DISCUSSION

Climatology

The crucial months defining the characteristics of the vintage are July, August, September and October – the period between veraison and ripening. Temperatures were higher in 2011 during the ripening period (September), while in 2010 the temperatures were more moderate, averaging up to 5ºC less than in 2011 (Figure 1). Maximum temperatures in 2010, in the LO plot, reached values slightly below that of the EM plot, with a peak in July. In contrast, in 2011 the highest temperatures appeared one month later than their peak in 2010, reaching markedly high values of vapor pressure deficit (VPD) at the end of August and September, corresponding with the grape ripening period. The maximum temperature in 2011 remained high for several months with no variance between plots. The annual rainfall in 2010 was lower by 75mm compared to 2011, with low rainfall between June and October, being almost null values in the months of August and September. Vintage 2010 did not carry continued VPD values as high as in 2011 in the same period. Thus, 2010 was defined as milder vintage.

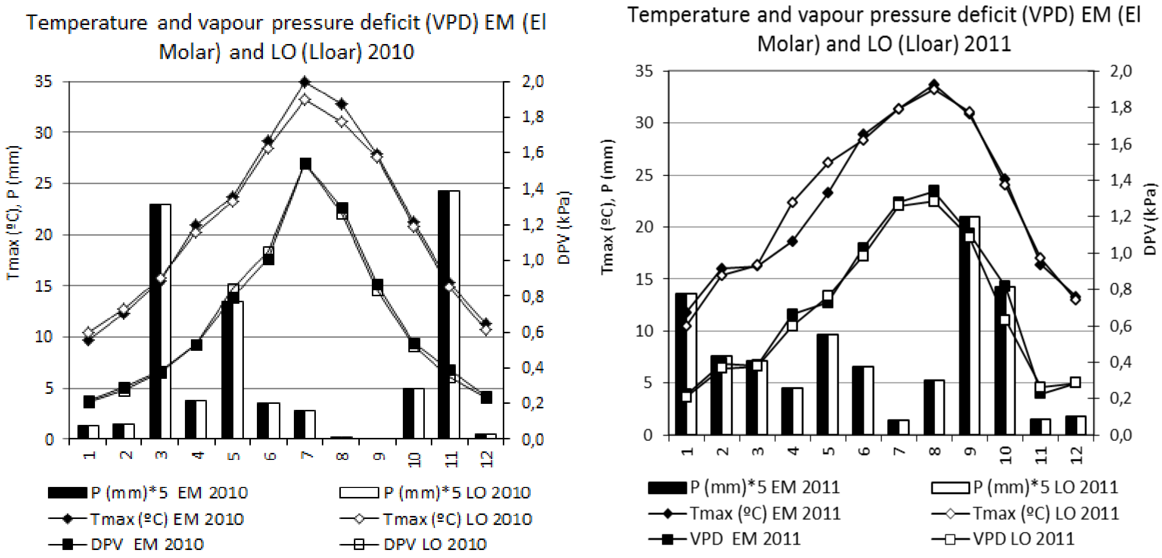

Figure 1: 2010 and 2011 climatology in EM (El Molar) and LO (El Lloar). Tmax (maximum Temperature), P (rainfall) and DPV (vapor pressure deficit)

Soil texture and vegetative growth (leaf area)

The plot of EM features a similar texture between the soil and subsoil layers. EM gravely elements in both soil and subsoil ranged between 35-40%, while the remaining percentage corresponds to fine particles giving a clay loam texture in USDA classification terminology (table 1). The vines under these conditions had a higher balance of water potential (Ψ12:00) at veraison in 2011 (-1.46 EM and -1.67 LO). In contrast, the LO subsoil contains less clay and is much richer in silt. The soil texture in the first layer, in LO, is clearly gravely, whereas in its subsoil silt is predominant. In LO, the soil is much more stony, with a clay content (25.3%) higher than that of the EM plot (5.3%). This heterogeneity results in the two plots having different water drainage characteristics, explaining the decrease in leaf area of LO vines at the end of the growing season (Figure 2).

Table 1: Soil and Subsoil Texture

		< 2mm	>2mm	% sand	% silt	% clay	USDA-Classification
EM	Soil	59.4%	40.6%	46.3	48.3	5.3	Sandy loam
	Subsoil	65.8%	34.2%	40.0	54.7	5.3	Sandy loam
LO	Soil	36.4%	63.6%	42.0	32.7	25.3	Silty loam
	Subsoil	70.3%	29.7%	25.3	70.0	4.7	Silty loam

In general, the evolution of TLA (total leaf area), PLA (primary leaf area) and SLA (secondary leaf area) was similar in both plots in the temperate year (2010), showing the same trend, with differences only at pea size (Figure 2). The leaf area of the two plots evolves differently in 2011; in the LO plot we observed more growth than in the EM plot. In 2011 the greater leaf area achieved in LO during veraison, induced by the continuous rainfall during the spring combined with extreme temperatures during maturation, resulted in a greater decrease in leaf area compared to the previous year. At ripening no leaf area differences were observed, in either vineyard, regardless of the vintage.

The VPD in 2010 was lower at ripening (September and October), reflecting lower temperatures. In 2010 the LO plot grew a slightly larger leaf area than the EM vines, given the scarcity in the distribution of rainfall during the spring. In 2011, from veraison to ripeness, the attached graph slopes of leaf size show a steep decrease compared to 2010. Toghether with a high VPD, this decrease in leaf area lasted until two weeks before harvest, coinciding with the period of grape maturation.

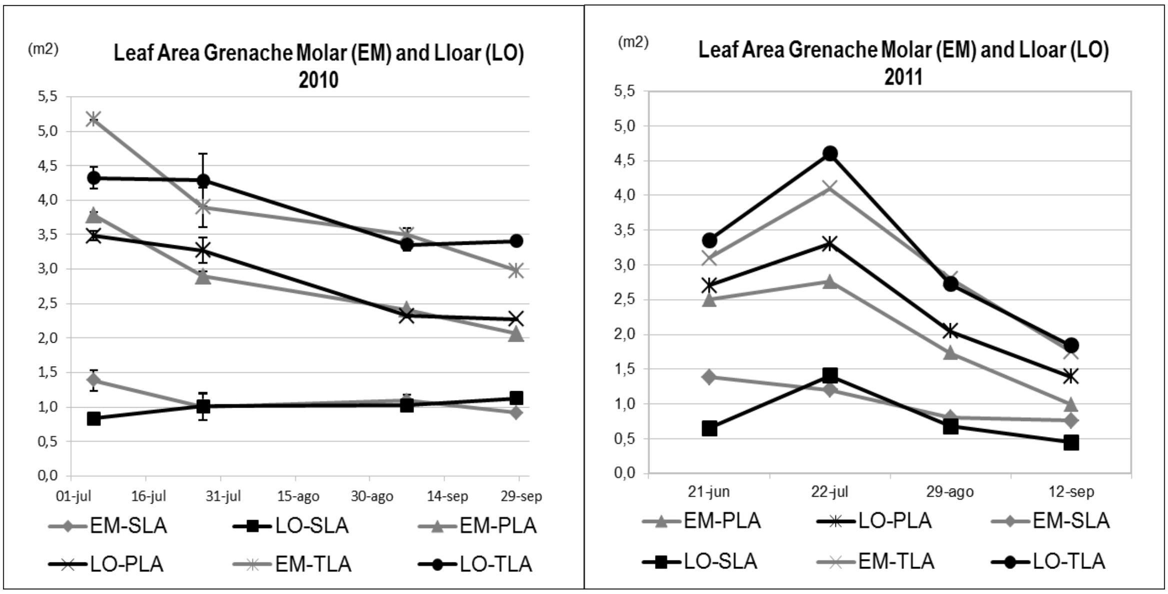

Figure 2: Leaf Area during the growing season in 2010 and 2011. TLA (total leaf area); PLA (Primary leaf area); SLA (secondary leaf area).

Grape juice and wine composition

Grape composition: our research indicates significant differences between the two plots in both years of study. For the EM plot, both vintages resulted in higher Brix values. The LO plot in 2011 had a particularly high value of TTA compared to the EM plot, but no differences in pH. Concerning phenolic composition, both years the EM plot showed the highest content of ANT T, ANT E, IPT and DMACA. It should be emphasized in the warmest year (2011) that differences between plots equalized, but were exacerbated in 2010. The EM plot's berry size was similar in both years, but the LO plot berry size differed each year depending on climate, and thus the final composition of the wine differed from one year to the next.

Table 2: Grape must composition and berry weight

	Berry weight (g)	**Brix**	**TTA (g/L)**	**pH**
EM 2010	1.44 (±0.05) b	27.4 (± 0.0) a	4.6 (± 0.1) a	3.55 (± 0.01) a
LO 2010	1.74 (±0.01) a	26.9 (± 0.1) b	4.2 (± 0.1) b	3.45 (± 0.02) b
EM 2011	1.40 (±0.02) a	27.5 (± 0.5) a	4.3 (± 0.2) b	3.40 (± 0.06) a
LO 2011	1.28 (±0.07) b	26.3 (± 0.4) b	5.6 (± 0.1) a	3.50 (± 0.05) a

Table 3: Grape phenolic composition

	ANT T (ppm)	ANT E (ppm)	IPT	DMACA (ppm)
EM 2010	661.5 (± 39.4) a	452.1 (± 8,1) a	65.7 (± 3.2) a	103.2 (± 5.2) a
LO 2010	520.3 (± 41.8) b	359.3 (± 23,5) b	54.2 (± 4.3) b	82.6 (± 4.8) b
EM 2011	557.7 (± 103.5) a	455.6 (± 57,0) a	69.0 (± 3.9) a	235.9 (± 20.3) a
LO 2011	479.5 (± 43.9) a	392.0 (± 43,9) a	64.0 (± 1.6) a	224.0 (± 28.5) a

Wine composition: for both vintages the highest concentration of anthocyanin was found in the EM treatment, showing major differences from the LO plot in 2010. The smaller the berry size, the higher the ANT T and DMACA, regardless of vintage. The greatest differences in concentration occurred during the temperate year (2010). The greatest amount of tannin concentration resulted from smaller berries. The total polyphenol index does not differ significantly between plots and years. Lower polymerization of the flavan-3-ol units were a function of the smaller berry size.

Table 4: Wine composition

	% ABV	TTA (g/L)	pH
EM 2010	16.1 (± 0.1) a	5.5 (± 0.0) a	3.55 (± 0.03) a
LO 2010	15.5 (± 0.4) a	5.0 (± 0.4) b	3.64 (± 0.08) a
EM 2011	15.5 (± 0.1) a	5.3 (± 0.4) a	3.65 (± 0.16) a
LO 2011	15.1 (± 0.2) a	5.3 (± 0.2) a	3.50 (± 0.07) a

Table 5: Wine phenolic composition

	ANT T (ppm)	DMACA (ppm)	IPT	Tannins (g/L)
EM 2010	239.9 (± 22.5) a	324.8 (± 47.0) a	47.0 (± 3.0) a	1.91 (± 0.05) a
LO 2010	186.8 (± 23.8) b	274.2 (± 64.8) a	38.2 (± 3.4) b	1.33 (± 0.12) b
EM 2011	361.4 (± 72.1) a	376.3 (± 94.4) a	40.3 (± 6.0) a	1.56 (± 0.33) a
LO 2011	355.7 (± 47.4) a	412.2 (± 36.3) a	45.9 (± 4.1) a	2.00 (± 0.61) a

4 CONCLUSIONS

Rainfall occurring during spring affects the vegetative growth, over two different climatic years. Temperatures during the ripening period, proved crucial, particularly the vapor pressure deficit. In the case of Grenache, grape composition is clearly affected by weather conditions in early September in the area studied, with major differences in phenolic composition between plots during the cooler year.

The warmer year did not change the quality of grape composition, must, or polyphenol composition as much as the temperate. A similar trend is observed in the wines, in which composition is similar between plots, suggesting that both, the climatology of the year and the soil profile have a higher impact on the quality of grapes than the topographical situation. The content of flavan-3-ol and tannins in the wines depends on the type of plot only in temperate years, while in warm years synthesis occurs equally regardless of the vineyard parcel

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