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Reducing the pH of wine by increasing grape sunlight exposure: a method to mitigate the effects of climate warming

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Summary

The objective of this work was reducing the pH of wine through manipulating grape exposure. Two different training systems (VSP = vertical shoot positioning and free cordon) combined with leaf thinning treatments were performed within a commercial vineyard in order to modify bunch exposition levels to the sunlight radiation during 2010 and 2011 years. Leaf thinning and trellis systems involved significant differences in the pH of wine during the two years: the pH of wine decreased when the bunch exposure was increased in the vineyard. Manipulating grape exposure is a valuable tool in order to modify the pH of wine.

Key words: trellis system, leaf thinning, pH of wine, sunlight exposition.

Introduction

Viticultural techniques have always been designed in order to produce a better ripeness. In the last few years, this aspect has been increased because of two different synergic facts: on the one hand, climate change has increased berry ripeness naturally (SCHULTZ and JONES 2010); and on the other, the latest market tendency for more full bodied wines has delayed harvesting date, in some cases by a big period, just to obtain a better phenol ripeness. Nevertheless, grapes with very high phenolic maturity frequently present high sugar and low acid concentrations. This global tendency is emerging all over the world, so wines are being made with higher alcohol content and the pH is even higher each time. Consequently, the resulting wines have the drawback of very high pH and alcohol content. High pH values in wines cause such problems as less colour and less antiseptic effectiveness of sulfur dioxide, higher oxidation potential of anthocyanidins and higher risk of problematic microorganism development, such as *Brettanomyces* or some non desirable bacteria.

Tartaric acid is a significantly stronger acid than is malic acid. Consequently, at similar values of total acidity, a lower tartaric acid/malic acid ratio may result in a higher pH (BOULTON 1980, GAWEL *et al.* 2000). Tartaric acid gives a crisp and fresh acid taste to the wine (RÜHL 2000), and therefore an optimum concentration of tartaric acid in juice is highly desirable. However, a high concentration of K in grape juice can lead to reduced tartaric acid/malic acid concentration ratio which is undesirable for the production of high quality wines (MPELASOKA *et al.* 2003). Consider-

able research has been undertaken in recent years on the effects of canopy management on grape composition and wine quality. According to SMART (1985) and SMART *et al.* (1985) a major contributor to poor quality is self shading in vines. These studies suggest that a shaded microclimate increases the pH and K content of the must and reduces both wine color and content of phenolic compounds on any one date. Subsequent studies have not consistently confirmed these assertions (JACKSON and LOMBARD 1993).

According to BERGQVIST *et al.* (2001), increased sunlight exposure had little effect on the juice pH of clusters on the south side of the canopy, likely because their elevated temperature was a more important factor influencing pH than light exposure (HALE and BUTTROSE 1974, KLEWER 1971, 1977). In contrast, results for fruit on the north side of the canopy were similar to previous studies reporting that exposed clusters have lower juice pH than shaded clusters (SMART 1985, SMART *et al.* 1985).

While some results are confusing, there is a pattern emerging which generally links excessive shading with unbalanced must, resulting in poor wine quality. As a result, research is now underway to evaluate specific training methods for effects on the light regime with the idea of encouraging improvements in canopy design (SMART 1985). According to JACKSON and LOMBARD (1993) practices to increase bunch exposure, for example by leaf removal, should be considered vineyard by vineyard, depending on the historical canopy exposure and previous wine quality. Vines where the foliage and berries already receive adequate exposure may not benefit and may even suffer from increased exposure. This discussion indicates that the consequences of such actions are not always clear and may produce different results when variation in ambient conditions occurs.

The objective of this work is to promote different bunch sunlight exposures, through leaf thinning treatments combined with trellis systems, in order to decrease the pH of wine.

Material and Methods

Plant material and climate: The study was conducted during the years 2010 and 2011 in a commercial vineyard located in Badarán (42.36 N, -2.81 W, 615 m) inside Rioja appellation, North of Spain. The *Vitis vinifera* 'Maturana Tinta de Navarrete' was grafted on 110-R rootstock and it was 12 years old. Plantation distance was 1.20 m between vines and 2.70 m between rows. The rows were North-South oriented along a 1.5 % sloping

terrain. The rain fed vines were trellised by simple horizontal cordon and the vineyard was subjected to the common viticultural practices in the region. Climatic data were obtained from the closest weather station, located 5 km West from the vineyard (42.37 N, -2.86 W, 727 m).

Experimental design: The experimental design was a randomized complete block with three replications. The experimental plot consisted of four rows, and each experimental unit consisted of six contiguous vines in each row. Four different treatments were applied, with combination of vertical shoot positioning (VSP) and free cordon (FC) training systems with a leaf thinning treatment or without (control): VSP control (VSP), VSP with leaf thinning (VSP-LP), FC control (FC) and FC with leaf thinning treatment (FC-LP). The leaf thinning treatment consisted of removing the basal leaves of each shoot until the node located above the upper bunch, as well as the lateral shoots. The treatment was performed at pepper size berries (4 mm).

Radiation measurements: Photosynthetically active radiation (PAR) on both sides of the cordon (East and West) at cluster area was measured three times (once a month) during berry development. The measurements were taken on clear days: 4 h before solar noon (8:00 h.), at solar noon (12:00 h) and 4 h after solar noon (16:00 h). Ten measurements per replicate were determined. PAR was measured using a handheld Li-Cor LI-189 quantum 1 m length sensor (Li-Cor, Inc., Lincoln, NE), placed on horizontal position on each side of the cluster zone along the cordon. Cluster sunlight exposure was expressed as percentage respect to the maxim PAR, which was measured perpendicular to sun radiation.

Winemaking and wine analysis: After the corresponding ripening control, harvesting date was determined and three micro-fermentations by treatment (one micro-fermentation by replicate) were performed, according to SAMPAIO *et al.* (2007) methodology. Wine analyses were performed after fermentation following OIV Standard Methods (OIV, 2013): alcohol content (%), pH, total acidity ($\text{g}\cdot\text{L}^{-1}$), malic acid ($\text{g}\cdot\text{L}^{-1}$) and tartaric acid ($\text{g}\cdot\text{L}^{-1}$) were measured on each micro-fermenter.

Statistical analysis: The statistical analysis was performed using the statistical package SPSS 15.0 for Windows. Data were subjected to variance analysis (ANOVA) and mean comparisons were performed using Student-Newman-Keuls test ($p = 0.05$).

Results

Grape sunlight exposure: The percentage of photosynthetically active radiation (PAR) compared to the maxim PAR was obtained for each treatment as the average of sunlight radiation in the eastern and western faces, as shown in the Figure. The percentage of PAR observed at 8:00 h. in the control treatments (without leaf thinning treatment) ranged from 7.2 to 10.5 %, while in the leaf thinning treatments it ranged from 19.2 to 27 %, which means triple the bunch exposition percentage. Similar PAR distribution was determined in the afternoon (16:00 h), ranging from

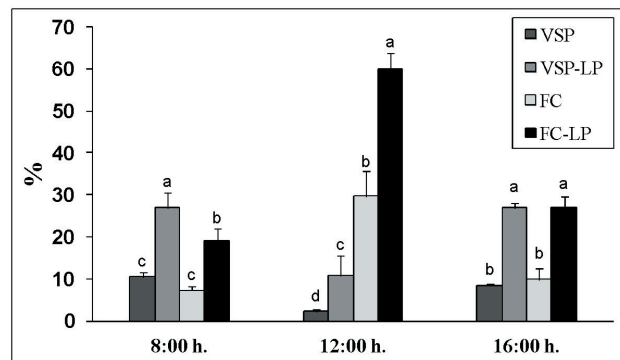


Figure: Grape sunlight radiation percentage respect to maximum in the four treatments along the day ($n = 180$). Values are mean \pm SE. Means indicated by different letters are significantly different at $p \leq 0.05$, according to SNK test.

8.5-9.9 % in the control treatments to 26.9-27 % in the leaf trimmed ones. The most remarkable differences were obtained at solar noon (12:00 h). The VSP trellis system shaded the bunch area (2.2-10.8 % PAR), while the FC provided at least three times higher sunlight exposition levels (29.7-59.9 % PAR). Leaf thinning treatment increased the bunch exposition in the FC and VSP treatments 2-5 times, respectively.

pH: The treatments showed significant differences (Tab. 1) in pH of wine ($p \leq 0.001$) in the two years. The highest level of pH corresponded to the VSP treatment in the two years with 3.95 and 4.02, respectively. The second level of pH was found in the FC treatment with 3.92 and 3.86, respectively. The third level of pH was found in the VSP-LP treatment with 3.79 and 3.80, respectively. The fourth and lowest level of pH corresponded to FC-LP treatment with 3.77 and 3.70, respectively. Between VSP and FC-LP treatments, a decrease of 0.18 and 0.32 in pH of wine was observed in 2010 and 2011, respectively.

The pH was negatively correlated with morning, mid-day and afternoon grape sunlight exposure in the two years (Tab. 2). The pH was also negatively and closely correlated to total acidity in the year 2010 but not in 2011. The correlation of pH was positive with malic acid and negative with tartaric acid in the two years although not significant (Tab. 2). No link has been proved between pH and % alcohol of wine.

Discussion

Grape sunlight exposure: All the treatments performed in the study showed a typical distribution of the sunlight radiation along the day, according to the training system and the leaf thinning practices. Identical bunch exposition levels in both sides of the canopy were found in 2010 and 2011, because the canopy morphology was similar (Figure). Bunch exposition found at morning (8:00 h) was similar as found in the afternoon (16:00 h) for all treatments, regardless of trellis system and leaf thinning practices; although within the leaf thinning treatments, the free cordon showed less radiation than VSP in the morning. Bunches located in the eastern face were mainly exposed

Table 1

Wine composition for the different treatments in the years 2010 and 2011. Vertical shoot positioning (VSP), VSP with leaf thinning (VSP-LT), Free cordon (FC) and FC with leaf thinning (FC-LT)

		VSP	VSP-LT	FC	FC-LT	Sig ¹
2010	Alcohol (% vol/vol)	13.70 a	13.29 b	13.36 b	13.55 ab	**
	pH	3.95 a	3.79 b	3.92 a	3.77 b	***
	Tartaric acid (g·L ⁻¹)	2.77	2.76	2.82	2.89	ns
	Malic acid (g·L ⁻¹)	3.20 a	2.53 b	2.11 c	2.08 c	***
	T A (g/L H ₂ SO ₄)	3.46 a	3.32 a	3.07 b	3.28 a	***
2011	Alcohol (% vol/vol)	13.92 b	14.52 a	13.41 c	14.00 b	***
	pH	4.02 a	3.80 c	3.86 b	3.70 c	***
	Tartaric acid (g·L ⁻¹)	2.50 b	2.60 a	2.30 c	2.60 a	***
	Malic acid (g·L ⁻¹)	2.54 ab	2.05 c	2.61 a	2.48 b	***
	T A (g/L H ₂ SO ₄)	4.80 c	4.96 bc	5.08 b	5.43 a	***

¹ ns, *, **, *** represent significant differences between treatments at P < 0.05, 0.01 or 0.001 respectively. Different letters within a row show significant differences between values, according to SNK test (P = 0.05).

Table 2

Pearson's correlation between pH and wine parameters or sunlight radiation in the two years of the study. *, ** represent significant level at p < 0.05 or 0.01 respectively

	% Alcohol	Total acidity	Malic acid	Tartaric acid	Radiation 8:00 h.	Radiation 12:00 h.	Radiation 16:00 h.
2010	0,341	-0,842**	0,503	-0,227	-0,823**	-0,533	-0,950**
2011	-0,279	-0,046	0,312	-0,399	-0,585*	-0,789**	-0,845**

during morning, while those located in the western side remained shaded. Exactly the opposite sunlight distribution was observed during the afternoon. At 8:00 h. VSP trellis system showed higher sunlight exposition (27 %) than FC (19.2 %) because the free shoots of this system slightly shaded the bunch area. The main factor that modifies sunlight radiation around bunch area at 8:00 h. and 16:00 h. (morning and afternoon) is leaf thinning, while the trellis system does not influence significantly in the afternoon. Nevertheless, both factors (trellis system and leaf removal) have a significant importance at midday.

pH: Considering bunch exposure and pH of wine, it can be asserted that PAR incident to bunch area was inversely related to pH in the two years. The negative correlation between pH and grape sunlight exposure could be due to tartaric acid being significantly stronger than malic acid; consequently, at similar values of total acid-

ity, a lower tartaric acid/malic acid ratio may result in a higher pH (BOULTON 1980, GAWEL *et al.* 2000). Although not significant, the correlation trend of pH was positive with malic acid and negative with tartaric acid in the two years. The high temperatures in high exposed bunches lead to less malic acid concentrations. This is a known phenomenon that has been reported by other authors (SMART *et al.* 1985).

The larger decrease of pH in 2011 than in 2010 could be due to different weather conditions in the two years (Tab. 3). The harvest date and the total radiation did not change significantly between the two years of the study. The average alcohol content of the wines in 2011 was 0.5° higher than in 2010 vintage; it could imply a higher berry ripeness. Another important factor to consider could be the mean and maximum daily temperatures during the growing season. Winkler Index increased 8 % regarding to the

Table 3

Basic harvesting data and weather conditions during growing season in the two years of the study

	Harvesting date	Average % alcohol	Winkler index (°C)	Average T _{max} daily (°C)	Total radiation (GJ/m ²)
2010	5 th Oct.	13.5	1.253	21.2	3.891
2011	7 th Oct.	14.0	1.362	22.6	3.943

previous year and the average maximum daily temperature increased 6 %. The warmer environmental conditions could have played an important role in the largest decrease of pH in the second year of the study.

Conclusions

Leaf thinning treatments and trellis systems modify bunch sunlight exposition during the whole day in the same way both years (2010 and 2011). Leaf thinning influences sunlight radiation during morning, at solar noon and during afternoon for both trellis systems, while VSP or FC canopies affect only PAR in bunch area at midday. Significant differences have been found in pH of wine in the two years. The pH of wine was highly correlated to bunch sunlight exposition of each treatment. The maximum was found in the VSP treatment and the minimum corresponded to the FC leaf thinning treatment. Between both treatments, a decrease of 0.18 and 0.32 in pH of wine was observed in 2010 and 2011 respectively, while the PAR was increased 80 %.

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