EFFECTS OF CLUSTER THINNING ON ANTHOCYANIN EXTRACTABILITY AND CHROMATIC PARAMETERS OF SYRAH AND TEMPRANILLO GRAPES AND WINES

R. GIL-MUÑOZ, VILA-LÓPEZ J.I.,
FERNÁNDEZ-FERNÁNDEZ and MARTÍNEZ-CUTILLAS A.

Instituto Murciano de Investigación y Desarrollo Agroalimentario, Ctra. La Alberca s/n,
30150 Murcia, Spain

Abstract

Aims: The effects of cluster thinning on yield and extractability parameters of Syrah and Tempranillo grapes, as well as the chromatic characteristics of the wines obtained in three consecutive seasons.

Methods and results: Grapes of *Vitis vinifera* L. var. Tempranillo and Syrah were harvested from a commercial vineyard in Jumilla. Two treatments were evaluated: (a) cluster thinned, where in every shoot all the clusters, except the basal one, were removed just before veraison; (b) unthinned control. Yield, physicochemical and extractability parameters were studied in the grapes. Vinifications were made from these grapes, and chromatic parameters were studied at the end of alcoholic fermentation. Results showed that cluster-thinned vines performed better than control vines during the three consecutive years of the experiment, although the best results were obtained in the driest year (2005). The Syrah variety always provided better results than the Tempranillo variety. The cluster-thinning treatment also influenced the chromatic characteristics of the wines obtained.

Conclusions: The results showed that thinning successfully reduced yield and produced an earlier harvest in the two varieties studied. The grape quality improved and, in general, wines made from cluster-thinned vines of both Syrah and Tempranillo had significantly better chromatic characteristics than control wines.

Significance and impact of the study: This study demonstrate that the practice of cluster-thinning may be recommended depending on several factors, as the varieties and the climatic conditions play also a role in the extractability parameters of grapes, and therefore its use cannot be generalized.

Keywords: cluster thinning, grapevine, Tempranillo, Syrah, wine, anthocyanin, French

Résumé

Objectifs: Les effets de l'éclaircissage des grappes sur le rendement et les paramètres d'extractibilité de raisins de Syrah et Tempranillo, ainsi que sur les caractéristiques chromatiques des vins de trois années consécutives.

Méthodes et résultats: Le raisin de *Vitis vinifera* L. var. Tempranillo et de Syrah a été récolté dans un vignoble commercial de Jumilla. Deux traitements ont été évalués: a) éclaircissage ou « vendange en vert », où toutes les grappes de chaque pied, à l'exception de celle qui se trouve à la base, ont été éliminées juste avant la véraison ; et b) témoin sans éclaircissage. Le rendement, les paramètres physico-chimiques et l'extractibilité ont été étudiés dans le raisin ainsi obtenu. Des vinifications ont été faites à partir de ces raisins et on a étudié les paramètres chromatiques à la fin de la fermentation alcoolique. Les résultats ont montré que le raisin produit par des vignes éclaircies donne de meilleurs résultats que celui des vignes témoins au cours de trois années d'expérimentation consécutives, bien que les meilleurs résultats aient été obtenus dans l'année la plus sèche (2005). La variété Syrah donne toujours de meilleurs résultats que la variété Tempranillo. L'éclaircissage influence également les caractéristiques chromatiques des vins obtenus.

Conclusions : Les résultats montrent que l'éclaircissage réussit à réduire le rendement et avance la date de la récolte dans les deux variétés étudiées. La qualité du raisin est meilleure et, en général, les vins issus de vignes éclaircies, tant de Syrah que de Tempranillo, avaient des caractéristiques chromatiques nettement meilleures que ceux des vins témoins.

Signification et impact de l'étude : Cette étude démontre que la pratique de l'éclaircissage des grappes peut être recommandée en fonction de plusieurs facteurs, mais étant donné que la variété et les conditions climatiques jouent aussi un rôle dans les paramètres d'extractibilité du raisin, son utilisation ne peut pas être généralisée.

Mots clés: éclaircissage, vigne, Tempranillo, Syrah, vin, anthocyanes

manuscript received the 26th April 2008 - revised manuscript received the 10th February 2009

*Corresponding author: mariar.gil2@carm.es

INTRODUCTION

Vineyard yields and grape quality are strongly influenced by viticultural practices. In certain circumstances, depending on the variety, region and year, it is commonly accepted that decreasing yields by using appropriate viticulture techniques can improve grape quality and, consequently, the wines obtained (ANTONACCI and LA NOTTE, 1993; SIPIORA, 1995).

One of the most widely used agronomic techniques for regulating the balance between vegetative growth and production is winter pruning and the removal of whole clusters or parts. The aim of cluster thinning is to adjust crop load to advance grape maturation and to improve potential wine quality. Cluster thinning decides the potential crop and modifies the ripening process. The first consequence of cluster-thinning is a decrease in crop yield, which is not necessarily proportional to the percentage of clusters removed (BERTAMINI *et al.*, 1989), due to the compensation of increased berry and, consequently, cluster weight (CARBONNEAU *et al.*, 1977).

Due to the importance of quality, there is particular interest in knowing how crop control in grapevine can be stabilised in order to improve grape composition through cluster-thinning, especially in highly productive vineyards and in years considered unfavourable for grape ripening (PALLIOTI and CARTECHINI, 2000). Decreasing the crop load/yield under such conditions improves grape ripening and increases the concentration of the molecules responsible for the grape colour that determines the final colour of wine (PALLIOTI and CARTECHINI, 2000).

Cluster thinning is also commonly used as a corrective viticultural measure to improve fruit composition. Previous studies have focused on its role in altering grape and/or must composition, particularly ºBrix, pH and titratable acidity (PETRIE *et al.* 2000; REYNOLDS *et al.*, 1994; VASCONCELOS and CASTAGNOLI, 2000).

Another aspect that is of importance for improving wine quality is the degree of ripeness of the grapes, which not only affects the concentration of acids and sugars in the berries, but also the compounds responsible for colour and other compounds that are associated with the final wine quality. According to GONZÁLEZ-NEVES *et al.*, (2004), knowledge of the extractability of grape pigments improves the management of red wine and the colour of the final wine. A high polyphenol content, (especially anthocyanins and tannins), small berry size (with a high skin to pulp ratio) and harvesting at optimum ripeness (based on chemical and phenolic grape composition) allow maximum anthocyanin and tannin extraction. These factors are all important with respect to wine quality.

In this research, we studied the effects of cluster-thinning on yield and extractability parameters of Syrah and Tempranillo grapes, as well as the chromatic characteristics of the wines obtained in three consecutives seasons.

MATERIAL AND METHODS

1. Vineyard site

Grapes of *Vitis vinifera* L. var. Tempranillo and Syrah were harvested from a commercial vineyard in Jumilla (S.E., Spain) (lat 38º23'40'' N, 1º25'30''W) planted in 1996. The climate is semi-arid Mediterranean, with hot and dry summers, mild winters and an average annual rainfall of 290 mm. The annual temperature of this area is 15.5-

Table 1 - Climatic conditions during 2005, 2006 and 2007.

Year	Month	Temperature (°C)			Humidity (%)			Rainfall (mm)		Solar radiation (w/m^2)
		Mean	Max	Min	Mean	Max	Min	Total	Max	Mean
2005	April	14.9	21.5	8.7	53.9	78.2	29.9	0.7	0.3	297.7
	May	19.4	26.8	11.9	52.1	83.5	25.6	0.4	0.3	316.0
	June	23.7	30.6	16.2	48.5	78.7	25.9	0.0	0.0	349.4
	July	25.9	33.1	18.6	51.8	85.4	25.9	0.1	0.1	339.8
	August	24.1	31.2	17.2	58.6	88.9	29.9	0.0	0.0	295.6
2006	April	15.9	22.4	9.8	65.2	93.2	35.3	1.0	0.8	268.8
	May	19.0	25.0	13.5	65.6	90.9	41.0	2.4	1.0	266.6
	June	22.3	29.1	15.5	55.9	82.7	30.0	0.0	0.0	290.8
	July	26.5	34.3	18.5	48.6	78.2	23.1	0.4	0.4	310.2
	August	24.8	31.9	18.4	56.2	81.7	28.8	0.0	0.0	278.2
2007	April	13.3	18.3	8.8	72.2	90.4	49.9	1.8	0.9	178.9
	May	19.1	25.7	12.3	50.4	76.1	28.3	0.5	0.2	292.4
	June	23.0	29.9	15.9	47.7	71.7	26.7	0.0	0.0	312.8
	July	25.3	33.0	17.6	50.6	78.4	25.7	0.0	0.0	318.3
	August	24.9	32.1	18.6	58.6	84.1	30.5	0.7	0.3	253.8

16 ºC, while frost occurs on 25-35 days. The climatic data for the three seasons studied are shown in table 1.

The grapevines were trained to a trellis and drip irrigated. The training system was a bilateral cordon, trellised with a three-wire-vertical system. Six two-bud spurs per vine were left at pruning time. All vines were spaced 1.25 m within the row and 2.50 m between rows. All other cultural practices were the standards in the DO Jumilla.

Two treatments were evaluated, one: cluster thinned, where in every shoot all the cluster, except the basal one, were removed just before veraison and two: unthinned control. Each treatment was applied on five replicate groups of the five contiguous vines. A completely randomized design was used in the experiment. Treatments were applied for three consecutive years (2005 to 2007) on the same plants.

The stage of optimum ripeness was determined for each treatment and variety according to the phenolic and the chemical composition of the grapes. The analyses were performed in triplicate on each repetition.

2. Yield quantification

At harvest, yields were quantified in plot of five vines of each row in order to obtain the following parameters: yield (kg/vine and kg/ha), berry mass (g/100 berries) and cluster mass (g). In this way, the influence of thinning on the quality parameters of grapes and the corresponding wines could be assessed.

3. Physicochemical determinations

The analyses were performed in triplicate for each repetition. The grape analyses included the classic berry and must analyses (berry weight, ºBrix, total acidity and pH). Total soluble solids (ºBrix) were measured using a digital refractometer (Atago RX-5000) and titratable acidity and pH were measured using an automatic titrator (Methrom, Herisau, Switzerland) with 0.1 N NaOH, following the methodology described in EEC regulation nº 2676/90.

4. Extractability parameters

The phenolic potential of grapes was calculated according to the method described by SAINT-CRICQ *et al.* (1998), macerating the grapes for four hours at two pH values (3.6 and 1).The previously described pH 3.2 solution was adapted to pH 3.6, which is better suited to the musts from the Jumilla region. The anthocyanin contents of the two solutions (ApH 3.6 and ApH 1) were chemically assayed by measuring the absorbance of the sample at 520 nm at pH 1, while the total phenol content (TPpH (3.6)) was calculated by measuring the optical density of the solution at pH 3.6 at 280 nm. The phenolic potential was calculated as follows:

Extractability index (%)

$$(EI) = \frac{(ApH1 - ApH\ 3.6) \times 100}{ApH1}$$

Seed maturityindex (%)

$$(SMI) = \frac{(TP(pH3.6) - (ApH3.6 \times 40)/1000) \times 100}{TP(pH3.6)}$$

5. Vinifications

Wines were made using 240 kg of grapes from each treatment and each variety. After cooling to 10 ºC, the grapes were crushed and destemmed and then metabisulphite was added (8 g of SO_2/100 kg of grapes). The crushed grapes were distributed in twelve 100 L tanks. The control and cluster-thinned vinifications were performed in triplicate. Total acidity was corrected to 5.5 g/L and selected yeasts were added (Laffort, DSM, Servian, France, 10 g of dry yeast/100 kg of grapes). All the vinifications were conducted at 25 ± 1 °C. Throughout the pomace contact period (10 days), the cap was punched down twice a day and the temperature and must density were recorded.

6. Colour determinations in wines

Wines were analyzed at the end of alcoholic fermentation. Absorbance measurements were made in a Shidmazu UV-1603 spectrophotometer with 0.2 cm path-length glass cells. Colour intensity (CI) was determined as the sum of the absorbances at 420, 520 and 620 nm (GLORIES, 1984), and the tint was calculated as the ratio between absorabance at 420 nm and at 520 nm (SUDRAUD, 1958). CIELAB parameters of anthocyanin-containing solutions were determined in the samples, diluted 1:10, by measuring the transmittance of the wine every 10 nm from 380 to 770 nm, using D65 illuminant and a 10_observer. Total anthocyanins (mg/L) were measured spectrophotometrically following the method described by Puissant-Leon (BLOUIN, 1992).

7. Statistical data treatment

Analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) were performed with the statistical package Statgraphics 5.1. Plus (Statistical Graphics Corp.; Rockville, M.D).

RESULTS AND DISCUSSION

1. Yield parameters

The results are shown in table 2. The cluster-thinned treatments applied to vines involved removing about

J. Int. Sci. Vigne Vin, 2009, **43**, n°1, 45-53

Table 2 - Yield components of cluster-thinned and non-thinned vines from Syrah and Tempranillo during the three seasons.

VARIETY	Yield (kg/vine)			Berry mass (g/100 berries)			Yield (kg/ha)			Cluster mass (g)		
	2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007
Syrah Control	1.9 a[a]	2.6 b	3.1 b	93.6a	122.1a	121.1a	5291 a	8506 b	9887.7 b	116.5 a	108.9 a	129.4 a
Syrah C-T	1.4 a	1.7 a	1.5 a	120.4b	127.3a	123.7a	3723 a	5554 a	4822.7 a	132.5 a	124.3 a	113.9 a
Tempranillo Control	4.3 b	4.7 b	3.6 b	183.7a	169.8a	158.9a	13859 a	15187 b	11668.8 b	221.8 a	190.8 a	207.4 a
Tempranillo C-T	2.5 a	2.8 a	2.2 a	185.2a	179.5a	154.9a	8079 a	8962 a	6967.2 a	256.4 a	208.1 a	218.9 a

[a] Different letters within the same column and for the same cultivar indicate significant differences according to LSD (p<0.05). Abbreviations: C-T:Cluster-thinned

Table 3 - Berry composition of cluster-thinned and non-thinned grapevines of Syrah and Tempranillo at harvest during 2005, 2006 and 2007.

VARIETY	° Brix			Total acidity[a]			pH		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
Syrah Control	25.25a[b]	25.30a	24.60a	3.65a	2.95a	3.07a	3.9a	4.18b	4.18a
Syrah C-T	26.55b	24.75a	26.98b	4.27b	3.01a	3.14a	3.9a	4.14a	4.26a
Tempranillo Control	24.60a	19.85a	21.38a	4.08a	3.24a	3.28b	4.1a	4.15a	4.07a
Tempranillo C-T	26.00b	21.82b	24.04b	3.91a	3.18a	3.09a	4.2b	4.18b	4.24a

[a]Expressed as g/L of tartaric acid.
[b] Different letters within the same column and for the same cultivar indicate significant differences according to LSD (p<0.05). Abbreviations:C-T:Cluster-thinned

40 % of the clusters. In our study we found that the yield was reduced on average by 37 % in the case of Syrah variety and 40 % in Tempranillo in the three seasons studied. Various authors have reported a reduction in yield for cluster-thinned vines. GUIDONI *et al.* (2002) found that thinned vines of the Nebbiolo variety produced an average yield that was 43 % lower than control plants over three consecutive years. PALLIOTI and CARTECHINI (2000) observed that cluster thinning treatments of 40 % caused reductions in vine yield that ranged from 22 to 47 % in Sangiovese, Merlot and Cabernet-Sauvignon cultivars. Thinning substantially reduces the number of clusters per vine and is undoubtedly the main contributing factor to reductions in yield and crop load (RUBIO and YUSTE, 2002).

There was a tendency for the cluster mass to be higher for cluster-thinned vines than control vines, although not significant, that could be attributed to a natural compensatory increase in the rest of the clusters when the yield was reduced. Similar results have been found by several authors for the Tempranillo variety (YUSTE *et al.*, 1997; YUSTE *et al.,* 2002) and for the Chaunac variety (LOONEY, 1981).

In general, there was a tendency for cluster-thinning to increase the mass of berries, except for Tempranillo during the 2007 season. Berry mass was always higher for Tempranillo than for Syrah. The smallest berries were found for the Syrah control grapevines in 2006 and the biggest berries for Tempranillo cluster-thinned grapevines in 2005 The 2006 season was the wettes and 2005, the driest. The differences were generally not significant during the three seasons for either variety studied. BRAVDO *et al.* (1984), CARBONNEAU *et al.* (1977) and FREEMAN (1983) found that berries of Cabernet-Sauvignon cluster thinned grapevines were significantly larger but other authors, such as YUSTE *et al.* (1997), found that the berry mass was independent of cluster-thinning when an irrigation was applied.

2. Physicochemical determinations

The physicochemical data of grapes at harvest are shown in table 3. As regards the grape composition, several authors have observed that cluster-thinning increases the level of sugars in musts (CARBONNEAU *et al.*, 1977; DUMARTIN *et al.*, 1990; MANCILLA and GODOY, 1990; MURISIER, 1985; PONI *et al.*, 1994).

GUIDONI *et al.* (2002) found a significantly increased concentration of soluble solids in Nebbiolo variety during two consecutive years. In contrast, WOLPERT *et al.* (1983) found no significant differences in ºBrix when cluster-thinning was applied to Vidal Blanc cultivars. SIPIORA (1998) found that thinning slightly increased the accumulation of sugars in Cariñena varieties, Chenin Blanc and Moristel, although only by 0.5 °Brix, which was not a significant increase.

Our results showed that ºBrix was generally higher in cluster-thinned grapes than control grapes for the three years studied. Significant differences were found in all cases except for Syrah in the 2006 season, when the highest value corresponded to the control vine. This can be explained by the fact the thinned vines had to be harvested one week before the control vines because the fruits ripened more quickly. PETRIE *et al.* (2006) suggest that such an increase in the concentration of soluble solids is more likely to be caused by an earlier fruit maturity than by an increased rate of sugar accumulation.

Titratable acidity and pH are of great importance for grape juice and wine stability, and both parameters are commonly used as indicators of quality (BAUTISTA-ORTÍN *et al.*, 2006). The total acidity of cluster-thinned Syrah vines tended to be higher than in control vines, while in Tempranillo variety the opposite was true. Significant differences were only found in Syrah during the 2005 season and in Tempranillo during the 2007 season. Several authors have found contradictory results in this respect, and while HEPNER and BRAVDO (1985) found no differences between thinned vines and control vines, MURISIER (1985) found significant differences. SIPIORA (1996) found that total acidity was lower in cluster-thinned vines of the Moristel variety, while the results for Chaunac and Cariñena varietes were not affected.

3. Extractability parameters

The results of the phenolic maturity index (phenolic extractability assay) are shown in table 4. This method is based on the assumption that at pH 1.0 there is a complete disruption of the vacuolar membrane which facilitates the liberation of phenolic compounds. When the pH of the macerating solution is 3.6, the natural degradation of the cells is respected and this situation is similar to that occurring during maceration at winemaking (GLORIES and SAUCIER, 2000). The values of this index are usually between 70 and 20, as reported by RIBÉREAU-GAYON *et al.* (1998). The extractability is considered good when the difference between the concentration of the anthcoyanins extracted at pH 1 and 3.6 is small and therefore, the phenolic maturity index is low.

As can be observed in the table, the quantity of anthocyanins extracted at pH 1 was always higher in cluster-thinned vines for both varieties. The differences were significant for Tempranillo during the three seasons and only for Syrah variety in the 2006 season. The same results were found when the macerating solution was at pH 3.6, although for Syrah variety significant differences were found during 2006 and 2007 seasons. Increases in the anthocyanin content of berries following cluster removal were also reported by REYNOLDS *et al.* (1995) in Pinot noir and by MAZZA *et al.* (1999) in Cabernet Franc, Merlot and Pinot noir.

In general, the anthocyanin values obtained at pH 1.0 and 3.6 led to relatively high value of the extractability index for control vines and lower, but similar, values in cluster-thinned vines of both Syrah and Tempranillo varieties. The factor responsible for the higher extractability index in control vines therefore may be the lower ºBrix of these grapes than in cluster-thinned grapes.

Table 4 - Extractability parameters of grapes from cluster-thinned and non-thinned vines from Syrah and Tempranillo at harvest during 2005, 2006 and 2007.

	2005				2006				2007			
	Syrah Control	Syrah C-T	Tempranillo Control	Tempranillo C-T	Syrah Control	Syrah C-T	Tempranillo Control	Tempranillo C-T	Syrah Control	Syrah C-T	Tempranillo Control	Tempranillo C-T
ApH 1	925.22 a[b]	941.81 a	494.95 a	560.44 b	567.67 a	700.33 b	260.21 a	372.13 b	498.87 a	519.77 a	448.78 a	546.6 b
ApH 3.6	443.82 a	444.24 a	260.21 a	372.13 b	373.37 a	406.56 b	193.1 a	255.36 b	285.97 a	339.78 b	238.55 a	363.41 b
EI (%)	47.62 a	52.83 b	47.37 b	33.68 a	39.38 a	39.07 a	43.03 a	45.86 a	42.43 b	34.73 a	46.79 b	32.15 a
SMI (%)	40.47 b	25.96 a	49.18 a	47.92 a	45.41 a	44.00 a	61.20 b	57.30 a	48.94 a	53.75 b	54.44 a	53.11 a
TP(pH 3.6)	23.97 a	32.60 b	20.49 a	28.92 b	27.36 a	29.05 b	19.91 a	23.89 b	22.40 a	29.36 b	20.98 a	30.91 b

[a]Abbreviations : ApH1: Anthocyanins extracted at pH 1; ApH 3.6: Anthocyanins extracted at pH 3.6; EI: Extractability index ; TP (pH 3.6): total phenol content of the solution at pH 3.6; SMI; Seed maturity index; CI: Colour intensity; C-T:Cluster-thinned
[a]Different letters within the same row and for the same cultivar indicate significant differences according to LSD ($p<0.05$).

So, some authors have maintained that the values of extractability index decrease as maturation progress (Saint-Cricq *et al*., 1998; Glories, 1999).

TPwine pH 3.6, also were higher during the three seasons in C-T vines than in control vines for the two varieties, indicating a higher accumulation of polyphenol compounds.

The seed maturity index (SMI) represents the percentage of seed tannins that will contribute to the tannin content in wine (ROMERO-CASCALES *et al*., 2005). It has been reported that a high SMI (%) means that a high quantity of tannins will be transferred to wine, especially when pomace contact time is prolonged during vinification (RIBÉREAU-GAYON *et al*., 1998). In our case, the lowest values in Tempranillo were found in cluster thinned vines, although the difference compared to non-thinned vines was only statistically significant in 2006. Similarly, for the Syrah variety the lowest values were obtained in cluster-thinned vines, except in the 2007 season, when the control vines showed lower values.

4. Multivariate analysis

a) Variety

Table 5 - Effect of variety, treatment and year on the fruit composition.

	Acidity	pH	ºBrix	ApH1	ApH3.6	EI (%)	SMI (%)	TPpH3.6
VARIETY								
Syrah	3.35a	4.07a	25.57b	695.78b	389.54b	42.69a	43.03a	27.47b
Tempranillo	3.46a	4.16b	22.97a	476.78a	280.59a	41.43a	53.89b	24.20a
TREATMENT								
Control	3.38a	4.07a	23.51a	553.63a	306.07a	44.41b	46.96a	23.98a
Cluster-thinned	3.43a	4.15b	25.03b	618.92a	364.06b	39.71a	49.96a	27.70b
YEAR								
2005	3.98b	4.01a	25.60a	730.61b	390.15b	45.37b	40.89a	26.49a
2006	3.09a	4.16b	22.94b	524.45a	307.81a	41.81ab	51.90b	25.07a
2007	3.14a	4.16b	24.27c	503.73a	307.22a	38.99a	52.59b	25.95a
MAIN EFFECTS								
Variety	ns	**	**	**	**	ns	**	**
Treatment	ns	**	**	ns	**	**	ns	**
Year	**	**	**	**	**	ns	**	ns
INTERACTIONS								
V x T	**	**	ns	**	**	**	ns	**
V x Y	ns	**	**	**	**	**	**	**
T x Y	ns	**	**	ns	ns	**	**	**
V x T x Y	**	**	**	ns	ns	**	**	**

[a]Abbreviations : ApH1: Anthocyanins extracted at pH 1; ApH 3.6: Anthocyanins extracted at pH 3.6; EI: Extractability index ; SMI; Seed maturity index; TP (pH 3.6): total phenol content of the solution at pH 3.6.
[b]Different letters within the same column indicate significant differences according to LSD (p<0.05).
**ns: Indicate significance at p<0.05 or not significant, respectively.

Table 6 - Chromatic characteristics of the studied wines at the end of alcoholic fermentation during the three seasons.

	2005				2006				2007			
	Syrah Control	Syrah C-T	Tempranillo Control	Tempranillo C-T	Syrah Control	Syrah C-T	Tempranillo Control	Tempranillo C-T	Syrah Control	Syrah C-T	Tempranillo Control	Tempranillo C-T
CI	23.59 a	25.39 b	10.90 a	12.72 b	24.31 a	27.07 b	8.86 a	14.08 b	21.38 a	23.39 b	13.91 a	18.96 b
Tint	0.49 a	0.51 a	0.57 a	0.57 a	0.43 a	0.45 b	0.47 a	0.48 a	0.45 a	0.47 a	0.46 a	0.46 a
Anthocyans (mg/l)	642.29 a	778.44 b	393.07 a	474.33 b	784.34 a	809.13 b	302.67 a	439.63 b	708 a	752.91 b	475.9 a	630.08 b
TPwine	57.62 a	60.33 b	35.48 a	45.42 b	57.06 a	59.18 b	35.60 a	45.89 b	56.15 a	64.09 b	46.77 a	61.59 b
L*	3.15 a	2.98 b	12.22 a	7.10 a	4.56 b	3.60 a	19.71 b	10.81 a	5.49 b	4.47 a	11.83 b	6.47 a
a*	27.20 a	24.26 a	43.43 a	36.96 a	29.67 b	25.10 a	52.52 b	42.03 a	32.92 b	29.15 a	43.28 b	34.64 a
b*	8.70 b	7.43 a	19.36 a	12.22 a	7.87 b	6.21 a	31.95 b	18.60 a	9.46 b	7.71 a	20.33 b	11.15 a

[a]Abbreviations: TPwine: total phenols; CI: colour intensity.
[b]Different letters within the same row and for the same cultivar indicate significant differences according to LSD (p < 0.05).

The results are shown in table 5. In the multivariate analysis, the variety proved to be a source of variation for all the variables except total acidity and EI (extractability index). As regards the parameters related with extractability, the EI (extractability index) was slightly higher in Syrah but with no significant differences, while the SMI (seed maturity index) was lower, meaning less astringent tannins during the process of vinification. Syrah showed the highest amount of total anthocyanins and total polyphenols.

b) Treatment

Thinning led to higher values for all the parameters except in the EI (extractability index), which was lower than in the control-vines, meaning that the phenolic compounds are easier to extract from the cell walls.

As regards the extractability parameters, the thinned vines showed higher levels of total phenolic compounds and anthocyanins (pH 1 and pH 3.6). Differences were significant in all cases except for acidity, anthocyanins (pH 1) and SMI (seed maturity index).

c) Year

The year was also a significant factor except in the case of EI (extractability index) and TP (Total Phenols at pH 3.6), so that musts showed the highest ºBrix and acidity in 2005, while lower levels in general were recorded in 2006 and 2007. For example, the highest values of totals anthocyanins, (ApH 3.6) extractible anthocyanins (ApH 1) and TP (Total Phenols at pH 3.6) were obtained in 2005. KELLER *et al.* (2005) also found that the accumulation of total anthocyanins in Cabernet Sauvignon grapes was much more influenced by seasonal conditions than by the cluster-thinning treatment. In our case, the 2005 season was the driest year and therefore the year with optimal environmental conditions for obtaining quality grapes.

d) Interactions

The three sources of variation (year, cultivar and cluster thinning treatment) had significant effects on some parameters of grape composition and extractability. The interactions V x Y (Variety x Year) were always significant except for the acidity parameter; and in the cases of V x T (Variety x Treatment), T x Y (Treatment x Year) and V x T x Y (Variety x Treatment x Year) they were almost always significant. .

In the case of total acidity, there were interactions between variety and treatment because in the most cases, the control vines had an acidity lower in Syrah than in Tempranillo vines. But in the case of cluster-thinned vines happened the opposite, obtained values higher in Syrah than Tempranillo.

For anthocyanins (at pH1 and pH 3.6) and TPpH 3.6 (total polyphenols), the most important interaction was due to the variety and the year, because Syrah variety always obtained values higher than Tempranillo variety for these parameters, except in 2007 where both varieties obtained values very similar.

For EI % (extractability index) and SMI % (seed maturity index) the interaction was easy to predict because both parameters did not show a clear tendency in the varieties, treatments and years.

e) Vinifications.

The studied grapes were vinified and their chromatic parameters measured. The results are shown in Table 6.

The best chromatic characteristics in both Tempranillo and Syrah varieties wines were obtained from cluster-thinned grapes in all three seasons, although other studies found no improvement in the anthocyanin content or colour of wines made from cluster-thinned Cabernet Sauvignon vines (OUGH and NAGAOKA, 1984; BRAVDO *et al.*, 1984). In all cases, the differences were significant, except in the case of tint, where the values obtained were very similar for the control and cluster-thinned wines.

CONCLUSIONS

The results showed that thinning successfully reduced yield and produced an earlier harvest in the two varieties studied.

The grape quality improved, providing, in general, higher anthocyanin and total polyphenol contents and less astringent tannins. The variety and the climatological conditions also influenced the final results, with the Syrah variety and the 2005 season providing the best results.

In all cases, the wines made from cluster-thinned vines of both Syrah and Tempranillo had significantly better chromatic characteristics than the control wines during the three seasons studied.

In conclusion, thinning is a useful viticultural practice for obtaining better quality wines, but what we gain in quality is at the expense of losing a significant amount of harvest, and besides numerous authors have not found high differences in the wines elaborate with cluster thinned vines compared with non-thinned vines.

The use of this practice is recommended depending of the several factors so the varieties and the climatological conditions also play a role and therefore its use can not be generalize.

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