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RESEARCH ARTICLE

Vine architecture and production control measures to improve the quality of the wine from Shiraz variety (*Vitis vinifera* L.)

Domingo M. Salazar[1], Borja Velázquez-Martí[2] and Isabel López-Cortés[1]

[1]Universitat Politècnica de València, Dept. Producción Vegetal. Camino de Vera s/n. 46022 Valencia, Spain. [2]Universitat Politècnica de València, Dept. Ingeniería Rural y Agroalimentaria. Camino de Vera s/n. 46022 Valencia, Spain.

Abstract

Aim of study: Six thinning treatments were studied to improve the chemical composition and quality of grapes of cv. 'Shiraz' under two vine architectures (vase and trellis).

Area of study: Spain (from 2015 to 2016).

Material and methods: The following thinning treatments were applied during four consecutive crop seasons: T0, control; T1, removal of 33% of the clusters (75 BBCH stage); T2, removal of 33% of the clusters (85 BBCH stage); T3, removal of the leaves at the base of the branches; T4, removal of the leaves at base of the branches together with removal of 33% of the clusters; T5, grouping of green branches; and T6, grouping of green branches and removal of 33% of the clusters.

Main results: All the treatments increased the luminosity and degree of polymerization, improving the color intensity and stability in the wines. In the musts, the levels of phenolic compounds (from 48.0 and 46.7 mg L^{-1} in T0 trellis and vase, respectively, to 66.8 and 68.9 mg L^{-1} in T6 trellis and vase, respectively), anthocyanins and sugars (from 22.0 and 22.1 mg L^{-1} in T0 trellis and vase, respectively, to 24.3 mg L^{-1} in T6 trellis and vase), were considerably improved.

Research highlights: Treatments T6 and T4 reported the best results. Branch grouping was more efficient than leaf removal regarding the contents of phenolic compounds. With respect to vine architecture, the results point out small differences, but we recommend the application of the treatments, mainly T4 and T6, under vase architecture. The season effect was mainly observed in the fourth year, probably due to the climatic conditions.

Additional key words: indigenous cultivars; ampelography; Shiraz wine; cultivation techniques; Spanish wines

Abbreviations used: DP (degree of polymerization), PCA (Principal component analysis); TPC (total phenols content)

Authors' contributions: Conception or design: DMS, BVM, ILC. Coordinating the research project: DMS. Acquisition, analysis, or interpretation of data; and obtaining funding: ILC, DMS. Statistical analysis, drafting and critical revision of the manuscript for important intellectual content: BVM. Administrative, technical, or material support: ILC. Supervising the work: DMS, BVM.

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Correspondence should be addressed to Isabel López-Cortés: islocor@upv.es

Introduction

One of the most important and prosperous areas of research in viticulture is the creation of well-differentiated wines together with the overall improvement of wine quality, by employing ampelography in indigenous cultivars. In the Comunidad Valenciana (East of Spain) 'Shiraz' is one of the most important varieties grown for wine production, totalizing a cultivated area of 76,138 ha in the region, and is the third most important red variety in Spain. Its importance is also noticed in other regions, being present in Corsica, South of Italy, and Sicily.

Canopy management and vine architecture are two crucial aspects regarding the quality of grapevine and of the resulting wine (Bordelon *et al.*, 2008; Pascual *et al.*, 2015; Ames *et al.*, 2016). The 'Shiraz' variety has been traditionally grown in vase architecture, but recently, its cultivation has been conducted in trellis. Regarding canopy management, thinning can be used to improve wine quality (Bahar & Yasasin, 2010; Soufleros *et al.*, 2011). Such principles and practices are intended to optimize sunlight interception, thus improving the photosynthetic capacity and yield, mainly in vigorous and shaded vineyards (Smart *et al.*, 1990). Thinning techniques also have a positive influence in the evolution of the aromatic components of musts and wines (Dami *et al.*, 2006; Diago *et al.*, 2010; Sun *et al.*, 2012).

Nevertheless, up to now, different thinning practices in the 'Shiraz' variety have not been evaluated and compared. Thinning is a usual practice which consists of removing leaves or clusters to control the quality of the production. The best time to carry out this practice as well as its respective intensity are difficult to define since they vary according to the vine variety. In addition, thinning is influenced by many factors, such as irrigation, fertilization, crop architecture, soil characteristics, and climate (Kamiloğlu, 2011). For these reasons, several studies have been carried out worldwide in order to determine the optimal conditions of adjustment to the different varieties and production conditions (Guidoni *et al.*, 2002; Naor *et al.*, 2002; Tardaguila *et al.*, 2008; Filippetti *et al.*, 2011).

'Shiraz' is one of the varieties with more aromatic attributes (Sánchez, 1999). The wines produced from this variety are usually red, both young and reserves, as well as rose. Basic quality variables in red wines from 'Shiraz' are, for instance, the high alcohol content and high content of anthocyanins with balanced polyphenols to achieve high stable color intensity. In rose wines, another characteristic is the high luminosity (L coordinate HunterLab) (Sánchez, 1999).

Therefore, the present work is intended to study the type of architecture (vase and trellis) and best period to perform the thinning treatment, focusing on the improvement of the oenological characteristics and quality of wines from the 'Shiraz' variety in rainfed grapevines during four consecutive crop seasons.

Material and methods

Plant material and studied location

In the present work, we studied vines from the 'Shiraz' variety (*Vitis vinifera* L.), previously characterized following the ampelographic rules of the UPOV TG 50/9 and Salazar & López-Cortés (2010). Overall, six leaf and fruit thinning treatments and one control treatment were evaluated to improve wine quality in two vine architectures: vase and trellis. The six treatments applied were the following: T0, control; T1, removal of 33% of the clusters (75 BBCH stage); T2, removal of 33% of the clusters (85 BBCH stage); T3, removal of the leaves at the base of the branches; T4, removal of the leaves at the base of the branches together with removal of 33% of the clusters; T5, grouping of green branches; and T6, grouping of green branches and removal of 33% of the clusters (Table 1).

The plots containing the vines grown under vase architecture were grafted on rootstock 41B (about 30 years old). Plantations established in trellis were on rootstock 110 R (25 years old). The study was conducted over four consecutive seasons, between 2012-2013 and 2015-2016, in Utiel-Requena, which is a typical vineyard area in the Spanish Mediterranean East. Climatic data of the evaluated crop seasons is shown in Table 2. The crop system usually applied in the studied area is rain-fed and therefore, the study was conducted in these conditions. Each treatment was performed in three linear blocks randomly distributed within the test plot. Each tested block was composed of forty vines, totalizing 120 vines per treatment.

In the thinning techniques tested, the most important quality characteristics were measured. For this purpose, samples were weekly collected from 10 consecutive vines of the different treatments tested. The samples (between six and eight) were characterized according to the procedures set by Bidan (1978) and summarized by Blouin & Guimberleau (2004).

Quality variables evaluated

In order to determine the quality variables, the grapes were cleaned and the excess of water was removed. Subsequently, the grape juice was extracted using a battery of blenders and a fraction was centrifuged and filtered

Table 1. Treatments applied to the vineyards during the four crop seasons studied.

Notation	Treatment	Phenological stage (BBCH scale)
T0	Control	-
T1	Removal of 33% of clusters	75
T2	Removal of 33% of clusters	85
T3	Removal of the leaves at the base of the branches [1]	75
T4	Removal of the leaves at the base of the branches and removal of 33% of clusters	75
T5	Grouping of green branches [2]	75
T6	Grouping of green branches, and removal of 33% of clusters	75

[1] In the trellis architecture, a thermal defoliation machine was used for eliminating the two or three basal leaves; in the vase architecture, manual leaf elimination was applied. [2] In the trellis architecture, the grouping was conducted in two axes; in the vase architecture, the grouping of green branches was conducted in a single vertical axis.

Table 2. Climatic data of the evaluated crop seasons.

Crop season	Average temperatures				Average monthly precipitation		Total accumulated precipitation (mm)
	Reserve period [1] (ºC)	Vegetative period [2] (ºC)	Crop season (ºC)	Warmer months (°C)	Reserve period (mm)	Vegetative period (mm)	
2012-2013	8.25	17.75	13.00	21.79	31.95	30.37	373.90
2013-2014	7.57	17.50	12.53	22.45	27.00	54.83	491.00
2014-2015	6.51	18.30	12.40	23.06	55.93	19.73	454.00
2015-2016	7.28	17.36	12.32	22.33	45.75	45.73	576.10

[1] Reserve period: between October and February. [2] Vegetative period: between March and September.

for solids removal. The liquid fractions of the must sample were used for analysis. The following variables were analyzed, which define the final quality of the wine:

- Total soluble solids (ºBrix) were measured by refractometry (Atago Atago WM-7 and 1T).
- Anthocyanins contents were measured following the method described by Ribereau-Gayon *et al.* (1999).
- Polyphenols contents (TPC) were determined according to the method described by Ribereau-Gayon *et al.* (1999) at 280 nm and a conversion factor of 0.08 was applied to quantify the total phenols content (TPC × 0.08).
- Color intensity was measured by absorbance readings at 420, 520 and 620 nm, according to the technique described by Glories (1984).
- The degree of polymerization (DP) was obtained after two spectrophotometric readings at 520 nm, the first reading being carried out in the recently produced must, and the second reading two hours after the application of potassium metasulfite 4 o/oo, being for the detection of discoloration (Ruiz, 2001).

The possible effects of the treatments tested in the ‘Shiraz’ clusters and grapes were also verified. Therefore, 100 grapes and 10 clusters were individually weighed in each sample.

Statistical analysis

Analysis of variance

An analysis of variance (ANOVA) with Type III sums of squares was performed using the GLM (General Linear Model procedure) of SPSS software, vers. 22.0 (IBM Corporation, New York). The fulfilment of ANOVA requirements, namely the normal distribution of the residuals and the homogeneity of variance, were evaluated by means of the Kolmogorov-Smirnov with Lilliefors correction (if $n>50$) or the Shapiro-Wilk`s test (if $n<50$), and the Levene´s tests, respectively. All the dependent variables were analyzed using a one-way ANOVA with or without Welch correction, depending on whether the requirement of homogeneity of variances was fulfilled or not. If a statistically significant effect was found, means were compared using Tukey´s honestly significant difference multiple comparison test or Dunnett T3 test, also depending on whether equal variances could be assumed or not. All the statistical tests were performed at a 5% significance level.

Principal component analysis

A principal component analysis (PCA) was applied for reducing the number of variables to a smaller number of new derived variables (principal component or factors) that adequately summarize the original information. Five variables corresponding to sugars, anthocyanins, polyphenols, berries, and clusters weights were used in PCA. The PCA was performed by using SPSS software, vers. 22.0 (IBM Corporation, New York).

Results and discussion

Vine architecture and crop-regulation techniques, such as cluster thinning, leaves removal and branch grouping, influenced the grapes content of sugars, anthocyanins, and polyphenols as well as the berries and clusters weight (Table 3; Figs. 1 and 2). The DP and luminosity of the musts obtained were also influenced by the studied treatments (Fig. 1). From the results obtained, it was observed that the crop-regulation techniques applied caused a higher impact on the variables studied than that of the vine architecture. We also observed that the influence of the crop season was reduced in the entire study, showing that the results were consistent mainly in the first three crop seasons considered (2012-2013, 2013-2014, and 2014-2015). In the fourth season (2015-2016), a reduction was found in the values of all the treatments studied, possibly related to the climatic conditions (Table 2).

Table 3. Influence of treatment, crop season, and vine architecture in the chemical composition of grapes (sugars, anthocyanins, and polyphenols) and in the berries and clusters weight.

Season	T0	T1	T2	T3	T4	T5	T6
	TRELLIS						
	Sugar (mg/L)						
2012-2013	22.3±0.1a	23.0±0.1b,c	22.7±0.2a,b	23.2±0.8c	24.6±0.1d	24.3±0.2d	24.5±0.1d
2013-2014	22.1±0.1a	23.7±0.2c	22.9±0.2b	23.8±0.7c	24.8±0.1d	24.5±0.3d	24.9±0.1d
2014-2015	23.1±0.5a	23.3±0.2a	23.2±0.3a	23.3±0.7a	24.3±0.2b	24.3±0.4b	24.7±0.2b
2015-2016	20.5±0.2a	23.1±0.2e	22.1±0.2b,c	22.0±0.4b	22.8±0.4d,e	22.5±0.3c,d	23.2±0.5e
All seasons	22.0±1.1	23.3±0.3	22.7±0.5	23.1±0.8	24.1±0.9	23.9±0.9	24.3±0.8
	Anthocyanins (mg/L)						
2012-2013	518±10a	540±20b	532±11a,b	573±8c	649±12e	586±7c	626±13d
2013-2014	639±6a	988±5g	894±9d	819±4c	918±7e	764±11b	966±36f
2014-2015	629±12a	738±12c	792±13d	647±3b	826±4e	799±8d	838±10e
2015-2016	680±20c	630±5b	635±4b	631±2b	700±3d	618±3a	717±3e
All seasons	617±69	724±194	714±161	667±106	773±122	691±105	787±148
	Polyphenols (mg/L)						
2012-2013	38.8±0.4a	40.8±0.8b	39.2±0.3a	53.3±0.6c	53.4±0.3c	58.5±0.5d	59.0±0.2d
2013-2014	44.1±0.7a	48.9±0.2b	48.9±0.2b	51.2±0.6c	49.4±0.5b	60.8±0.3d	65.7±0.5e
2014-2015	50.9±0.2a	54.0±0.2b	56.2±0.4c	60.2±0.3d	61.0±0.2e	62.2±0.2f	67.2±0.4g
2015-2016	58.2±0.3a	69.1±0.3b	70.3±0.4c	73.2±1.2d	76.0±0.3e	70.3±0.3c	75.3±0.3e
All seasons	48.0±8.4	53.2±11.9	53.7±13.1	59.5±9.9	60.0±11.7	62.9±5.1	66.8±6.7
	Berries weight (g)						
2012-2013	1.88±0.22a	2.07±0.11b,c	2.12±0.17c	1.94±0.01a,b	2.13±0.05c	1.79±0.12a	2.36±0.03d
2013-2014	2.08±0.02a	2.08±0.02a	2.13±0.05a	1.97±0.05a	2.18±0.47a	2.15±0.11a	2.50±0.07b
2014-2015	2.05±0.05a	2.13±0.02a-c	2.19±0.03b-d	2.09±0.15a,b	2.22±0.09c,d	2.14±0.03a-c	2.25±0.04d
2015-2016	1.65±0.23a	2.07±0.03b	2.13±0.03b	1.59±0.31a	2.01±0.11b	1.45±0.33a	1.64±0.21a
All seasons	1.91±0.20	2.09±0.03	2.14±0.03	1.90±0.21	2.14±0.09	1.88±0.33	2.18±0.38
	Cluster weight (g)						
2012-2013	444±71a	494±10b	544±43c	480±24a,b	503±8b,c	496±4b,c	485±35a,b
2013-2014	410±53a	469±21b,c	495±39c	445±18a,b	437±10a,b	469±46b,c	495±18c
2014-2015	417±31a	455±20a,b	463±46b	430±21a,b	463±32b	434±27a,b	459±34a,b
2015-2016	357±28a	420±35b,c	430±23b,c	451±6c	442±42b,c	361±51a	403±42a,b
All seasons	407±36	460±31	483±49	451±21	461±30	440±59	460±41
	VASE						
	Sugar (mg/L)						
2012-2013	22.2±0.6a	23.0±0.1b	22.4±0.2a	23.1±0.4b	24.4±0.3d	23.5±0.4c	24.9±0.2e
2013-2014	22.6±0.1a	23.2±0.1b	22.5±0.1a	23.2±0.4b	24.1±0.2c	24.2±0.3c	24.7±0.1d
2014-2015	22.6±0.1a	23.1±0.1b	22.4±0.1a	23.4±0.5b,c	23.8±0.3d	23.7±0.4c,d	24.7±0.2e
2015-2016	21.0±0.1a	23.1±0.4c,d	21.4±0.1a,b	21.8±0.0b	22.6±0.5c	21.7±0.5b	23.1±0.5d
All seasons	22.1±0.8	23.1±0.1	22.2±0.5	22.8±0.7	23.7±0.8	23.3±1.1	24.4±0.8
	Anthocyanins (mg/L)						
2012-2013	460±15a	495±9b	464±14a	708±10e	728±16e	547±14c	580±39d
2013-2014	519±17a	883±10d	884±2d	840±2b	896±2e	871±2c	925±10f
2014-2015	557±22a	625±10b	662±20c	795±2d	823±3e	783±3d	885±20f
2015-2016	608±27a	681±2d	645±1c	724±15e	763±2f	616±2a,b	629±8b,c
All seasons	536±62	671±161	664±172	767±62	802±74	704±149	755±175

Table 3 Continued.

Season	T0	T1	T2	T3	T4	T5	T6
				VASE			
				Polyphenols (mg/L)			
2012-2013	48.5±2.1b,c	46.8±0.8b	34.5±2.0a	46.8±0.3b	70.4±1.3e	49.8±0.3c	68.0±0.2d
2013-2014	49.6±0.5c	47.9±0.8b	34.2±0.8a	49.8±1.7c	68.4±1.6d	49.8±0.3c	68.9±0.3d
2014-2015	45.2±1.1a	50.8±1.2c	49.6±0.5b	55.0±0.2d	69.4±0.4f	64.1±05e	68.9±0.5f
2015-2016	43.8±1.8a	50.2±0.6c	49.8±0.3c	49.6±0.7c	46.6±0.6b	69.2±0.3d	69.8±0.5d
All seasons	46.7±2.8	48.9±1.9	42.0±8.9	50.3±3.4	63.7±11.4	58.2±9.9	68.9±0.8
				Berries weight (g)			
2012-2013	1.97±0.04a	2.10±0.06b,c	2.08±0.03b	1.98±0.02a	2.26±0.06d	2.07±0.03a,b	2.18±0.15c,d
2013-2014	2.14±0.21b	2.32±0.13b	2.46±0.06c	1.78±0.25a	2.21±0.17b	2.12±0.06b	2.51±0.04c
2014-2015	2.15±0.12b	2.32±0.08c-e	2.34±0.07d,e	2.04±0.16a	2.27±0.02c,d	2.24±0.03c	2.36±0.04e
2015-2016	1.59±0.35a	2.07±0.04b,c	2.33±0.19c	1.87±0.16a,b	2.26±0.14c	1.67±0.28a	2.19±0.09c
All seasons	1.97±0.26	2.21±0.13	2.30±0.16	1.91±0.11	2.25±0.03	2.03±0.25	2.31±0.16
				Cluster weight (g)			
2012-2013	375±22a	485±37d	397±40a	447±30b-d	415±25a,b	469±31c,d	442±30b,c
2013-2014	484±16b	463±23a,b	466±18a,b	431±17a	480±55b	498±13b	492±14b
2014-2015	446±13a,b	459±20a,b	470±21b,c	444±23a,b	431±15a	470±37b,c	500±23c
2015-2016	391±44b,c	390±12b,c	417±14c	474±31d	496±25d	329±36a	362±32a,b
All seasons	424±50	449±41	437±36	449±18	456±39	441±76	449±63

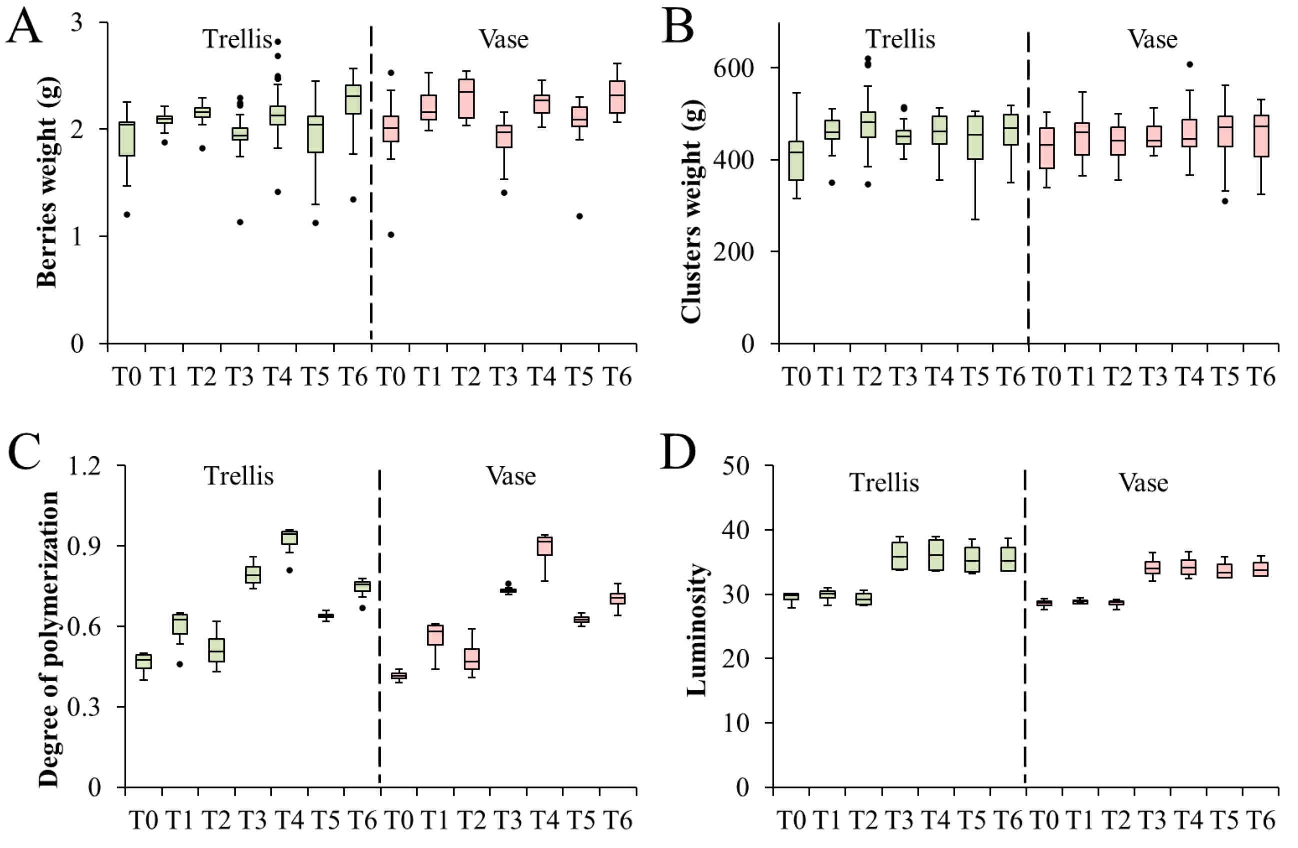

Figure 1. Boxplot of physico-chemical characteristics of grapes and musts from the 'Shiraz' variety grown under different thinning treatments and vine architecture. A, berries weight; B, clusters weight; C, degree of polymerization; D, luminosity

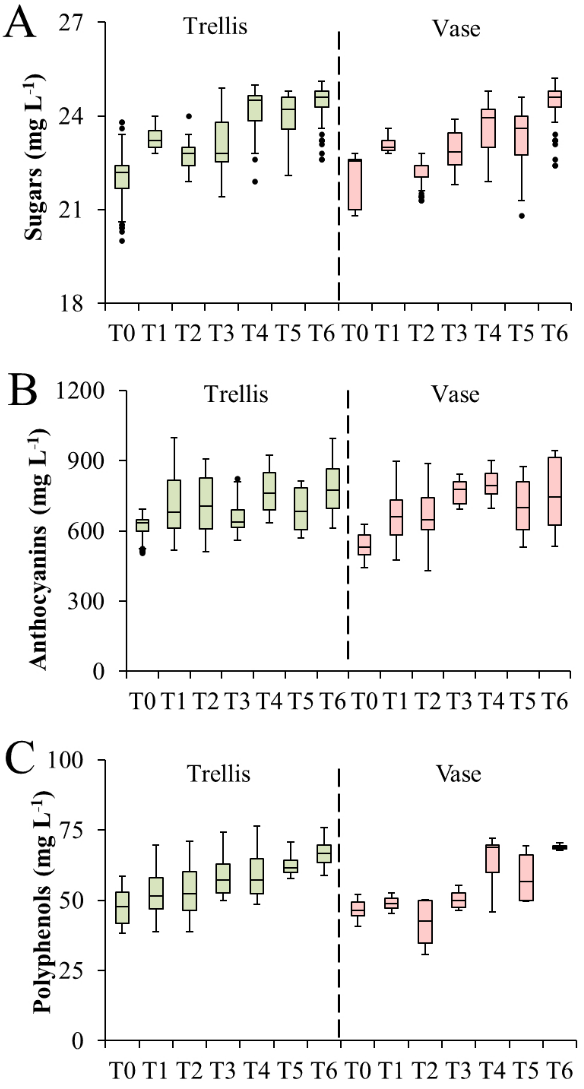

Figure 2. Boxplot of chemical composition of grapes from the 'Shiraz' variety grown under different thinning treatments and vine architecture. A, sugars; B, anthocyanins; C, polyphenols

In the four crop seasons studied, the berries and clusters weight increased in all the crop-regulation techniques applied (Fig. 1), with the only exception of T3 (basal leaf removal) (Table 3). In both vine architectures, the berries weight was higher in T6 (grouping of branches and removal of 33% of clusters) with 2.18 g and 2.31 g (trellis and vase, respectively). Regarding the clusters weight, treatment T2 (removal of 33% of the clusters) reported the highest weight in trellis (483 g). In the case of vase architecture, treatment T4 (removal of basal leaves and 33% of the clusters) reported the highest cluster weight (456 g). These results are in line with those obtained by other authors (Gatti *et al.*, 2012; Gil *et al.*, 2013; Bogicevic *et al.*, 2015). These authors reported higher berries and clusters weights with cluster thinning, and a reduction with vine defoliation. This is a compensation response from the vines. With clusters thinning, the vines can redistribute the available resources among a small number of clusters and grapes, improving their nutrition and consequent development.

As in the case of berries and clusters weight, the DP (Fig. 1C) and luminosity (Fig. 1D) of the obtained musts also increased with the different crop-regulation techniques studied, regardless of the vine architecture. The DP of the musts was higher with treatment T4 (Fig. 1C) in both vine architectures. Regarding musts luminosity, it was higher in treatments T3 to T6 in both architectures, while T1 and T2 (removal of 33% of the clusters at 75 and 85 BBCH, respectively) did not considerably influence this variable (Fig. 1D). The increase of DP is mainly related to the composition of grapes, namely the phenolic compounds. As we will report ahead, the different crop-regulation treatments also caused an increase in phenolic compounds. Since the DP is the polymerization and association of phenolic molecules, including tannins and anthocyanins, its values also increased with the higher levels of phenols (Table 3). The increase in the polymerization degree and luminosity improves the stability and intensity of wines color but they can also contribute to a higher astringency and bitterness (González-Manzano *et al.*, 2006).

Regarding sugars, anthocyanins, and polyphenols, treatment T6 (grouping of green branches, and removal of 33% of the clusters) followed by T4 (removal of the leaves at the base of the branches and removal 33% of the clusters) caused a higher increase in the contents. On average, in the four crop seasons studied, sugars contents increased from 22.0 mg/L in T0 to 24.3 mg/L in T6 (trellis), and from 22.1 mg/L in T0 to 24.4 mg/L in T6 (vase). Regarding anthocyanins, the same pattern was observed for vines grown under trellis architecture. Anthocyanins contents increased from 617 mg/L in T0 to 787 mg/L in T6 (trellis). In vase architecture, anthocyanins increased from 536 mg/L to 802 mg/L for T0 and T4, respectively (Table 3). With respect to polyphenols the same pattern was observed in both vine architectures. Polyphenols increased from 48.0 mg/L (T0) to 66.8 mg/L (T6) in trellis, and from 46.7 mg/L (T0) to 68.9 mg/L (T6) in vase vines (Table 3).

In Fig. 2, the data distribution allows perceiving the impact of treatments T6 and T4 in the contents of sugars (Fig. 2A), anthocyanins (Fig. 2B), and polyphenols (Fig. 2C) of 'Shiraz' grapes. Such results are in line with those obtained in several grape varieties and crop-regulation techniques, mostly cluster thinning. Gatti *et al.* (2012) also found an increase in soluble solids (ºBrix), phenols and anthocyanins in 'Sangiovese grapes', while Guidoni *et al.* (2002) improved anthocyanins content in the skin of grapes from the variety 'Nebbiolo'.

The considerable increase in polyphenols contents in treatments T4 and T6 could be attributed to the balance between the leaf surface area and fruit. The removal of leaves or the grouping of branches result in the increase of substrates necessary for the synthesis of phenolic compounds (Prajitna *et al.*, 2007). Also, the higher exposure of the cluster-thinned grapevines to sunlight enhances the production of substrates that in turn enhance the activity of the phenylalanine ammonia lyase, an enzyme involved in the biosynthesis of phenolic compounds in grapes (Chen *et al.*, 2006).

To verify the impact of the crop-regulation techniques studied on the changes inflicted on the grapes, the data were analyzed by PCA. Figure 3 shows the analysis of sugars, anthocyanins, phenolic compounds and berries and clusters weights per crop season, and the differentiation between the treatments applied can clearly be seen. In the first three crop seasons studied (2012-2013, 2013-2014, and 2014-2015), it is visible that those samples from T4 and T6 were represented in the positive region of PC1. In the same region, and for the same three crop seasons, all the variables studied were represented. This means that in general, the higher values were obtained for these two treatments (T4 and T6; Fig. 3). However, in the last crop

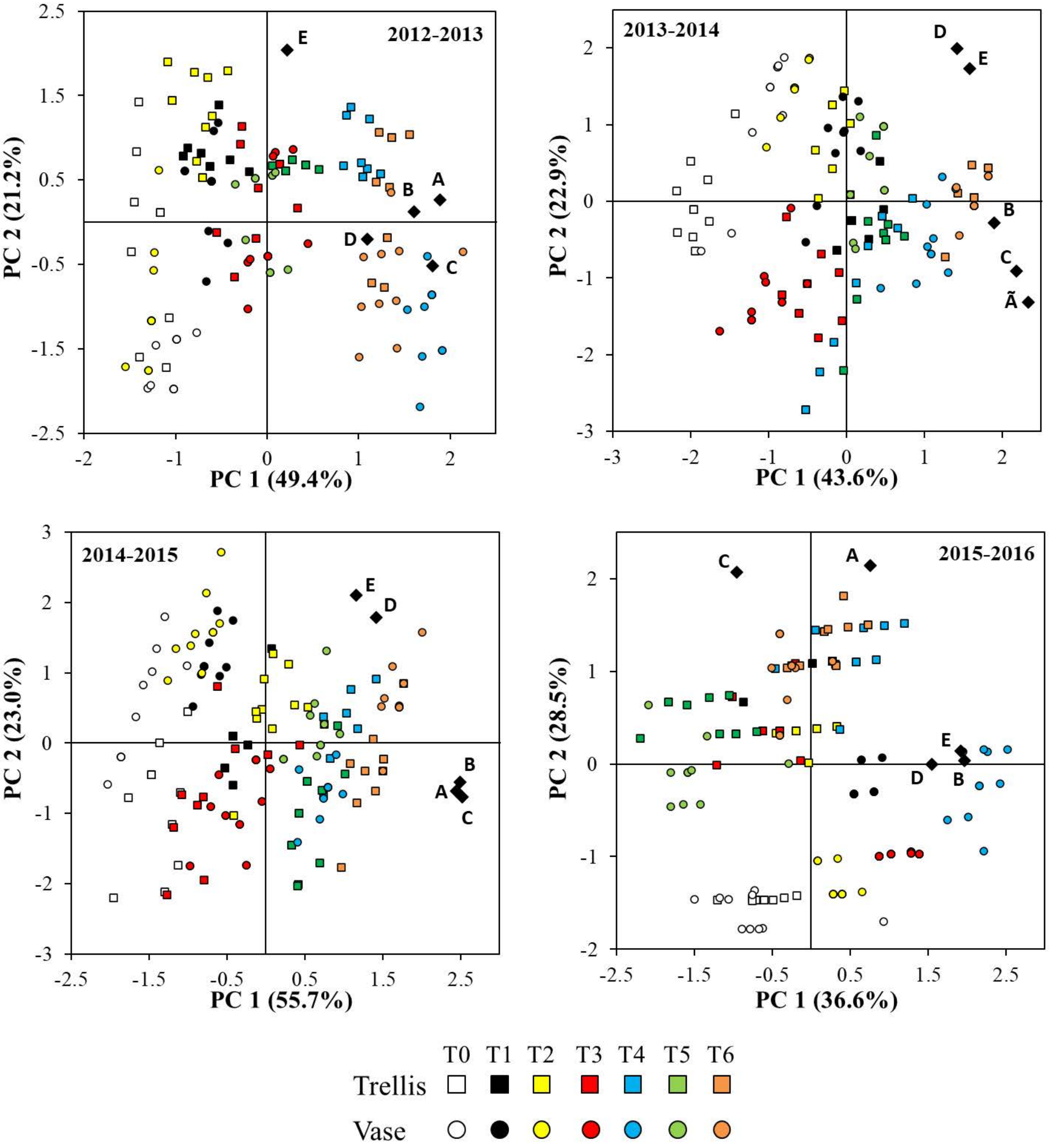

Figure 3. Principal component analysis of the data obtained according to the treatment applied and the vine architecture studied per crop season. The principal component analyses explain 70.6% (2012-2013), 78.7% (2013-2014), 78.7% (2014-2015), and 65.1% (2015-2016) of the total variance. A, sugars; B, anthocyanins; C, phenolic compounds; D, berries weight; E, clusters weight.

season studied (2015-2016), there was a noticeable differentiation of those samples from T4 in vase architecture, which reported higher values concerning anthocyanins, berries and clusters weight. In the four crop seasons studied, the control samples (treatment T0) were always represented in the extreme opposite region of the variables studied (Fig. 3). This means that grapes from the control treatment reported lower values, thus highlighting that the crop-regulation techniques improved the grapes composition, berries, and clusters weight, and consequently the musts DP and luminosity.

Such crop-regulation treatments influence grapes composition, which will change the final composition and quality of the wine. For instance, Gil *et al.* (2013) were able to obtain wines from Syrah variety with greater polyphenols, flavonols, proanthocyanidins and polysaccharide concentrations, and lower titratable acidity. These wines originated from grapes whose vines were submitted to cluster thinning. Using similar cluster thinning techniques, Prajitna *et al.* (2007) also improved the amounts of polyphenols, anthocyanins, and resveratrols in wines from the 'Chambourcin' variety, improving the antioxidant properties as well. Condurso *et al.* (2016) were able to improve grapes and wine polyphenol contents as well as volatile fraction through cluster thinning, thus improving the overall quality of the wine obtained.

In summary, the data obtained allowed concluding that treatment T6, *i.e.*, grouping of green branches and removal of 33% of the clusters, produce 'Shiraz' grapes with higher levels of anthocyanins, polyphenols, and sugars, which will possibly result in better-quality wines. The removal of 33% of the clusters alone also increased these components levels, but the effect in higher when applied in combination with grouping of branches. We also concluded that cluster thinning is more effective if applied at the 75 BBCH stage (T1) rather than at the 85BBCH stage (T2), mainly regarding sugars content. It was also concluded that all the treatments applied improved the luminosity and degree of polymerization when compared to control. Therefore, the stability and intensity of wines color may be increased as well. Another conclusion drawn from the study was that grapes characteristics and musts composition were not considerably influenced by the crop season or by the vine architecture. Nevertheless, based on the overall results, we would recommend the application of treatments T4 and T6 in the vase architecture, to improve the quality of grapes and wines from cv. 'Shiraz'.

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