EFFECTS OF TRADITIONAL AND LIGHT PRUNING ON VITICULTURAL AND OENOLOGICAL PERFORMANCE OF BOBAL AND TEMPRANILLO VINEYARDS

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Abstract

Aim : Light pruning may improve vine yield and quality although vineyard responses are variable. We assessed the effects of traditional manual pruning and mechanical light pruning on the viticultural and oenological performance of *Vitis vinifera* cv. Bobal and cv. Tempranillo.

Methods and results : During 2008-2011, Bobal and Tempranillo vineyards underwent traditional pruning or light pruning. The effects of both pruning techniques were determined in vine vigour and yield, and grape and wine characteristics. Both cultivars responded similarly to the pruning techniques assayed : i) light-pruned plants tended to overcrop, ii) grape yield significantly increased with light pruning and produced more clusters with smaller berries, and iii) the oenological characteristics of grapes were slightly affected since fruit ripeness was delayed in mechanically light-pruned vineyards.

Conclusion : Mechanical light pruning *vs.* traditional manual pruning offers potential benefits : 30 % higher yields ; lower cluster and berry weights ; a 40 % reduction in pruning costs ; and production of wines with lower alcohol while maintaining colour and phenolics.

Significance and impact of the study : No detrimental effect of light pruning on grape characteristics was found, and the wines deriving from these grapevines offered good oenological characteristics. Mechanical light pruning may prove a suitable tool to prolong the vine vegetative cycle, which is reduced by the climate change in the Utiel-Requena region.

Key words : grape and wine quality, grapevine yield, microvinification, light pruning, vine vigour

Résumé

Objectif : La taille mécanique légère du vignoble peut améliorer la croissance et la qualité des vignes, bien que les résultats soient variés. Nous avons comparé les effets de cette taille légère et ceux de la taille traditionnelle sévère sur les performances viticoles et œnologiques de *Vitis vinifera* cv. Bobal et cv. Tempranillo.

Méthodes et résultats : De 2008 à 2011, les vignobles de Bobal et Tempranillo ont été soumis à des techniques de taille mécanique légère ou de taille traditionnelle plus sévère. Les effets de ces deux techniques de taille ont été déterminés pour la production de fruits des vignobles et pour la vigueur, ainsi que pour les caractéristiques du raisin et du vin. Les deux types de cultures ont eu des résultats similaires : i) les plantes, qui avaient été taillées mécaniquement, tendent vers une surproduction, ii) la production de raisin s'est aussi accrue dans les plantes à taille mécanique légère, en produisant plus de grappes avec des baies plus petites et iii) les caractéristiques œnologiques du raisin ont été un peu affectées, car leur maturité a été retardée dans les vignobles taillés légèrement.

Conclusion : La taille mécanique légère, en comparaison avec la taille traditionnelle, offre plusieurs bénéfices potentiels : une augmentation de 30 % de la production en fruits des plantes ; une diminution du poids des grappes et des baies de raisin ; 40 % de réduction dans les coûts de la taille et la production de vins avec une moindre teneur alcoolique tout en conservant la couleur et la teneur en phénols.

Signification et impact de l'étude : Aucun effet négatif n'a été rencontré dans les caractéristiques du raisin taillé mécaniquement, et les vins provenant de ces vignobles offrent de bonnes caractéristiques œnologiques. La taille légère peut donc être un outil adéquat pour prolonger le cycle végétatif de la vigne, qui a été réduit par les changements climatiques de la région de Utiel-Requena.

Mots clés : qualité du vin et du raisin, production des vignobles, microvinification, taille mécanique légère, vigueur de la vigne

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Table 1 – Comparison of mechanical light (MP) and traditional manual (TP) pruning costs of the Bobal and Tempranillo vineyards (approx. 2500 vines/ha). *Salary and pruning yields data have been rounded off to the mean values of the four year experiment (2008 to2011).

Pruning activity	Requirements	Salary/day* (euros)	No. of pruned vines/day*	Total costs/ha (euros)	Total costs/vine (euros)
MP (mechanical prepruning)	1 person + tractor (8 h/day)	280	10000 (equiv. 4 ha)	280: 4 ha = 70	—
MP (manually touched up)	1 person (8 h/day)	65	1250 (equiv. 0.5 ha)	65 x 2 days = 130	-----
MP	—	—	—	70 + 130 = **200**	200: 2500 = **0.08**
TP	1 person (8 h/day)	65	500 (equiv. 0.2 ha)	65 x 5 days = **325**	325: 2500 = **0.13**

INTRODUCTION

The impact of crop management, climate and soil on the quality of musts and wines is the basis of much discussion about grapevine (Jackson and Lombard, 1993 ; Keller, 2005 ; Guerra and Steenwerth, 2012). A sustainable vineyard management would help reduce inputs, while enhancing or maintaining yield quantity and quality. In the 1930's, Prof. Winkler conducted early trials on grapevine growth and productivity at U. C. Davis to conclude that unpruned vines had the greatest inherent productivity (see Lakso, 1999). Until the late 20th century, the commercial application of light or minimal mechanical pruning was delayed and limited technologically. In the 1990's, mechanical pruning techniques extended rapidly to different winegrowing regions because, in many countries, hand pruning represented 30 % of yearly wine grape production costs. Initially, light pruning proved successful ; later, however, response variability became evident. The variations seen in minimally-pruned vines (incompatible climate conditions ; different grapevine cultivars reactions) meant that it was necessary to understand what was actually happening (McCarthy and Cirami, 1990 ; Clingeleffer *et al.*, 2005).

Several works have reported that light mechanical pruning not only increases yield, but also cuts vineyards management costs (Reynolds and Wardle, 2001 ; Archer and Van Schalkwyk, 2007 ; Main and Morris, 2008 ; Clingeleffer, 2013). Some of the above-cited works also mention that light pruning produces more smaller-sized bunches and may modify must oenological characteristics. Nonetheless, the results vary in accordance with grapevine vigour and grape cultivar (Tomasi *et al.*, 2013). Research done over the last 30 years has shown that there is a potential to develop integrated systems to stabilize the yield and quality of vineyards across seasons, but also that annual variability, largely dependent on environmental conditions, is much greater than that which can be achieved by modifying management practices (Clingeleffer, 2010).

This work aims to characterise the behaviour of autochthonous Bobal grape variety, which occupies more than 70 % of the total grapevine area in the Denomination by Origin (D.O.) Utiel-Requena (Valencia, Spain), as compared with the well-known Tempranillo variety. Bobal and Tempranillo vineyards were subjected to traditional hand pruning or light mechanical pruning with a view to

Table 2 - Influence of mechanical (MP) and traditional pruning (TP) on Bobal and Tempranillo vine yields.

Cultivar (pruning method)	Yield Parameters			
	Total yield (kg/vine)	Number of clusters/vine	Cluster weight (g)	Berry weight (g)
Bobal (MP)	5.9b	19b	300a	2.30a
Bobal (TP)	4.6a	11a	416b	2.75b
Tempranillo (MP)	5.7b	34b	165a	1.32a
Tempranillo (TP)	4.1a	20a	201b	1.57b

Data are mean values of four years (2008 to 2011) with six replications per year, where five vines/row were considered a replication unit. For each cultivar and parameter, the means with the same letter are not significantly different (t-test level $p < 0.05$)

assessing the effects on the viticultural and oenological performance of these grapevines.

MATERIALS AND METHODS

1. Study site and experiment description

From 2008 to 2011, the tests reported in this work were done in a commercial vineyard (Fuenteseca) located at Camporrobles (Valencia, E. Spain, UTM 8310, 980 m above sea level) within the D.O. Utiel-Requena area. This industrial winery is adapting all the aspects of sustainable measures in winegrowing to produce ecological wines.

Typical soils in the region are haplic Calcisols (FAO, 2014) with profile type Ap Bwk Ck, and are mainly calcareous given parent material characteristics. Soils presented an anthropic diagnostic horizon (Ap, 0-35 cm depth), a canvic-calcic horizon (Bwk, 35-55 cm depth) and a calcic horizon (Ck, 55-80 cm depth). According to Thornthwaite's climate classification (Thornthwaite, 1948), climate is Mediterranean with a continental influence, and dry subhumid. Average annual temperature in this vineyard is 13 ºC and annual rainfall is ca. 400-500 mm; thus, the soil temperature regime is Mesic, whereas soil moisture regime is Xeric (Roca-Pérez *et al.*, 2005).

Varietals *Vitis vinifera* L. cv. Bobal and cv. Tempranillo, grafted on Richter 110, were chosen for this study. The vineyards were planted in 1997 and vines were spaced at 1.35 m x 2.85 m (approx. 2,500 vines/ha). Spur pruned grapevines were trained in permanent bilateral cordons. The vineyards received irrigation merely to avoid water deficits, and the total volume of water was approx.

Table 3 - Influence of mechanical (MP) and traditional pruning (TP) on Bobal and Tempranillo grapes' composition.

Parameter	Bobal		Tempranillo	
	MP	TP	MP	TP
Brix	18.2a	20.1b	21.4a	23.2b
Sugar (g)/vine	760b	614a	836b	662a
pH	3.4a	3.5a	3.6a	3.7a
Titratable acidity (g/L)	6.74a	6.55a	5.45a	5.34a
Total polyphenol index	60a	69b	61a	73b
K (mg/L)	1624a	1798b	1951a	2185b
Assimilable N (mg/L)	250a	258a	240a	257a

Data are mean values of four years (2008 to 2011) with six replications per harvest, where five vines/row were considered a replication unit. For each cultivar and parameter, the means with the same letter are not significantly different (t-test level $p < 0.05$)

500-700 m^3/ha distributed as three irrigations per year. Four experimental plots, each plot consisting of six vine rows, were delimited in the Bobal and Tempranillo vineyards. For the sampling and analytical determinations, thirty vines/cultivar over six rows were selected. For the statistical analysis, the five vines/row chosen for the analytical determinations were considered a replication unit; in other words, there were six replicates per treatment, cultivar and year.

Both vineyards underwent mechanical light pruning (MP) or traditional severe manual pruning (TP) with traditional soil tillage (bare floor). Pruned canes were removed, weighed, crushed and then returned to vineyard soils. During manual

Table 4 - Vegetative vigour of Bobal and Tempranillo vines subjected to mechanical (MP) or traditional pruning (TP) over 4 years (2008 to2011).

Cultivar (pruning method)	2008	2009	2010	2011
Bobal (MP)	12.3cd	9.6bc	13.2d	13.5d
Bobal (TP)	7.3ab	6.5a	6.3a	6.6a
Tempranillo (MP)	10.8b	10.5b	12.5b	12.9b
Tempranillo (TP)	6.0a	6.6a	6.8a	6.7a

Data are the means of six replications, where five vines/row were considered a replication unit. For each cultivar, the mean Ravaz Index values with the same letter are not significantly different (t-test level $p < 0.05$)

pruning, 85-90 % of vine annual growth was removed and 6-8 two-bud spurs (approx. 12-16 buds/vine) were retained per vine. Light pruning was firstly carried out with a tractor equipped with a disco pre-pruner (Pellenc). Then, spur tips were manually touched up. In light pruning, 10-12 longer spurs, with 4 buds per spur, were retained on each vine (approx. 40-48 buds/vine).

Grapes from both cultivars were always hand-picked during the first two weeks of October (2008 to 2011), which was the most appropriate time for grape harvest according to the data for technological maturity represented by the measurements of must sugar contents, colour and pH. The prediction of rainfall and grapes' sanitary condition were also considered to determine harvest time.

2. Evaluation of the pruning technique with respect to vine performance and grape quality

The two techniques described above were employed on Tempranillo and Bobal grapevines during winter dormancy over four years (January, 2008 to 2011). Sixty Bobal and sixty Tempranillo vines were analysed in four consecutive years to determine vine yield, vine vigour and grape characteristics.

Vine yield. Total yield (fruit weight) and total number of clusters per vine were recorded at harvest. These yield data were used to calculate the mean weight of the Bobal or Tempranillo clusters. Mean berry weight was determined by selecting grapes randomly from different clusters. There were six replicates per pruning treatment, cultivar and year, and each replication unit consisted of 100 berries. Berries were weighed on a Kern balance (capacity 1,200 g, precision 0.01 g)

Vine vegetative vigour. The vegetative vigour of the 120 vines under study was measured by determining their Ravaz Index (Ravaz, 1903), this being the ratio between vine yield at harvest and the dormant pruning weight of the following winter (kg of fruit/kg of wood). Pruning wood was measured on a PCE hanging scale (capacity 10 kg, precision 30 g).

Grape characteristics. Immediately after each harvest, the juice of pressed berries (100 berries per sample) was used to perform the chemical analyses (see below). Berry samples were representative of all the cluster positions and all the positions within the cluster. There were six replicates per pruning treatment, cultivar and year, and each replication unit consisted of five vines. Besides the grape analysis described below, we calculated the parameter sugar yield per vine (expressed in g) in accordance with Martínez de Toda and Sancha (1999).

3. Winemaking

The Bobal and Tempranillo hand-picked berries from mechanically- or manually-pruned vines were subjected to microvinification for two consecutive years : 2010 and 2011. The winemaking process was performed in triplicate (3 x 40 kg of fruit) for each grape cultivar, pruning treatment and vintage. Clusters, representative of all the positions within the vine, were randomly divided to create three fermentation replicates (40 kg per replicate). Immediately after harvest, unwashed clusters were added directly to the top hopper of a crusher-destemmer electric machine equipped with a horizontal roller. Musts were placed in 50-L steel microvinificators with skins and seeds present. Juice yields ranged between 0.75 L and 0.80 L per kg of grape. Samples were collected for analysis before adding sulphur dioxide (30 mg/L).

For alcoholic fermentation, commercial yeast was incorporated at a dosage of 200 mg DW/L (*Saccharomyces cerevisiae*, strain Excellence XR, Lamothe-Abiet, Bordeaux). Yeasts were rehydrated with water (37 ºC for 20 minutes), mixed with 100 mL of fresh must (10 minutes), and then inoculated into the fermenters. Musts were mixed manually every 12 h. Containers were maintained at 25 ºC. After 10 to 15 days of maceration, when the alcoholic fermentation was almost completed, skins, seeds and other solid matter were removed and the wines were transferred to glass containers. Jars were kept at 18 to 22 ºC until malolactic fermentation had ended. After spontaneous malolactic fermentation completion (25 to 30 days), lees were removed and sulfur dioxide was added (30 mg/L). Clarifying agents were not added to the wines. On average, the complete fermentation period lasted 40 to 45 days. Then, wines were decanted into clean glass containers, transferred to bottles after one month of rest and stored horizontally at 15 ºC. The final wine yield was 0.69 ± 0.03 L per kg of grape.

This winemaking process was performed in triplicate for each cultivar, pruning treatment and harvest (3 x 2 x 2 x 2), with a total of 24 vinifications. After two months of bottling, all three fermentation replications made in both vintages, from each cultivar and pruning treatment, were analysed twice for the physicochemical parameters.

4. Grape and wine characterisation

Most of the basic chemistry for each grape or wine sample was determined by Fourier-transform infrared spectrometry (FTIR), using WineScan FT120 equipment (Foss Electric, Denmark) with the Foss WineScan software version 2.2.2 (PN 1010968). Colour intensity (OD_{420} + OD_{520} + OD_{620}) was measured by spectrophotometry and total anthocyanins were determined as proposed by Saint-Criq de Gaulejac *et al.* (1998). Grape juice samples were filtered (0.45 µm) to eliminate particles. WineScan was calibrated for individual parameters according to the manufacturer's instructions and data sets were validated with the control wine samples employed with this equipment in Bodega Sierra Norte (Requena, Valencia). Reference OIV analytical methods were used to correlate with the FTIR data obtained for the different measured parameters in order to determine a predicted level of accuracy (2 x standard error); the following values were calculated for grape and wine parameters:

i) Grape analysis: Brix (± 0.10); pH (± 0.05); Titratable acidity, as tartaric acid, (± 0.11); Total Polyphenol Index (± 0.46); K (± 45); Assimilable N (± 8).

ii) Wine analysis: pH (± 0.07); Volatile acidity, as acetic acid, (± 0.036); Titratable acidity, as tartaric acid, (± 0.10); % Ethanol (± 0.16); Total Polyphenol Index (± 0.41); Colour intensity (± 0.08); Anthocyanins (± 16).

5. Wine sensory evaluation

The wines from the 2010 and 2011 grape harvests were evaluated by a group of six independent qualified assessors, with a recognised knowledge in Utiel-Requena wines (three oenologists and three winemakers), who rated their different sensory components on a 100-point scale according to the OIV (2009). The evaluated parameters included appearance, nose and taste, and were subdivided into several attributes as indicated in the OIV score sheet. Visual appearance (up to 15 points) was investigated in relation to limpidity, intensity and colour; aroma (up to 30 points) was scored for genuineness, positive intensity and quality. These three attributes, besides persistence, were evaluated for taste (up to 44 points), and an overall judgement of wine harmony was rated with up to 11 points. The twelve wines from each harvest were given an internal code. Bottles were opened just before serving the wines, which were randomly presented.

6. Statistics

The data presented in the tables are arithmetic means, and details of the number of replicates are provided above, either in this section or in the respective table headings. The effects of pruning methods on the different parameters were evaluated by analysis of variance (ANOVA) followed by an independent samples t-test ($p<0.05$). All statistical analyses were performed using the SPSS 17.0 software package.

RESULTS AND DISCUSSION

1. Reduced management costs in light-pruned vineyards

There is no unique vineyard management model that can be generally applied as each vineyard has a particular form of management based on the location, size, parcel structure, age of the vines, machinery requirements, etc.

In our particular case, the Bobal and Tempranillo vineyards are grown on the same rootstock, are located in similar plots close to each other, have been applied identical soil and canopy managements, and vines have received the same irrigation, fertilization and chemical treatments (for weed control, and against insects, mites or diseases), etc. Therefore, we do not wish to estimate costs of the numerous variants in annual operating costs (fixed or variable) of a mature vineyard. The only objective of this section was to determine the different costs arising from the application of traditional manual or mechanical light pruning to a medium-sized exploitation. Thus, it can be easily discerned if light mechanical pruning actually reduces the management costs of the Bobal and Tempranillo vineyards studied herein.

The mean costs (per hectare or vine) for both pruning methods are provided in Table 1. The application of traditional manual pruning generates costs of 325 €/ha (13 centimes of a euro per vine) *vs.* 200 €/ha (8 centimes of a euro per vine) calculated when vineyards are lightly pruned. These results demonstrate that light mechanical pruning, as compared to traditional manual pruning, offers approximately a 40 % reduction in costs. Our results agree with others previously reported which have demonstrated that light mechanical pruning cuts vineyards management costs, and have indicated that in many countries, hand pruning represents 30 % of the annual wine grape production costs (Main and Morris, 2008 ; Clingeleffer, 2013). Lower pruning costs derived from applying light pruning to the Bobal and Tempranillo vineyards was the first benefit observed ; any other potential benefits are described and discussed below.

2. Impact of pruning on the yield of Bobal and Tempranillo grapevines

At harvest, the effect of mechanical and traditional pruning on Bobal and Tempranillo vine yield was evaluated by measuring number of clusters and total fruit per vine, and by calculating the mean weights of clusters and berries. The data obtained with Bobal and Tempranillo grapevines are compared in Table 2. Total fruit yield per vine was similar for both cultivars for hand-pruning (4.1 to 4.6 kg). Both varietals showed a similar, yet significantly increased, yield (ca. 35 %) after being mechanically pruned over the four-year experiment. Total grape yield ranged from 5.7 kg to 5.9 kg (Table 2). The number of clusters per vine significantly increased with light pruning (ca. 70 %), this being the determining factor of total vine yield given the larger number of resting buds (approx. 40-48 buds/vine in light pruning *vs.* approx. 12-16 buds/vine in severely hand-pruned plants). Hence, the numerous buds resting in mechanically-pruned vines developed into a large number of clusters, which were smaller than those on hand-pruned plants as a result of fruit competitiveness. This effect was significant in both cultivars (Table 2), and it became more evident in Bobal vines because the mean weight of clusters was about one third lower (416 g *vs.* 300 g). Moreover, the bunches of mechanically-pruned plants were looser and produced smaller berries, with a weight of approx. 16 % lower in both cultivars.

Our results agree with previous studies reporting several grape cultivars, with poorer yields for manually-pruned vines than minimally-pruned vines. However, lower cluster weights, berry weights and number of berries per cluster were found (Reynolds, 1988 ; Reynolds and Wardle, 2001 ; Clingeleffer *et al.*, 2005 ; Pezzi *et al.*, 2013). There are some studies which have reported that the yields in minimally-pruned vineyards vary, and that yield stabilisation can occur several years after treatment has commenced (Main and Morris, 2008) or vary widely among seasons (Clingeleffer, 2010).

Apart from higher grape production, our results reveal that light mechanical pruning contributes to the development of looser clusters with smaller berries, which favours homogeneous fruit ripeness.

3. Effects of pruning on Bobal and Tempranillo grape characteristics

Brix, titratable acidity, total polyphenol index (TPI), pH, K content and assimilable nitrogen were assessed in fruit samples representative of all collected bunches. Sugar yield/vine was also calculated. Accumulation of soluble solids, polyphenol concentrations, and K contents were somewhat lower in the Bobal berries than in the Tempranillo grapes (Table 3). The range of variation in this experiment in must quality and fruit composition was slight, although we found four significant differences in relation to the pruning technique used. Our results reveal that a lighter pruning of both cultivars significantly lowers Brix, TPI, and K accumulation in fruits of both cultivars (Table 3). The measurements taken for the other oenological parameters (titratable acidity, pH and assimilable nitrogen) in the obtained musts indicated no significant differences between pruning techniques. However, pH and assimilable nitrogen tended to lower, whereas titratable acidity tended to increase in the mechanically-pruned vines of both varietals. These tendencies, besides the above-mentioned reductions in sugars, polyphenols and K, clearly denote delayed fruit ripeness with lighter pruning at harvest. A similar physiological plant response was observed when light pruning methods were applied to Cabernet-Sauvignon vines (Petrie *et al.*, 2003) or to other *V. vinifera* cultivars (see Clingeleffer, 2010). When comparing total sugar yield per vine, this parameter was clearly superior in those grapes formed in the lighter pruned Bobal and Tempranillo grapevines (Table 3). Despite the slightly lower maturity levels of MP vines, they had a greater capacity for total sugar production per vine; this superiority is due to this pruning method given the larger number of resting buds that provide higher yields (Table 2).

Although different cultivars may react differently to light pruning (McCarthy and Cirami, 1990), we consider that, in some cases, the statistical results may not be determined by the differential behavior of cultivars to pruning, but by the homogeneity of the data recorded for varietal. Along these lines, our data sets support previous observations given that annual yields are seen to be more variable and heterogeneous in light mechanically-pruned vines than with traditional severe pruning treatments (Martínez de Toda and Sancha, 1999). These authors accounted for this response by stating that the interaction of manually-pruned vines with environmental factors is more limited given the smaller number of buds; thus, yields prove more homogeneous.

4. Pruning techniques and vine balance

Vine balance is a key concept in studying vine physiology that relates closely to pruning decision making. In short, crop load is a ratio reflecting the relationship between reproductive and vegetative development. The most widespread equation for crop load assessments is known as the Ravaz Index (Ravaz, 1903), which indicates vine status: values of 5 to 10 imply that plants are balanced and are capable of producing high quality fruit; higher values indicate overcropping, and lower values are indicative of excessive vegetative growth (Bravdo *et al.*, 1985; Smart *et al.*, 1990). Nevertheless, distinct vine balance ranges have been proposed according to the productivity or shoot thickness of grapevine cultivars (Santesteban *et al.*, 2010).

To obtain the Ravaz Index (kg of fruit/kg of pruned wood), we related vine production at harvest with the dormant pruning weight as determined during the following winter. For the Bobal and Tempranillo cultivars, the mean Ravaz Index values for both pruning methods are provided in Table 4. The response of both cultivars was similar, manually-pruned Bobal and Tempranillo vines were balanced, whereas light-pruned plants tended to be overcropped. This overcropping tendency did not vary substantially between the study years when mechanical methods were successively applied (see Table 4). According to the variation range observed, we can expect unbalanced vines to produce grapes with a markedly reduced quality. Yet, as discussed below, no clear relationship between vine vigour and fruit composition was found in either cultivar after the four-year treatment. In line with this, Santesteban *et al.* (2010) reported that the Ravaz Index relates to sugar content for the circumstances in which the fruit to leaf ratio becomes the limiting factor in either a cool or warm climates; however, such a relation is not usually found in Mediterranean vineyards of southern Europe, where sugar content is limited mainly by water deficit (see the references cited in Santesteban *et al.*, 2010).

In order to maintain vineyard sustainability and to prevent ageing and overcropping tendency due to light pruning, it seems advisable to work the vines in the Utiel-Requena area with mechanical pruning for a maximum period of three consecutive years, and thereafter to regenerate vines for one year with traditional severe pruning.

5. Effects of pruning on Bobal and Tempranillo wines

The Bobal and Tempranillo musts extracted from the berries formed in the mechanically- or traditionally-pruned vines (2010 and 2011 vintages) were subjected to microvinification: alcoholic fermentation with commercial yeasts, followed by spontaneous malolactic fermentation.

Young Bobal and Tempranillo wines (2-month-old) were evaluated for their basic physicochemical

Table 5 - Influence of mechanical (MP) and traditional pruning (TP) on the oenological classic parameters of the Bobal and Tempranillo wines.

	Bobal		Tempranillo	
Parameter	MP	TP	MP	TP
pH	3.5a	3.6a	3.8a	3.9a
Volatile acidity (g/L)	0.58a	0.60a	0.65a	0.62a
Titratable acidity (g/L)	5.87a	5.70a	4.18a	4.14a
Ethanol (% v/v)	12.6a	13.3b	12.3a	13.1b
Colour intensity	9.7a	10.1a	7.5a	7.6a
Total polyphenol index	52a	50a	39a	38a
Anthocyanins (mg/L)	505a	494a	405a	402a

Data are mean values of two microvinifications (2010 and 2011) with six replications (three samples with two measurements) for each cultivar and pruning treatment per vintage. For each cultivar and parameter, the means with the same letter are not significantly different (t-test level $p < 0.05$)

properties (Table 5). The comparison of Bobal and Tempranillo wines showed that, despite the influence of the pruning method, the former gave higher values of titratable acidity and phenolic compounds, and that they were more intensely coloured (high colour intensity and anthocyanin concentrations) than the Tempranillo wines; for the remaining measured oenological parameters (pH, volatile acidity and ethanol percentage), we obtained similar values for both varietals.

In terms of how the pruning method influences the final product, it is remarkable to note that both cultivars' responses to mechanical light pruning were identical since it provoked only one significant effect: reduced wine alcohol levels (Table 5). Ethanol reduction was quantitatively similar in both varietal wines representing 0.7-0.8 % (v/v). On the whole, our data suggest a potentially new benefit deriving from the use of light pruning as compared with severe pruning: that is, production of wines with lower alcohol without compromising other wine attributes such as colour and phenolics. This appreciation and our results for Bobal and Tempranillo largely agree with those reported by Petrie *et al.* (2003), who worked with Cabernet-Sauvignon berries produced by vines subjected to severe pruning or to different light pruning regimes, which were harvested at similar maturities.

Finally, we made attempts to discern whether light pruning can be linked to changes in wine aroma and taste. For this evaluation purpose, six panellists rated the different sensory components of the wines produced in both vintages (Figure 1). The evaluated parameters included appearance, nose and taste, and were subdivided into several attributes as indicated in the OIV score sheet (2009). The three fermentation replications made from each cultivar, treatment and harvest were tested by the same panel, which did not detect significant variations among these replicates. In both cultivars, it is noteworthy that: i) there was no significant variation among the three replicates in each study, ii) there were no noticeable differences between the 2010 and 2011 vintages, iii) the wines from the light-pruned vines obtained the lowest scores (72 to 74 points *vs.* 79 in Bobal; 71 to 72 *vs.* 74 to 77 in Tempranillo), and iv) scoring differences cannot be particularly linked to defective aroma or taste attributes.

Yield determines the source-sink relationship of plants, so it is not surprising that yield affects grape and wine characteristics. Some studies have reported that vines with larger yields produce wines with fewer attributes. Chapman *et al.* (2004) conducted a study to investigate the effects of yield manipulation on the sensory attributes of Cabernet Sauvignon wines. Interestingly, a trained panel evaluated and found that the wines from the light-pruned vines had diminished veggie aromas and enhanced fruity aromas for two consecutive vintages. Nevertheless, the authors concluded that more testing was required to determine whether the differences can be perceived by less experienced consumers and how sensory attributes affect wine preferences. On the other hand, there are numerous works, conducted with different grape cultivars, which support the results of our study showing little impact of lighter pruning on wine quality attributes (Rousseau *et al.*, 2013; Tomasi *et al.*, 2013).

CONCLUSION

Mechanical light pruning, as compared to traditional manual pruning, offers several potential benefits: a 30 % increase in yields and lower cluster and berry weights. These data support the results reported in previous studies in terms of light-pruned wine grape viticultural performance. Light pruning also implies a clear cut (ca. 40 %) in pruning management costs, which was estimated at 8 centimes of a euro per vine (mechanical light pruning) *vs.* 13 centimes per grapevine (hand-pruned vines). No detrimental effect of light

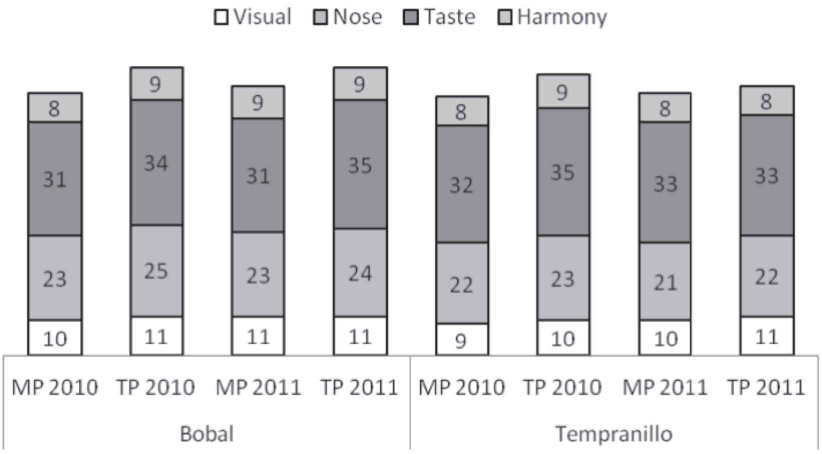

Figure 1 - Sensory evaluation of the Bobal and Tempranillo wines obtained from the 2010 and 2011 vintages. Vines were subjected to mechanical (MP) or traditional pruning (TP) over 4 years (2008-2011).
The evaluated parameters included visual appearance, nose, taste and harmony, with values of up to 15, 30, 44 and 11 points, respectively, according to the OIV score sheet (2009). Data on the bars are the means of the values given to each parameter by six panellists.

pruning on grape characteristics was found, which remained close to optimum, and the wines that derived from these grapevines presented good oenological characteristics, despite the vines' tendency to lose vigour. Wine scoring differences in our study cannot be linked to defective aroma or taste attributes since all the evaluated wines actually had similar oenological characteristics, which allow them to be placed on the market within the same quality range, be it with distinct sensory properties which can be differently tasted and accepted by experts or consumers.

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