SUCCESSFUL TECHNOLOGY TRANSFER OF THE EARLY DEFOLIATION TECHNIQUE IN CV. MANDÓ, AN AUTOCHTHON VARIETY FROM SOUTH-EAST SPAIN

I. Gómez[(1)], J. Revert[(2)], M.D. Esteve[(3)], M.D. Climent[(3)] and D.S. Intrigliolo[(4)]

[1]Tresge Wine Consulting S.L., Ctra. Malilla 25-20
46026 Valencia, Spain
[2]Celler del Roure SL. Ctra. Les Alcusses, Km 2.5
46640 Moixent, Valencia, Spain
[3]Universidad Politécnica de Valencia. Dept Quimica, Camino de Vera s/n, Valencia, Spain
[4]Instituto Valenciano Investigaciones Agrarias. Centro Agricultura Sostenible. Apartado oficial 46113, Moncada, Valencia: intrigliolo_die@ivia.gva.es

ABSTRACT

In the old-world viticulture autochthonous varieties are an important inheritance because they can provide wines with authenticity and distinction. Cultivar Mandó is an almost extinguished variety from the south-east of Spain with very large and tight clusters. In addition, it is quite late-season ripening. Celler del Roure winery is using Mandó grapes for premium quality wine production. The winery commonly employs cluster thinning to reduce crop level and, at harvest, only the fully healthy clusters are picked. Indeed, around 50%of the initial crop is then not used for wine-making. The aim of this study was to asses the usefulness of early defoliation as a possible tool to reduce cluster compactness, improving fruit composition and reducing the labor costs associated with cluster thinning. With this in mind, an experiment was conducted with cv. Mandó in deficit irrigated vines trained with a divided Lyra system. Control (C), un-defoliated vines, were compared with de-foliation carried out either; just before anthesis (phenological phase H, (Def-H)), at flowering (phenological phase I, (Def-I)) or at fruit set (phenological stage J, (Def-J)). In all the defoliation treatments, leaves from the first eight nodes, including laterals, were removed. The experimental design was a complete randomized block with three replicates per treatment and 24 experimental vines per experimental plot. As an average for all defoliation treatments, fruit set, berry weight and yield were reduced by 44, 16 and 45%, respectively. Defoliation increased berry soluble solids concentration only in the Def-H treatment. On the other hand, berry acidity was only decreased in the Def-H treatment. In the ED and LD defoliation treatments, leaf pulling improved berry quality determined with a berry tasting panel. In agreement, berries from the ED and LD also had higher total phenolics, anthocyanins and tannins concentration. Results obtained were judged positively by the winery owners and defoliation, particularly at stage J, will be now more widely conducted in the vineyards planted with the Mandó variety. This is because the detrimental effects of defoliation on yield were similar to the crop reduction previously needed when cluster thinning and selection had to be carried out. The research is indeed an example of a successful transfer of a research technique under commercial situations.

KEYWORDS

Berry taste–yield–total soluble solids–phenolics

INTRODUCTION

Traditionally, leaf pulling around the cluster zone has been used as a canopy management technique with the objective to increase fruit exposure to sun-light, improving berry

composition (Jackson and Lombard 1993). This cultural practice is more often applied in cool climates or with vigorous vines where cluster micro-climate and the environmental conditions are often inadequate to ensure a proper berry ripening. With this objective in mind, traditional defoliation is often performed around veraison when it should not have major impacts on vine performance (i.e. berry set and growth). This is because, at veraison, the potential berry growth is already established and buds are already differentiated, which is important for the next season vine performance. In addition, late in the season, vines normally have enough vegetative growth and source capacity to withstand some degree of leaf removal. At that moment, the leaves removed are the oldest in a shoot, hence with lower photosynthesis activity (Poni et al. 1994).

On the other hand, ancillary studies showed that when leaves are removed early in the season (around flowering) de-foliation can detrimentally affects fruit set, fruit growth and vine performance in the next season (Coombe 1959, Candolfi-Vasconcelos and Koblet 1990).

Poni et al 2006 exploited and adapted this knowledge to develop, what is named as "early defoliation", a technique nowadays used to reduce vine crop level and cluster compactness. Considering that defoliation can be performed mechanically, the objective was to look for alternatives to reduce labor costs associated with cluster thinning.

Previous investigations have showed that early defoliation successfully improved fruit composition and reduced cluster compactness in vigorous vineyards in northern-Italy (Poni et al. 2006 and 2009). However, very little research has been done in warmer less vigorous conditions. Only recently investigations have been initiated with Tempranillo vines in Valencia (Risco et al. 2010). This research, currently in course (see paper by Risco et al in this proceedings) is showing that early leaf pulling might have an heavier impact on vine performance than what it was previously reported by Poni and co-workers.

Cultivar Mandó is an almost extinguished late-season ripening variety from the south-east of Spain with very large and tight clusters. Nowadays this variety is basically only cultivated by the winery Celler del Roure SL and it is used for premium wine production. The winery commonly employs cluster thinning to reduce crop level and, at harvest, only the fully healthy clusters are picked. Indeed, around 50%of the initial crop is then not used for wine-making.

The aim of this study was to asses the usefulness of early defoliation as a possible tool to reduce cluster compactness, improve fruit composition and reducing the labor costs associated with cluster thinning.

MATERIALS AND METHODS

Site description and experimental design. The experiment was carried out during 2009 in a *Vitis vinifera* L. (cv. Mandó) vineyard planted in 1999 on R-100 rootstock at a spacing of 1.5 by 2.8m (2381 vines/ha). The vineyard is located near Moixent (38º, 52' N; 0º, 44' W; elevation 550m), Valencia, Spain. Vines were irrigated by micro-.sprinklers and trained with a divided Lyra system in rows oriented east-west. The soil is sandy loam, and vines were deficit irrigated to replace only 40% of the grapevine potential water needs.

Defoliation treatments. The experimental design was a complete randomized with three blocks and four treatments. Each experimental unit was compromised of 24 vines. Treatments applied were:

- C: Control, un-defoliated.
- Def-H: Leaf pulling was carried out just before flowering (phenological stage H, Baggiolini 1952). All the leaves of the first eight nodes were removed, including leaves from lateral shoots.

- Def-I: Leaf pulling was carried out at flowering (phenological stage I, Baggiolini 1952). All the leaves of the first eight nodes were removed, including leaves from the lateral shoots.
- Def-J: Leaf pulling was carried out at fruit set (phenological stage J, Baggiolini 1952). All the leaves of the first eight nodes were removed, including leaves from the lateral shoots.

Flowering, fruit set, yield determinations. In each experimental vine, a cluster was harvested one week before vintage. The number of berries per cluster were counted. At harvest, the remaining clusters per vine were counted and weighted separately to obtain the total yield per vine.

Berry composition. Samples of 100 berries per experimental unit (three samples per treatment) were collected at harvest. After gentle crushing using a Thermomix (F6, 30 seconds) juice components were analyzed. Total soluble solids (ºBrix) were determined with a digital refractometer (Atago). The titratable acidity was determined with NaOH 0.1M to an end point of pH = 8.2. Acidity and pH were measured using a automatic titrator (785 DMP Titrino).

Phenolic compounds were analyzed in another three independent replicates per treatment (150g per sample) crushed with seeds (Ultraturrax, at 16000 rpm) until homogenization. Then 10 ml of ethanol (1:1 v/v) were added to 1 g of homogenate and after 1 hour of gentle agitation samples were centrifuged at 8000 *g* (P Selecta Medifriger BL-S) for 10 min a 5ºC. Later, the supernatants were frozen at -20ºC until analysis. The concentration of total polyphenols and anthocyanins was determined following procedures described by Iland et al. (2004) and the analysis of tannins done by the method of metilcellulose precipitation with the modifications proposed by Sarneckis et al. (2006). Standard calibration with (+) Catechin (Aldrich), Gallic Acid (Sigma), Oenin Chloride (Fluka) were performed.

Berry taste. Samples of around 200 berries per experimental unit (three samples per treatment) were collected at harvest. Berries from all experimental units were blind tasted by five judges, (wine makers and viticulture specialists from the winery). Descriptors used were those commonly employed by the winery and included fruit aroma, skin ripeness, berry health and dehydration. Results were reported in an arbitrary score with a range from 1 to 5, being 5 the highest score indicating better quality. Scores obtained for each descriptor were then summed together for an overall berry quality score.

Statistical analysis. Analysis of variance was performed by means of ANOVA with irrigation treatments as main factor. When the defoliation factor was statistically significant at $P<0.05$ then differences between treatments were assessed by Duncan multiple range test at $P<0.05$. Statistical analysis was performed using Statgraphics Centurion XV.

RESULTS AND DISCUSSION

Flowering, fruit set, yield. Yield was decreased by leaf pulling from a 29% as in the treatment Def-H to a 58% as in the treatment Def-J (Tab. 1). This decrease in yield was due the lower cluster weight registered in all the leaf pulling treatments. This fact was consequence of both; less berries per cluster and lower berry fresh weight (Tab. 1). Cluster compactness was also lower in all defoliated treatments (Tab. 1) indicating that leaf pulling successfully reduced cluster compactness.

Overall these results are in agreement with previous reports by Poni et al. 2006 who also showed that early defoliation decreased berry fresh weight and fruit set. However, in the present study, the detrimental impact of leaf pulling on crop performance was more severe. This was probably because the more intense leaf pulling carried out (8 leaves removed in contrast with 6 leaves as done by Poni and co-workers). On the other hand, similar research carried out with Tempranillo vines in Valencia, showed that, in the first season, early leaf-

pulling only decreased berry fresh weight but not fruit set (Risco et al. 2010). Only in the second season, Risco et al. (published in this proceedings) found a decreased in both, berry fresh weight and fruit set.

Table 1. Yield and yield components s in the different treatments. Means followed by a different letter within each column are significantly different at the P < 0.05 level

Treatment	Yield (t ha^{-1})	# Cluster vine $^{-1}$	Cluster weight (g)	# berries cluster^{-1}	Cluster Compactness	Berry weight (g)
Control	9.0a	11	327a	196a	3.7a	1.61a
Def-H	6.4b	14	192b	122b	2.9b	1.52b
Def-I	3.8c	11	137c	96c	2.3c	1.35c
Def-J	4.9ab	12	167bc	108b	2.5c	1.49b

Fruit composition. Total soluble solids concentration was only increased by leaf pulling when defoliation was carried out either; at phenological stages H or J (Tab. 2). However, the total soluble solids synthesized by the vines (i.e. concentration*yield) was in all cases detrimentally affected by leaf defoliation. This suggests that sugar synthesis was impaired by the severe defoliation carried out. On the other hand, must titratable acidity was only decreased by leaf pulling in the Def-H treatment, which also had higher pH (Tab. 2). In warm climates, in occasions, berry acidity tends to be too low. It is then important that any sort leaf-pulling treatment does not decrease must acidity.

Table 2. Technological berry parameters. Means followed by a different letter within each column are significantly different at the P < 0.05 level

Treatment	Total Soluble solids concentration (ºBrix)	Total soluble synthesis (kg vine^{-1})	Titratable acidity (g l^{-1} tartaric acid)	pH
Control	25.4b	0.92a	4.8a	3.41ab
Def-H	26.3a	0.69b	4.1b	3.52a
Def-I	25.4b	0.38c	4.7a	3.39b
Def-J	26.5a	0.53bc	4.5a	3.52a

Berry quality determined by a tasting panel was only significantly increased in the Def-H and Def-J treatments. Among the different descriptors, only the berry dehydration one was clearly affected by leaf pulling (Tab. 3).

Table 3. Berry taste results for each descriptor and for the overall berry quality. Means followed by a different letter within each column are significantly different at the P < 0.05 level

Treatment	Fruit	Skin ripeness	Berry health	Dehydration	Overall berry quality
Control	3.2	2.9	3.7	2.5b	3.1a
Def-H	3.3	3.1	3.9	3.5a	3.4b
Def-I	3.2	2.9	3.9	3.1ab	3.2ab
Def-J	3.3	2.9	3.7	3.6a	3.4b

In agreement with the berry tasting results above reported, treatments Def-H and Def-I also had higher concentration of berry total phenolics, anthocyanins and tannins (Tab. 4). These results are in agreement with results reported by Poni et al. 2009 and Risco et al. 2010 that

also showed that leaf-pulling increased berry phenolic concentration. In addition, it should be noted that Risco et al. 2010, in Tempranillo vines, also showed that defoliation carried out at fruit set had the best scores in terms of berry composition among different phenological moments of early de-foliation applications.

Similarly to what reported for the total soluble solids, the total amount of phenolic substances produced by the whole vine (i.e. the total synthesis) was not increased by de-foliation (results not shown). This is because the decrease reported in yield due to leaf pulling (Tab. 1) was more pronounced that the increase obtained in berry total phenolics, anthocyanins and tannins concentrations (Tab. 4).

Table 4. Phenological berry parameters. Means followed by a different letter within each column are significantly different at the $P < 0.05$ level

Treatment	Polyphenols (mg L^{-1} gallic ac.)	Anthocyanins (mg L^{-1} malvidin 3-glucoside)	Tanins (mg L^{-1} (+) catechin)
Control	3.30a	0.62a	4.02a
Def-H	4.13b	0.67b	5.92b
Def-I	3.19a	0.54b	4.04a
Def-J	4.01b	0.83c	4.89c

CONCLUSIONS

Leaf pulling, particularly when applied at phase J, allowed to achieve the vineyards goals, decreasing cluster compactness, improving the berry phenolics concentration without negatively affecting berry acidity. These results were then judged positively by the winery owners and defoliation, particularly at stage J, will be now more widely conducted in the vineyards planted with the Mandó variety. This is because the detrimental effects of defoliation on yield were similar to the crop reduction previously needed when cluster thinning and selection had to be carried out. The research is indeed an example of a successful transfer of a research technique under commercial situations. In order to know if this technique can be applied over years, further research is however needed to asses the mid- and long-term effects of early leaf pulling on vine performance.

ACKNOWLEDGMENTS

This research was supported by funds from Celler del Roure SL and the Spanish Ministry of Science and Innovation trough project TRACE 2009_120 and by funds from INIA-FEDER project RTA2008-0037-C04 and from project Rideco-Consolider CSD2006-0067.

BIBLIOGRAFY

Baggiolini M. 1952. Les stades repérés dans le développement annuel de la vigne et leur utilisation pratique. *Rev. Romande Agric.Vitic. Arboric*. 8: 4-6.

Candolfi-Vasconcelos M.C., Koblet W. 1990. Yield, fruit quality, bud fertility and starch reserves of the wood as a function of leaf removal in *Vitis vinifera*: Evidence of compensation and stress recovering. *Vitis* 29:199-221.

Coombe, B.G. 1959. Fruit-set development in seeded grape varieties as affected by defoliation, topping, girdling, and other treatments. *Am. J. Enol. Vitic*. 10:85-100.

Iland P., Bruer N., Edwards G., Weeks S., Wikes E. 2004. Chemical Analysis of Grapes and Wine: Techniques and concepts. Patrick Iland, Campelltown, South Australia.

Jackson, D.I., and P.B. Lombard. 1993. Environmental and management practices affecting grape composition and wine quality-A review. *Am. J. Enol. Vitic*. 44:409-430.

Poni, S., C. Intrieri, and Silvestroni, O. 1994. Interactions of leaf age, fruiting and exogenous cytokinins in Sangiovese grapevines under non-irrigated conditions. I. Gas exchange. *Am. J. Enol. Vitic*. 45:71-78.

Poni S., Casalini L., Bernizzoni F., Civardi S., Intrieri C. 2006. Effects of early defoliation on shoot photosynthesis, yield components, and grape composition. *Am. J. Enol. Vitic*. 57: 397-407.

Poni S., Bernizzoni F., Civardi S., Libelli C. 2009. Effects of pre-bloom leaf removal on growth of berry tissues and must composition in two red Vitis vinifera L. cultivars. *Aust. J. Grape Wine Res*. 15: 185-193.

Risco, D.; Yeves, A.; Pérez, D.; Intrigliolo, D.S. y Castel, J.R. .2009. Efectos del deshojado temprano sobre el cuajado, tamaño de la baya y calidad de la uva en la vid cv. Tempranillo en Requena. *Acta de Horticultura*: 54: 870-873. (In Spanish).

Sarneckis C.J., Dambergs R.G., Jones P., Mercurio M., Herderich M.J., Smith P.A. 2006. Quantification of condensed tannins by precipitation with methyl cellulose: development and validation of an optimised tool for grape and wine analysis. *Aust. J Grape Wine Res*. 12; 39-49.