THE CHALLENGE OF IMPROVING OENOLOGICAL QUALITY IN FAVORABLE CONDITIONS FOR PRODUCTIVITY

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Abstract:

Context and purpose of the study

Marselan (Cabernet-Sauvignon x Grenache), has been planted for more than 20 years now in Uruguay. Due to its good agronomic and oenological aptitudes under uruguayan conditions, it is currently the red variety with highest plantation rate. The objective of the study was to identify management practices, aimed at improving quality in highly productive vineyards, different fruit/leaf regulation methods were tested in southern Uruguay.

Material and methods

The experiment was carried out during 2020 and 2021 seasons, on a non-irrigated Marselan/110R vineyard, planted in 2002 in Lyra (3.0 x 1.25 m - row x plant spacing) in the Cerrillos region, Canelones, Southern Uruguay. Plants were pruned to double guyot (28 buds per plant). The interrow was maintained with permanent cover crops. Five treatments were applied in a complete randomized block design, with three repetitions. Pre-flowering defoliation (PFD) at stage 17 (Coombe, 1995), defoliation at fruit set (DC) at stage 29 (Combe, 1995), the same treatments in combination with cluster thinning at veraison (PFD+R and DC+R) and an untreated control (T). Plots comprised 10 consecutive plants.

Results

Control treatment was associated with higher yield, Ravaz index and lower soluble solids and anthocyanins concentration (Table 1 y 2). Related to a lower bunch exposure (PAR % at fruit zone) bunch rot incidence was also significantly higher than in defoliation treatments (Table 1). Total leaf area was not significantly affected by DC or PFD treatment. Leaf area in PFD treatment, was recomposed from the greater development of lateral shoots from basal buds. As a result, PAR % at the fruit zone was significantly higher in DC compared to PFD. PFD treatment significantly reduce fruit yields the first season, however yield was comparable with the treatments without cluster thinning the second season. The high number of clusters in PFD treatment the second season compared to T and DC (no cluster thinning treatments) suggest an improved conditions for cluster induction. Probably the reduction of crop early in season may also affect the reserves accumulation. Although PFD+R and DC-R increased the leaf/fruit ratio, mostly explained by cluster thinning (R), total vegetative growth (pruning weight) was also increased. In terms of grape composition, defoliation treatments in combination with crop adjustment, produced berries with higher concentration of all secondary metabolites associated with oenological quality. The impact of PFD and DC on fruit composition and wine anthocyanins concentration was minor compared to it observed associated to cluster thinning (R). PFD treatment significantly reduce cluster compactness and bunch rot. This is undoubtedly a relevant effect for humid climate viticulture. In our experiment all treatments were harvested at the same day, however the opportunity to reach fruit full maturation even under favorable conditions for bunch rot development, may be considered the main advantage of this practice compared to a later leaf removal (DC).

Keywords: Grapevine, Pre flowering defoliation, Leaf to fruit ratio, bunch rot, Marselan.

1. Introduction

Marselan (Cabernet-Sauvignon x Grenache Noir) has been in Uruguayan vineyard for more than 20 years and due its agronomic and enological potential, supported by several studies (Echeveria et al., 2009; Cagnoli and Muñoz, 2010), is currently the grape variety with highest implantation rate. Due to its high potential yield It is needed to progress in the regulation of the vegetative/reproductive balance (Kliewer and Dokoozlian, 2005, Otero et al., 2010). In this context, it is important to adjust traditional practices such as cluster thinning (Yuste et al., 1997; Matus et al., 2006) and leaf removal (Petrie et al., 2003) to achieve different productive objectives.
Pre-flowering defoliation (PFD) reduces carbon availability, which affects fruit set rate and as a consequence, reduces plant yield (Poni et al., 2005, 2006, Tardáguila et al., 2010, Diago 2010, Sabbatini and Howell 2010, Verdenal et al., 2017). This practice is usually associated with an improvement in the oenological quality of the must and also, allows a better control of bunch rot (Poni et al., 2006) particularly relevant for humid climate conditions (Petrie et al., 2003, Arrillaga et al., 2021). The objective of the study was to identify management practices aimed to improving vine balance and so grape composition in overcropped vineyards. Different fruit/leaf regulation methods were tested in southern Uruguay.

2. Material and methods

Plant material, experimental design and treatments. The experiment was carried out during 2020 and 2021 seasons, on a non-irrigated Marselan/110R commercial vineyard, in the Cerrillos region, Canelones, Southern Uruguay, planted in 2002 in Lyra. The vines were spaced 1.25 m x 3.0 m, in N-S orientated rows. Plants were pruned to double guyot (28 buds per plant). The interrow was maintained with permanent cover crops. The soil at this site is typical Vertic Argiudoll with a slope of less than 3 % and 120 mm of water holding capacity.

Five treatments were applied in a complete randomized block design, with three repetitions. Pre-flowering defoliation (PFD), defoliation at fruit set (DC), PFD and DC combined with cluster thinning at veraison (PFD+R and DC+R) and an untreated control (T). Plots comprised 10 consecutive plants. PFD was carried out by hand: 6-8 leaves were removed from the base to the top of the shoot, and the secondary shoot was also removed when present, at stage 17 (Coombe, 1995). DC comprising the removal of 4 basal leaves at berries pepper size, stage 29 (Combe, 1995).

Weather data, were obtained from the INIA Gras platform (http://www.inia.uy/gras/) from INIA Las Brujas meteorological station located 11 km from the experimental site.

Plant measurements and microclimate evaluation. Photosynthetically active radiation (PAR), was recorded using HOBO S-LIA-M003 sensors connected to a HOBO micro station ®H21-USB. The records were taken hourly from pre-flowering to harvest. Potential exposed leaf area (Leaf area) was assessed at veraison according to Carbonneau (1995). The percentage of exposed clusters and inner leaves was determined using the Point Quadrat method (Smart and Robinson, 1991). In winter, the pruning weight was determined for all plants and the Ravaz index (RI) calculated. Yield components, cluster compactness and cluster rot incidence were evaluated at harvest. The grape composition was determined following official methods (OIV, 2009). To monitor vine water status in the treatments, midday stem water potential (SWP) was periodically measured (~bi-weekly) from veraison to harvest between 13:00 and 15:00 h using a leaf pressure chamber (Soil Moisture Equipment Corp., Santa Barbara, CA) on two leaves per treatment replication (Myburgh, 2010). *Statistical analyses*: ANOVA was carried out for the comparison of the treatments effect. The mean comparison was carried out with an Tukey test at 5 % significance. Statistical analyses were carried out using the InfoStat 2018® software.

Winemaking and analysis. Approximately 10 kg of fruit per treatment replicate was used for winemaking. Sulfur dioxide was added at a rate of 50 mg/kg, and the must was inoculated with *Saccharomyces cerevisiae* ex *bayanus* Natuferm 804; Oenobiotech, Paris, France at 20g/hL. After maceration was completed, wines were pressed and placed into sterile 5-L glass containers. Anthocyanins in wines was measured 9 months after alcoholic fermentation according to Riberau-Gayon and Stonestreet, 1965.

3. Results and discussion

The climatic conditions (Fig. 1) of the 2019-2020 season (year 1) were drier than those of the 2020-2021 season (year 2). A significant year effect was detected from most parameters evaluated. In general, year 1 had no bunch rot, less vegetative development (leaf area and pruning weight), smaller berry size and lower yields than year 2.
Control treatment was associated with higher yield, Ravaz index and lower soluble solids and anthocyanins concentration (Table 1 and 2). Related to a lower bunch exposure (PAR % at fruit zone) bunch rot incidence was also significantly higher than in defoliation treatments (Table 1). Total leaf area was not significantly affected by DC or PFD treatment. Leaf area in PFD treatment, was recomposed from the greater development of lateral shoots from basal buds. As a result, PAR % at the fruit zone was significantly higher in DC compared to PFD. After the first season pruning weight increased in bunch thinning treatments and/or lower yields. PFD treatment significantly reduce fruit yields the first season; however, yield was comparable with treatments without cluster thinning the second season. The high number of clusters in PFD treatment the second season compared to Control and DC (no cluster thinning treatments) suggest an improved conditions for cluster induction. Probably the reduction of crop early in season may also affect the reserves accumulation and available photosynthates. The evolution of leaf water potential in the fifteen days prior to ripening in year 1 (not shown data) was in the high stress range, between -1.26 MPa to -1.39 MPa. This situation would have negatively affected the carbon balance during DC and T treatments the first season.
Although PFD+R and DC-R increased the leaf/fruit ratio, mostly explained by cluster thinning (R), total vegetative growth (pruning weight) was also increased.

In terms of grape composition, treatments with lower yields (PFD+ R; DC+R and PFD) had higher soluble solids concentration and secondary metabolites associated with oenological quality. A significant correlation was detected both seasons between RI and soluble solids in berries and anthocyanin concentration in wine (R^2 = 0.65 and 0.39 for soluble solids, and R^2 = 0.71 and 0.52 for anthocyanins; 2020 and 2021 harvest respectively). The impact of PFD and DC on fruit composition and wine anthocyanins concentration was minor compared to it observed associated to cluster thinning (R). Defoliation treatments but itself tends also to increase anthocyanins concentration (P=0.1). PFD treatments reduced fruit set, producing smaller and more lax bunches, but even it could be expected no differences in berry weight were in general detected. Berry weight differences were detected just between PFD and DC treatment, the second season.

4. Conclusions

The combination of defoliation and cluster thinning produce grapes and wines with high solids soluble and anthocyanins concentration. The effect was closely related with crop load. PFD treatment significantly reduce cluster compactness and bunch rot. This is undoubtedly a relevant effect for humid climate viticulture. In our experiment all treatments were harvested at the same day, however the opportunity to reach fruit full maturation even under favorable conditions for bunch rot development, may be considered the main advantage of this practice compared to a later leaf removal (DC).

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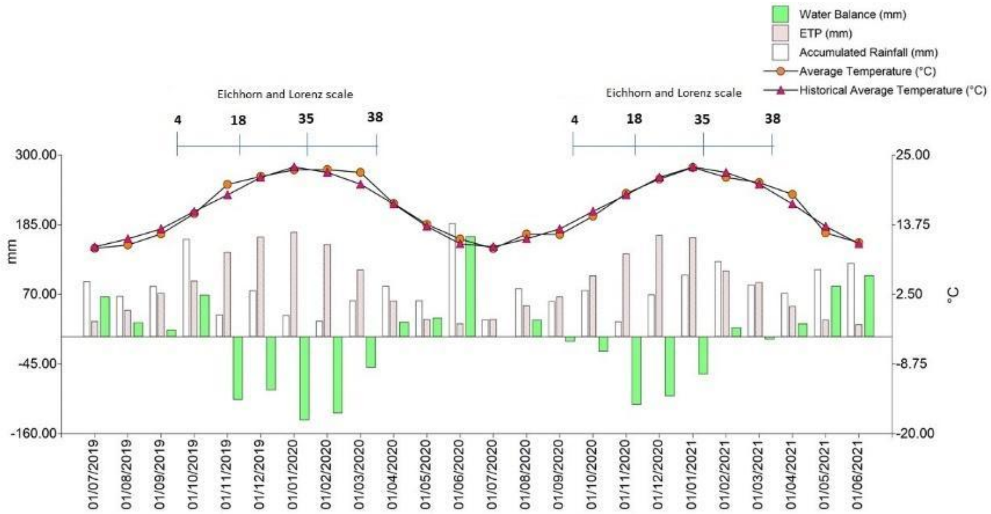

Figure 1: Evolution of decadic temperatures, rainfall, evapotranspiration (ETP) and water balance (accumulated rainfall less ETP), for the 2019-2020 and 2020-2021 harvests. Weather variables were recorded in meteorological station Las Brujas (-34.6700 /- 56.3300) of the National Institute for Agricultural Research. (Stage 4 = budburst and stage 38 = harvest)

Table 1: Effect of the treatments on vegetative and yield variables, by year. Each value is the average of three replicates.

Year	Treatment	Leaf area/ vine	Pruning weight/ vine	Cluster/ vine	Cluster exposure	Yield/ vine	Sick weight/ vine	Cluster weight	Cluster compactness	Berry weight
		(m^2)	(kg)	(n°)	(%)	(kg)	(kg)	(g)	(Berries/ cm rachis)	(g)
2020	T	3.13	0.70 a	60 b	8 a	10.33 c	0	172 b	8.7 b	1.23
	DC	2.94	0.82 ab	65 b	82 b	11.65 d	0	178 b	6.5 a	1.26
	DC+R	2.77	0.91 abc	29 a	95 c	4.62 a	0	162 b	6.1 a	1.20
	PFD	2.86	0.99 bc	62 b	91 c	8.61 b	0	140 a	5.6 a	1.23
	PFD+R	2.80	1.13 c	30 a	97 c	4.21 a	0	139 a	5.6 a	1.24
2021	T	3.29 b	0.88 a	72 b	13 a	12.29 b	1.41 b	171 b	8.8 bc	1.36 ab
	DC	2.94 a	0.97 ab	76 bc	81 b	12.51 b	0.86 ab	165 ab	9.7 c	1.33 ab
	DC+R	2.75 a	1.25 c	39 a	93 b	6.55 a	0.76 ab	167 ab	8.1 bc	1.31 a
	PFD	2.72 a	1.16 bc	87 c	83 b	12.47 b	0.77 ab	144 a	6.6 ab	1.39 b
	PFD+R	3.02ab	1.55 d	37 a	93 b	5.59 a	0.49 a	150 ab	5.6 a	1.34 ab

Values followed by different letters are significantly different according to the Tukey test ($p<= 0.05$)
Treatments: Control (T); defoliation at fruit set (DC); defoliation at fruit set and cluster thinning (DC+R); pre-flowering defoliation (PFD); pre-flowering defoliation and cluster thinning (PFD+R)

Table 2: Effect of the treatments on berry composition variables at harvest, anthocyanins in wine, stem water potential and physiological index, by year. Except SWP, each value is the average of three replicates. SWP data corresponds to the average during maturation.

Year	Treatment	Total soluble solids	pH	Total acidity	Anthocyanins in wine	RI	Leaf area /Yield	SWP
		(Brix°)		(g/L)	(mg/L)	(kg/kg)	(m^2/kg)	(MPa)
2020	T	22.3 a	3.12 a	4.6	241 a	15.1 c	0.30 a	-1.09
	DC	23.0 a	3.16 ab	4.8	288 ab	14.5 c	0.25 a	sd
	DC+R	24.6 b	3.19 ab	5.1	423 c	5.1 a	0.60 b	-1.09
	PFD	24.3 b	3.16 ab	4.8	318 ab	8.7 b	0.33 a	-1.05
	PFD+R	24.9 b	3.23 b	4.5	374 bc	3.9 a	0.67 b	sd
2021	T	21.4 ab	3.15	3.8 a	257 a	14.2 c	0.27 a	-0.9
	DC	21.1 a	3.13	3.9 a	490 ab	12.9 c	0.24 a	sd
	DC+R	21.9 ab	3.21	4.1 ab	614 b	5.3 a	0.42 b	-0.87
	PFD	21.8 ab	3.16	4.0 ab	383 ab	10.8 b	0.22 a	-0.83
	PFD+R	22.6 b	3.17	4.3 b	650 b	3.6 a	0.54 c	sd

Values followed by different letters are significantly different according to the Tukey test ($p <= 0.05$)
Treatments: Control (T); defoliation at fruit set (DC); defoliation at fruit set and cluster thinning (DC+R); pre-flowering defoliation (PFD); pre-flowering defoliation and cluster thinning (PFD+R)