Combining effect of leaf removal and natural shading on grape ripening under two irrigation strategies in Manto negro (Vitis vinifera L.)

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Abstract

The increasingly frequent heat waves during grape ripening pose challenges for high quality wine grape production in warm areas, especially when defoliation practices are applied. A field experiment was carried out during 2021 using Manto negro wine grapes. Two irrigation treatments were imposed based on the frequency and amount of water doses in a four-block experimental vineyard at Bodega Ribas (Mallorca). Three light exposure treatments were randomly applied in each irrigation plot: control, defoliation at pea size, and defoliation at pea size and shaded clusters after berry softening. Midday leaf water potential was measured weekly. Bunch temperature and radiation were measured continuously during grape ripening. The effect of irrigation and cluster light exposure on berry weight, TSS, TA, malic acid, tartaric acid, K+, and pH were analysed at 5 moments along grape ripening. The natural shading technique decreased the maximum bunch temperature up to 12 °C respect to the exposed bunches in both irrigation strategies. The combination of defoliation and shading techniques after softening decreased TSS at harvest and affected most of the quality parameters during the last stages of ripening, showing an interesting technique to delay ripening in warm viticulture areas.

Introduction

Climate change is causing an advance on fruit ripening and plant phenology mainly due to higher temperatures. The increasingly frequent and intense heat waves during the ripening period contribute to an imbalance in berry ripening that results in unbalanced musts and wines (Sadras & Moran, 2012; Venios et al., 2020). A clear effect of advancing ripening due to higher temperatures is the increased accumulation of sugar, which translates into higher alcohol content in wines (Duchêne & Schneider 2005, Alston et al. 2011, Neethling et al. 2012). Also, high temperatures accelerate the decrease in grape acidity, mainly due to a more rapid degradation of malic acid (Lakso & Kliewer, 1975; Spayd et al., 2002; C. Sweetman et al., 2014), decreasing the total titratable acidity of the must (Kliewer, 1965) and affecting the balance between sugars and acids. The berry accumulates malic acid largely through metabolism of sugars transported to the berry (Sweetman et al., 2009), but also potentially through photosynthesis of the fruit that partly compensates for respiratory losses (Hale & Weaver, 1962; Hernández-Montes et al., 2021). The regulation of malic acid metabolism is known to differ between berries at pre-veraison stages and those at post-veraison ripening stages (Sweetman et al., 2014).
Grapes exposed to solar radiation reach temperatures over the optimum for berry development and maturation. This problem is even greater when defoliation is applied to improve the control of diseases in the bunch zone, increasing the exposure of bunches to sunlight and aggravating the consequences of excess radiation and temperature on grape quality.
Therefore, the development of irrigation and canopy management techniques is of great importance in order to maximize yield and grape quality until the last stages of grape ripening. Partial solar radiation exclusion with shade nets has been proved as an useful technique to avoid overexposure to sun and reduce bunch temperature (Martínez-Lüscher et al., 2017). However, shade nets have an installation cost and may interfere with several practices in vineyards, making it difficult to implement in many winegrowing areas. In order to investigate

cheaper shading alternatives, and their interaction with irrigation, the aim of this study was to investigate the effect of different irrigation amounts and different light exposure treatments on grape ripening.

Materials and methods

Plant material and treatments

This study was carried out in a commercial vineyard of Bodegas Ribas (Consell, Mallorca, Spain) during 2021 using Manto negro cultivar (*Vitis vinifera* L.). Vines were planted in 2015 in rows (distance between rows was 2.4 m and between plants 1 m) and grafted onto rootstock 110 Richter. Vines were trained to simple cordon and spur pruned with an average of 12 buds per vine.
A randomize 4-block design was used in the experiment. Each block had two irrigation treatments: high frequency (HF), irrigated to keep stem water potential values above -0.9 MPa; and low frequency (LF), irrigated to keep stem water potential values above -1.3 MPa. Three light exposure treatments were randomized applied along the rows of each block, and they included: control (C), defoliation at pea-size (D), and defoliation at pea-size followed by shading after berry softening (D+S). The vines from D and D+S treatments were defoliated only on the east side of the canopy, from the base of the shoot until the level of the second cluster. Shoots from the shaded treatment vines were repositioned by simulating a "curtain" on the east side of the canopy.
Weekly, irrigation doses were calculated from the ETo registered by a meteorological station. The crop coefficient for the HF was fixed at 30%. Vines were drip-irrigated using one drip emitter per plant (3.3 L/h).

Stem water potential measurements and soil water content

Weekly, plant water status of HF and LF vines was monitored by measuring midday stem water potential. using a Scholander pressure chamber. Additionally, apparent electrical conductivity was measured between rows in order to quantify the soil water content in all replicates using the EM38 device (Geonics Ltd, Ontario, Canada).

Temperature and light intensity at cluster level

Light and temperature sensors (HOBO Pendant® model UA-002-64, Bourne, MA) were installed at the cluster level to quantify the differences in temperature and light intensity among treatments.

Berry sampling, physical and chemical properties along grape ripening

Berry samples (100 berries) were collected in plastic bags at five moments during berry ripening. After sampling, plastic bags were moved to the laboratory in a portable cooler, then samples were weighted and crashed inside the plastic bags. The effect of irrigation and cluster light exposure on berry weight, TSS, TA, malic acid, tartaric acid, K+, and pH were analyzed.

Statistical analysis

Data were processed using ANOVA procedures, and means were separated by Tukey's test using JMP 14 (SAS Institute Inc., Cary, NC, USA).

Results and discussion

Maximum temperatures and light intensity dramatically increased in the defoliated clusters, respect to the non-defoliated (control) clusters. During a heat wave, shading the east side of the canopy after softening reduced the maximum bunch temperatures by up to 12 ºC compared to the defoliated vines (Figure 1). This reduction occurred in both irrigation treatments and throughout the day, with the highest temperature reduction at midday. During the heat waves of summer 2021, shaded bunches recorded similar temperature than control ones.
Irrigation treatments were stablished by measuring stem water potential weekly. The effect of irrigation and canopy management on grape quality at harvest is reported in Table 1. Berry weight was affected by irrigation and canopy management. As expected, irrigated vines at harvest had the highest berry weight. Defoliated vines had lower berry weight than control vines in HF and LF conditions. However, the effect of canopy management on berry weight was dependent on the irrigation treatment, since a significant interaction of both effects was recorded in this parameter (Table 1). Total soluble

solids, malic acid concentration, and tartaric acid concentration were affected by the canopy management treatments. pH and TA were affected by the irrigation treatment, but potassium concentration was not influenced by any of the treatments.

Conclusion

The "natural shading" technique reduced bunch temperature respect to the defoliated vines on the hottest days of the summer, keeping berry weight values similar to those of the control vines. Defoliating followed by natural shading after berry softening increased the concentration of malic acid respect to defoliated vines under moderate deficit irrigation conditions. Tartaric concentration increased in defoliated vines respect to control.

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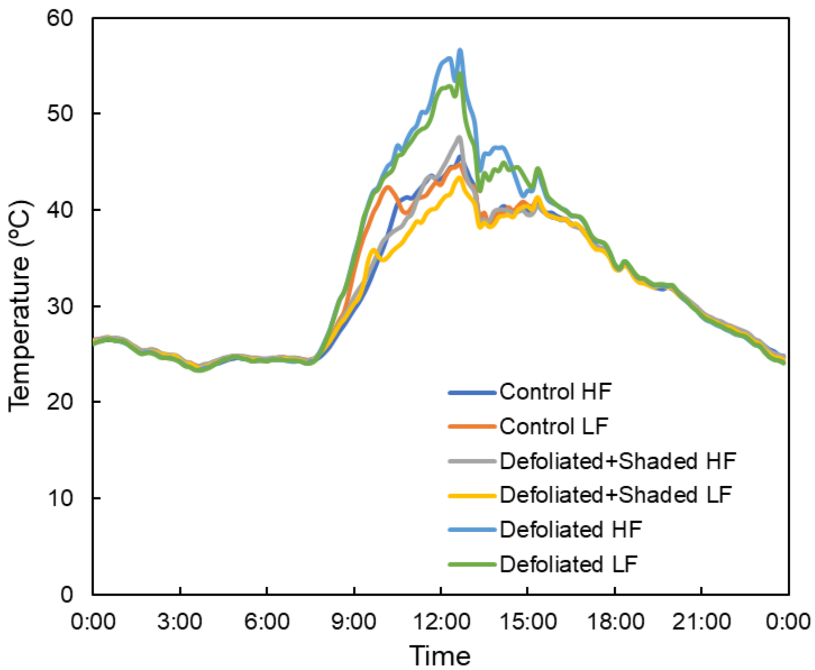

Figure 1. Maximum bunch temperature recorded in the different treatments during a heat wave of 12th of August 2021.

Table 1. Berry weight and must composition of plants untreated (C), defoliated (D) and defoliated and shaded (D+S).

Irrigation treatment	Canopy treatment	Berry weight (g)	Total soluble solids (ºBrix)	pH	TA (g/L)	Malic acid (g/L)	Tartaric acid (g/L)	Potassium (mg/L)
High frequency	C	2.72	26.18	4.06	2.96	1.675	4.95	2516
	D	2.40	25.55	4.01	3.21	1.36	5.32	2546
	D+S	2.70	25.18	4.02	3.13	1.56	4.83	2402
Low frequency	C	2.46	24.73	3.97	3.04	1.31	4.95	2340
	D	2.45	25.95	4.00	2.98	1.18	5.11	2436
	D+S	2.64	25.18	3.97	2.89	1.29	4.95	2336
Significance of effects	Irrigation	**	ns	**	**	***	ns	ns
	Canopy	***	**	ns	ns	**	***	ns
	I x C	**	ns	ns	**	ns	**	ns

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