Extreme canopy management for vineyard adaptation to climate change: is it a good idea?

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Abstract

Climate change constitutes an enormous challenge for humankind and for all human activities, viticulture not being an exception. Long-term strategic changes are probably needed the most, but growers also need to deal with short-term changes: summers that are getting progressively warmer, earlier harvest dates and higher pH in musts and wines. In the last 10-15 years, a relevant corpus of research is being developed worldwide in order to evaluate to which extent extreme canopy management operations, aimed at reducing leaf area and, thus, limiting the source to sink ratio, could be useful to delay ripening. Although extreme canopy management can result in relevant delays in harvest dates, longer term studies, as well as detailed analysis of their implications on carbohydrate reserves, bud fertility and future yield are desirable before these practices can be recommended.

Introduction

Climate change on a global scale is undeniable, as is evident from the increase in temperature in the atmosphere and oceans, the decrease in snow and ice cover, and the rise in sea level that have occurred in the past decades. In viticulture, one of the most evident impacts of rising temperatures is an advanced phenology, leading to earlier budburst, flowering and harvest dates, to increased sugar concentration and pH, and to uncoupled sugar and phenolic ripening processes that may result in unbalanced wines (Bonada et al., 2015; Droulia & Charalampopoulos, 2021; Neethling et al., 2012).

In order to adapt to this unprecedented challenge at a global scale, growers need to make decisions at several time-scales. Since decision-making processes in viticulture have a multifaceted and dynamic nature (Coulon-Leroy et al., 2012), growers have, at the same time, to revise and adapt their annual practices to the new conditions, and they to consider longer term scenarios for the establishment of new vineyards (Neethling et al., 2017).

In the shorter term, canopy management operations constitute a very attractive tool for growers and researchers to modulate grapevine behaviour, as they allow a very effective and rapid change in crucial aspects such as microclimatic conditions and carbohydrate balance. As a consequence, in the last 10-15 years, there has been a proliferation of research works exploring how canopy management operations could contribute to gain adaptation of currently established vineyards to global warming promoting a delayed ripening and, therefore, a later harvest. In a recently published comprehensive work, Gutiérrez-Gamboa et al. (2021) reviewed some of these practices, compiling, showing that severe shoot trimming, leaf removal, late winter pruning and forced regrowth may significantly delay grapevine ripening.

In order to make them effective, those management practices are frequently applied at a severe or even extreme intensity, which, a priori, could be also causing some imbalance in the plants for seasons to come and compromise vineyard productivity in the mid- and long-terms. The aim of this work is to revisit some of the research performed to date to critically analyse if we have a sound background allowing the implementation of these practices in a realistic context.

Canopy management to limit source to sink ratio

Growers and viticulturists have classically considered that there is an optimum range for leaf to fruit ratio that guarantees that, provided no other major limiting factors arise, grapes will ripen properly, and that below this

range ripening process will be undesirably slowed down (Gutiérrez-Gamboa et al., 2021; Santesteban & Royo, 2006). However, in the current conditions, with longer growing seasons, this slowing down could be beneficial as a tool to delay ripening and to obtain later harvests. Based on this hypothesis, severe trimming and severe defoliation have been studied as source-limiting tools. In any case, it is necessary to analyse the implications that these operations taking into account their carry-over effects on bud-fertility and plant reserves since, as outlined in Lopes et al. (2020), undesired yield reduction may appear associated.

Table 1 compiles some experiments that have been performed with grape varieties at several wine regions worldwide aiming at delaying harvest limiting source to sink ratios using either shoot severe trimming or defoliation. The list of works presented does not constitute a comprehensive collection systematically obtained, provided the space and reference no. limits, but can be considered to be representative of current research. According to the analysis done, relatively little relevance is given to mid-term effects of this practices and to their carry-over effects. On the one side, the longest experiments included have considered three seasons, i.e.; the carry-over effect is analysed only in two seasons, and even more, some of the research published presents data from a single season, not taking into account the implications for next season.

Despite the object of this type of research is source (carbohydrate) limitation, most researchers (the signing author included in this group) are not paying much attention to reserve accumulation. However, when measured, these practices are observed to affect them significantly. Thus, Lu et al. (2022) observed an average decrease of 12% in cane sugars and 9% in cane starch in defoliated plants, whereas Valentini et al. (2019) observed 29 % decrease in cane starch after three years. This trend, at a longer term, could result in relevant yield reductions, incomplete wood ripening and increased sensibility to diseases and frost events.

Table 1. Characteristics of some experiments where limiting source to sink ratio has been used to delay ripening

				Delay in	TSS	Studied carry-over effects		
	Ref†.	Yrs of study	Moment(s)	harvest (days)	reduction (ºBrix)	Reserves	Accum.. effect	other
Severe trimming	1	1	After veraison	0		no	no	
	2	1	Full bloom		1,9	no	no	
	3	3	Before veraison	6		no	no	
	4	3	Full veraison		1,4	yes	yes	
	5	2	Early veraison		1	no	no	
			Full veraison		1			
			After veraison		2			
Leaf removal	6	2	After veraison	5	1	no	no	¤
	7	1	After veraison	0		no	no	
	8	3	Early veraison	6,6		yes	yes	
			Late veraison	4				
	4	3	Before bloom		-1,6	no	no	¤
			Fruit set		-1,7			

†[1]O'brien et al., 2021 [2]Ahumada et al., 2021 [3]Abad et al., 2019; Santesteban et al., 2017 [4]Valentini et al., 2019 [5]Caccavello et al., 2019 [6]Buesa et al., 2019 [7]O'brien et al., 2021 [8]Lu et al., 2022 [9] Moreno et al., 2021; Risco et al., 2014, TSS: total soluble solids. ¤ carry-over effect evaluated measuring bud fruitfulness one year after the experiment was finished

Additionally, it is necessary to keep in mind that this kind of agronomic practices imply such deep changes in plant balance that it is complicated to anticipate if the allegedly positive effects of delaying ripening will result in better wines. For instance, Caccavello et al. (2019) found negative impacts on the wine sensory score in the most limiting source to sink conditions. Similarly, Ahumada et al. (2021) found that the wines from the most severely trimmed vines had less phenolic compounds and were found to present less aromatic complexity.

Conclusion

Although extreme canopy management can result in changes in grapevine carbohydrate balance that can lead to relevant delays in harvest dates, their practical implications need to be evaluated before considering them a

suitable tool for short-term adaptation to climate change. In this regard, longer term studies, as well as detailed analysis of their implications on carbohydrate reserves and future yield are desirable.

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