CARRY OVER EFFECT OF SHOOT TRIMMING AND DEFICIT IRRIGATION ON FRUIT YIELD AND BERRY TOTAL SOLUBLE SOLIDS

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Abstract:

Context and purpose of the study – The increase in air temperature that is occurring in many important wine-growing areas around the world is resulting in the decoupling between the phenolic and the technological maturity of grapevine berries. This new ripening pattern leads to the production of light-bodied high alcoholic wines, but this is in countertendency with the increasing consumers' demand for wines with low-to-mid alcohol concentrations. The oenological techniques proposed to reduce wine alcohol content are often very expensive and lead to detrimental effects on wine quality. Many viticultural practices have been proposed to slow down sugar accumulation the berry. One possible strategy that was previously found to be suitable for Aglianico grapevine is post-veraison shoot trimming. The aim of this work was to assess the carry over effects on the following year of shoot trimming and vine water status on yield and total soluble solids because the expected reduction in vine fertility could lead to a reduction in the effectiveness of shoot trimming.

Material and methods – The trial was carried out over four years (from 2017 to 2020) in a commercial vineyard located in Mirabella Eclano (Avellino, Italy). Vines were 13-year-old Aglianico grapevines (*Vitis vinifera* L.) grafted onto K5BB, spaced 2.5 × 1.0 m, trained to a bilateral spur cordon with a N-S row orientation. The experimental design was a randomized complete block design with nine treatments and four blocks; The treatments resulted from the combination of three levels of shoot trimming with three different irrigation strategies applied when the total soluble solids (TSS) were 12 °Brix. Shoot trimming treatments consisted in the removal of 30% and 60% of leaf area (respectively T30 and T60) and a untrimmed control (T0), whereas irrigation treatments replaced 0%, 50% or 100% of Etc (I0, I50, and I100, respectively). The harvest was performed when all the treatments reached phenolic maturity and yield and berry composition were measured.

Results – The results showed how severe shoot trimming can lead to a reduction in vine yield in the following years. This effect was manifested starting from the second year of the trial in rainfed vines exposed to severe trimmed, whereas this effect appeared later in irrigated and severely trimmed vines (3rd year of experiment). We found a negative relationship between yield and the intensity of water stress in the previous year, but this relationship is affected by the intensity of shoot trimming applied. However, yield reduction did not cause an increase in TSS as compensating effect in T60 vines. Severe shoot trimming reduced TSS content each year but the effect was found to be greater for dryer years. Mild shoot trimming conversely increased TSS in berry juice in particular during mild seasons.

Keywords: Aglianico, canopy management, climate change, water stress, Southern Italy.

1. Introduction

In the last decades, a gradual increase in air temperature is occurring (IPCC, 2021) and this is endangering many crops including grapevine (Jones et al., 2005). One of the consequences is that grapevine cultivation is migrating toward higher latitudes and altitudes (Allam et al., 2020; Fraga et al., 2013, 2012). One of the most studied effects of climate change on grape composition is the faster accumulation in total soluble solids (TSS) compared to phenolics (Bonada et al., 2013; Sadras and Moran, 2012; Sadras and Petrie, 2011). This condition, that is becoming increasingly common in warm viticultural regions, is often referred to as decoupling between the phenolic and the technological maturity and leads to the production of light bodied wines with high alcohol concentration. This is not in line with the increasing consumer's demand for low-alcohol wines (Saliba et al., 2013). Many strategies have been proposed to reduce sugar in the must during winemaking such as partial dealcoholization, but these techniques are usually very expensive and highly detrimental to wine quality (Diban et al., 2008; Varavuth et al., 2009). One other possibility is to use different canopy management techniques to reduce TSS accumulation in the berries (Palliotti et al., 2014). Late shoot trimming was previously found to be a suitable strategy to reduce TSS in 'Aglianico' grapevines (Caccavello et al., 2017, 2019), but its effectiveness was found to vary depending on the vintage and to decrease when applied in consecutive growing seasons (Valentini et al., 2018). The aim of this 4-year study was to assess the carry over effects of shoot trimming and vine water status on fruit yield and berry total soluble solids at harvest.

2. Material and methods

Plant material and growing conditions

Plant materials and experimental site – The trial was carried out over four growing seasons (2017-2020) in a commercial vineyard located in Mirabella Eclano (Avellino, Italy). The vines were 13-year old 'Aglianico' grapevines (*Vitis vinifera* L.) grafted onto K5BB (*Vitis berlandieri* × *V. riparia*). The vines were spaced 2.5 × 1.0 m and trained to a double spur cordon with N-S row orientation. The vines were trained to a bilateral spur cordon bearing 4 spurs per cordon with 2 buds each (16 buds/vine). The soil was a sandy clay loam with 12% slope.

Experimental treatments – The experimental design was a randomized complete block design with nine treatments and four blocks; the treatments were generated by the combination of three level of shoot trimming with three different irrigation strategies applied when the total soluble solids (TSS) reached 12 °Brix. Shoot trimming treatments consisted in the removal of 30% and 60% of leaf area (respectively T30 and T60) and a untrimmed control (T0), whereas irrigation treatments replaced 0, 43, and 21 mm corresponding to 0%, 50% or 100% of Etc (I0, I50, and I100, respectively).

Plant measurements and harvest – Midday stem water potential (Ψs) was measured with a Scholander-type pressure chamber (3005F01, Soil moisture equipment corp., Santa Barbara, CA, USA) in different dates (in 2017: DOY 221, 244, 249, 265 and in 2018: DOY 208, 243, 262, 269 and in 2019: DOY 239, 249, 273, 290 and in 2020: DOY 240, 250 and 291) on non transpiring leaves (leaves included in opaque aluminum foil bag for at least one hour prior to the measurements). At fruit harvest, that was carried out when all the treatments reached phenolic maturity, fruit yield and its components (number of bunches per vine, average bunch weight) were measured on 6 vine per block. A sub sample of 100 berries per block was used to determine TSS, titratable acidity (TA), and pH of berry juice at harvest (pH and TA data not shown).

Meteorological data – Air temperature, relative humidity, solar radiation, rainfall, wind speed, and wind direction were measured hourly in a weather station located close to the experimental site. These data were used to calculate ETo according to the Penman–Monteith equation.

Statistical analysis - Three-way ANOVA was used to study the significance of the effects of year (Y), shoot trimming intensity (T), irrigation strategy (I) and their interactions on fruit yield, bunch weight, number of bunches per vine TSS, pH and TA. Duncan's test ($p \leq 0.05$) was used for mean separation. All analyses were performed with a statistical software package SPSS (IBM, Chicago, IL, USA).

3. Results and discussion

3.1. *Weather data*

Average growing season temperature ranged between 19.2 and 19.7 °C (Table1) and, thus, the growing area could be classified as 'hot' according to Jones et al. (2010). The most variable climatic parameter among the four years was the dryness index, that takes in account monthly evapotranspiration and rainfall to classify the climate according to aridity (Conceição et al., 2016). According to this index, 2017 was 'very dry', 2018 'sub humid', and 2019 and 2020 'moderately dry'.

3.2. Yield components and grape composition

All yield components were influenced both by shoot trimming (T) and year (Y), conversely irrigation did not influence any of the yield components. Total vine yield was affected significantly by the T×Y and T×I×Y interactions as well, whereas the number of bunches per vine was influeced by I×Y and T×I×Y interactions (Table 2). The year effect suggested a strong influence of previous year rainfall on the yield in the following year. This carry over effect was previously highlighted by Guilpart et al. (2014).
Similarly to previous findings, severe shoot trimming reduced fruit yield during the following year mainly due to intense carbon limitations (Filippetti et al., 2015), the carbon starvation affected yield by reducing both the number of bunches per vine and bunch weight. Interestingly, this effect was not found in T30 plants suggesting that carbon limitation for this treatment was not enough strong to induce a reduction in vine yield. TSS was reduced by severe shoot trimming confirming previous findings that pointed out how carbon limitations during berry ripening can effectively slow down sugar accumulation in the berry (Caccavello et al., 2019, 2017; Martínez De Toda et al., 2014; Tessarin et al., 2018; Valentini et al., 2018). Conversely, mild shoot trimming (T30) was found to increase TSS at harvest, this result is in contrast with previous results on 'Aglianico' where the removed leaf area was comparable (Caccavello et al., 2019, 2017). This was not observed in T60 vines throughout the four-year experiment and this is in contrast with previous experiments showing long term compensating carry-over effects on shoot trimming (Filippetti et al., 2015). In general, irrigation induced an increase in TSS regardless of the percentage of ET replaced.

4. Conclusions

Severe shoot trimming consistently reduced TSS accumulation at harvest each year, whereas mild shoot trimming increased TSS accumulation. It was also clear how previous year leaf removal and water stress can impair the carbon balance in the vine affecting the following year fruit yield.

5. Acknowledgments

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Table 1: Weather data at the experimental site during the growing seasons 2017, 2018, 2019, and 2020.

Year	Annual mean air Temperature (°C)	Annual rainfall (mm)	Air T mean Apr-Oct (°C)	Rainfall Apr-Oct (mm)	Huglin index (°C)	Winkler index (°C)	Dryness index (mm)
2017	14.5	647	19.2	218	2525	1961	-107
2018	15.2	989	19.6	505	2606	2062	51
2019	15.3	800	19.7	355	2498	2076	-28
2020	15.4	746	19.5	406	2537	2037	-74

Table 2: Effect of Trimming (T), Irrigation (I), year (Y) and their interactions, assessed with three-way ANOVA, on fruit yield, number of bunches per vine, bunch weight, and on juice TSS, of 'Aglianico'.

Source of variation	Fruit yield (kg/vine)	N° of bunches per vine	Bunch weight (g/bunch)	TSS (°Brix)
Trimming (T)	***	***	***	***
Irrigation (I)	ns	ns	ns	**
Year (Y)	***	***	***	***
T×I	ns	ns	ns	ns
T×Y	*	ns	ns	*
I×Y	ns	*	ns	ns
T×I×Y	*	*	ns	ns

[1] **= p ≤ 0.05; ** = p ≤ 0.01; *** =p<0.001; ns = not significant*

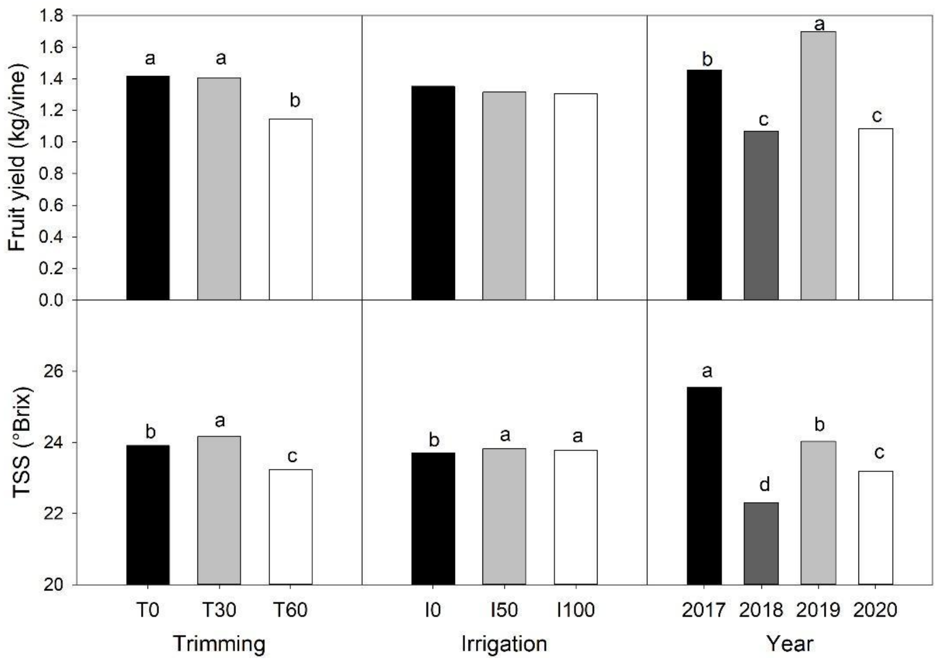

Figure 1 Fruit yield and TSS at harvest of 'Aglianico' grapevines. Within each panel, different letters indicate significantly differences between treatments according to the Duncan's test (p ≤ 0.05)