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Extreme viticulture:
from a cultural landscape to an economic and environmental sustainability

11-14 May 2022, Vila Real (UTAD)

Book of Proceedings

EDITED BY: **Alberto Baptista and Catarina Cepêda**
Universidade de Trás-os-Montes e Alto Douro (UTAD)
Centre for Transdisciplinary Development Studies (CETRAD)

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Influence of pruning system and deficit irrigation on grapevine physiology, yield and grape quality of cv. Sousão (*Vitis vinifera* L.) growing under Mediterranean conditions

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Keywords: *Vitis vinifera* L.; pruning system; water productivity; yield, berry composition.

Abstract. Different strategies are currently being sought to mitigate the effects of grapevine summer water stress. Regulated Deficit Irrigation (RDI) is a strategy that has been successfully adapted. Also, some pruning systems have been identified as capable of influencing vine water balance. The aim of this work was to evaluate the effect of two RDI strategies and two pruning systems on grapevine physiology, yield and grape quality of the Sousão variety grown under Mediterranean conditions. This study was conducted in an organic vineyard in northeastern Portugal (41º31´N; 7º5´W; 326 m a.s.l.), planted in 2011 with 1103 P rootstock. The pruning systems, single Cordon and single Guyot were established in 2013. In 2019, three irrigation treatments were implemented: a full irrigation control, FI (100% ETc), and two deficit irrigations treatments, RDI25 (25% ETc) and RDI50 (50% of ETc). During the growing season, grapevine water status and physiological parameters were monitored. At harvest, yield, yield components, and grape composition were evaluated and analyzed. The results showed that the vines under an RDI regime presented significantly lower leaf water potential values than those under FI in both pruning systems. Therefore, the grapevine's physiological performance was affected by decreasing its stomatal conductance, transpiration, and photosynthesis. However, the lower physiological performance did not significantly affect yield. No significant differences were observed in total soluble solids and total acidity regarding the grape composition. However, there was an increase in anthocyanins and phenolic compounds in grapes with less irrigation.

Introduction

The majority of the world's grape production regions are located in seasonally dry climates with varying degrees of summer drought (e.g., climate of the Mediterranean type), where soil and atmospheric water deficits, together with high temperatures, exert significant constraints on yield and quality (Chaves *et al.,* 2007; Keller, 2016). The use of irrigation in these environments arises as a solution to prevent excessive canopy temperature, maintain quality in wine production and, in extremes cases, guarantee plant survival (Chaves *et al.,* 2010). Regulated Deficit Irrigation (RDI) is one of the most frequently used drip-irrigation strategies in vineyards to balance grapevine vegetative and reproductive growth, to improve water use efficiency and to induce beneficial changes in berry composition by applying less than the full vineyard water use at specific periods of the growing season (Dry et al., 2001; Medrano *et al.* 2015; Shellie, 2019). However, successful strategies may vary among regions with different climates and can even be site specific, depending on the interactions within the grapevine variety, soil type, viticultural practices, irrigation system design, and purpose of the production. The objective of this study was to evaluate the effects of two regulated deficit irrigation regimes and two pruning systems (Guyot and cordon Royat) on grapevine physiology, yield and grape quality of Portuguese cv. Sousão (*Vitis vinifera* L.) growing under Mediterranean conditions.

Methods and sources

The study was conducted over the 2019 growing season in a commercial vineyard located in the *Douro* Demarcated *Region*, north of Portugal (41º31´N; 7º5´W; 326 m a.s.l.). The vineyard was planted in 2011 with 1.0 m between vines and 2.2 m between rows (4545 vines/ha) with the grapevine variety Sousão, grafted onto 1103P rootstock. The vines were pruned in two different systems: Guyot simple and unilateral cordon Royat and trained as a vertical shoot positioning. Irrigation treatments consisted of two regulated deficit irrigation regimes (25% (RDI_{25}) and 50% (RDI_{50}) of crop evapotranspiration (ETc) and a control full-irrigated (100% (FI) of ETc) (Table 1). Water was applied three times a week, from pre-veraison until harvest. The experimental layout had three replicates in a randomized complete block design. Each replicate consisted of five plants in central rows, and the adjacent rows were used as buffers.

Table 1. Code for different irrigation and pruning treatments and total water applied (m^3 ha^{-1})

Code	Pruning	% of ETc	Water applied (m^3 ha^{-1})
SG25	Guyot	25	345
SG50	Guyot	50	689
SG100	Guyot	100	1378
SR25	Royat	25	345
SR50	Royat	50	689
SR100	Royat	100	1378

According to each irrigation regime, the irrigation water applied weekly was calculated according to the previous week's accumulated crop evapotranspiration ($ET_c = ET_0 \times Kc$) and effective precipitation (P_e) using the following equation:

$$\text{Irrigation (mm)} = (ET_c - P_e)/Er$$

Reference evapotranspiration (ET_0) was calculated according to the Penman-Monteith equation (Allen *et al.*, 1998), using data collected by an on-site weather station (Campbell Scientific, Logan, UT) located near the vineyard. A variable crop coefficient (K_c), varying from 0.7 prior to veraison to 0.4 by harvest, was applied to calculate ETc.

Vine water status was monitored using a pressure chamber (Model 1000, PMS Instrument Company, Albany, USA) according to the method of Scholander et al. (1965). Predawn leaf water potential (Ψ_{pd}) was measured in four fully expanded leaves per plot (4 per treatment) of four representative vines.

Leaf gas-exchange rates were measured using a portable gas exchange system (LCA-4, Analytical Development Co., Hoddesdon, England). Measurements were performed in six fully expanded leaves per treatment.

The production per vine was weighed at harvest, and the number of bunches was recorded. Subsequently, representative samples of grapes were taken and kept in a refrigerated box and transported to the laboratory.

In the laboratory, the samples were used to measure the Total Soluble Solids (TSS, in ºBrix) by refractometry (Optic Ivymen System, Madrid, Spain), pH with a potentiometer (370 pH meter; Jenway, Essex, UK), and the titratable acidity (TA), determined by the titration using a standard solution of sodium hydroxide. These parameters were determined using the official methods of the Organisation Internationale de la Vigne et du Vin (OIV, 2014).

Statistical data analysis was performed by analysis of variance. Tukey HSD tests were carried out to determine the significance of differences between treatment means, using Statgraphics Centurión XVI software.

Results

Climate conditions and vine water status. The 2019 growing season was hot and very dry (Fig. 1). The annual and seasonal precipitation were lower than the site average. The maximum and minimum temperatures were similar to the 30-year site average.

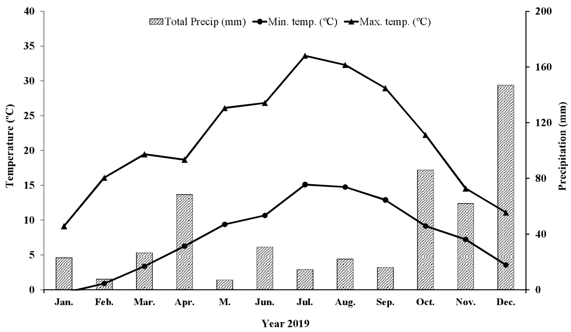

Figure 1. Monthly total precipitation (bars) and average minimum and maximum temperature (lines) during the 2019 growing season.

In general, the physiological parameters of the vines were strongly affected by the irrigation regime. Predawn leaf water potential values of less irrigated vines significantly declined during the ripening period (Fig. 2). The lower values (Ψ_{pd} < -0.8 MPa) are indicative of a relatively severe water stress (Deloire *et al.,* 2004; van Leeuwen *et al.,* 2009). Vines pruned in the Guyot system showed higher values of Ψ_{pd} in comparison with vines pruned in cordon Royat in all irrigation regimes.

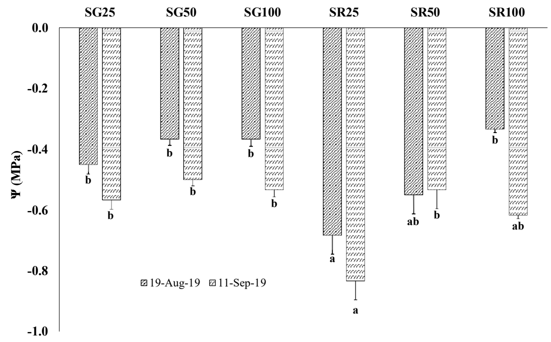

Figure 2. Predawn leaf water potential (Ψ_{pd}) measured in two days (19 Aug and 11 Sep) during ripening period. For the same date, bars with different letters differ significantly ($p < 0.05$).

Net CO_2 assimilation and transpiration rates. The results showed that the deficit irrigation significantly affected the stomatal conductance, transpiration rate, and net CO_2 assimilation rate (Figures 3, 4, and 5). The lower water availability of the deficit irrigation vines led to a lower stomatal conductance and transpiration rate during the ripening period. The significant differences in transpiration rate observed among the three irrigation regimes reflect the response of the plants, through increased stomatal conductance, under conditions of higher water availability.

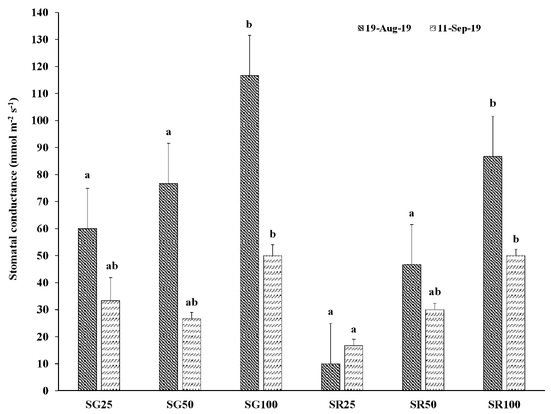

Figure 3. Stomatal conductance measured in two days (19 Aug and 11 Sep) during ripening period. For the same date, bars with different letters differ significantly ($p < 0.05$).

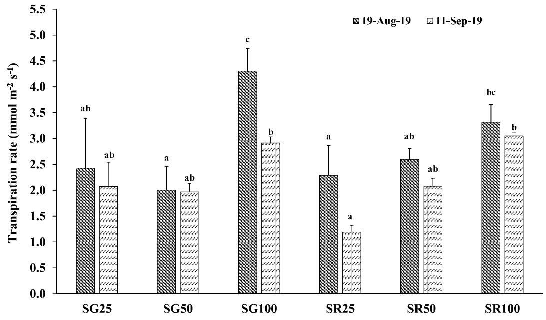

Figure 4. Transpiration rate measured in two days (19 Aug and 11 Sep) during ripening period. For the same date, bars with different letters differ significantly ($p < 0.05$).

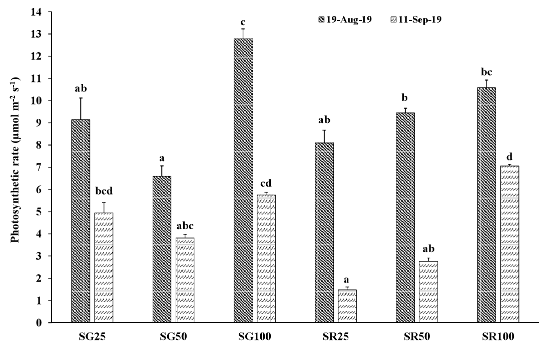

Figure 5. Photosynthetic rate measured in two days (19 Aug and 11 Sep) during ripening period. For the same date, bars with different letters differ significantly ($p < 0.05$).

Yield, water productivity, and berry composition. This first year showed no significant results either in yield or yield components in the different irrigation regimes (Figures 6 and 7). Water productivity increased as water supply decreased from FI to RDI_{25} (Fig. 8). These results support other findings (Shellie, 2014, Romero *et al.,* 2013, Chaves *et al.,* 2007). No significant effect on water productivity was observed between pruning treatments.

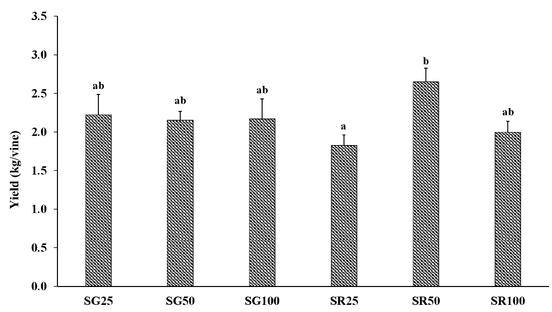

Figure 6. Yield (kg/vine) measured at harvest. Bars with different letters differ significantly ($p < 0.05$).

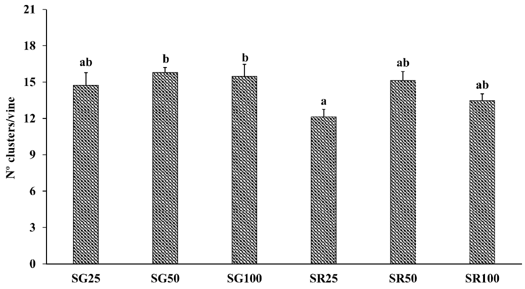

Figure 7. Number of clusters per vine measured at harvest. Bars with different letters differ significantly (p < 0.05).

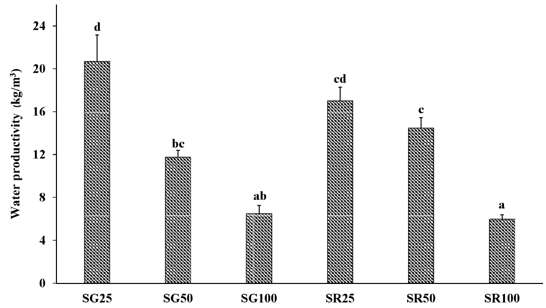

Figure 8. Water productivity (kg/m^3). Bars with different letters differ significantly (p < 0.05).

In this first year of study, the must composition was not significantly affected by deficit irrigation or the pruning system in most parameters (Table 2). There was a tendency to decrease total soluble solids in the deficit irrigation treatments. Water deficit reduced net assimilation and, as a result, sugar accumulation during ripening. Other authors described similar results (Matthews and Anderson, 1988). Regarding pH, the tendency for a decrease in its value in the deficit irrigation treatments was not statistically significant. RDI strategies resulted in a tendency (not statistically significant) to increase the concentration of total phenolics.

Table 2. Berry composition at harvest measured in 2019 in Sousão (*Vitis vinifera* L.) grapevines subjected to different irrigation regimes and pruning systems. TSS (Total Soluble Solids), TA (Total acidity), pH, TPI (total polyphenol Index) (mean ± standard deviation). Mean values with different lowercase letters differ significantly (p≤0.05).

Parameters	Treatments					
	SG25	SG50	SG100	SC25	SC50	SC100
TSS (ºBrix)	23.43±1.21^{a}	23.83±0.55^{ab}	24.00±0.70^{ab}	24.13±0.21^{ab}	24.17±0.29^{ab}	25.47±0.64^{b}
TA (g/L)	8.52±0.67^{ab}	9.08±0.33^{b}	7.72±0.33^{ab}	7.53±0.30^{ab}	8.07±0.57^{ab}	7.86±0.79^{ab}
pH	2.94±0.05^{ab}	2.91±0.01^{a}	3.00±0.05^{ab}	3.07±0.08^{b}	3.05±0.04^{ab}	3.06±0.06^{b}
TPI	63.60±1.08	66.77±2.35	67.20±3.55	66.37±7.93	69.30±3.45	76.77±10.45

Conclusions

The present study evaluated the performance of the Portuguese variety Sousão, under two RDI regimes, in a vineyard located in the Demarcated Douro Region. The results showed that the vines under RDI25 and RDI50 regimes presented leaf water potential values significantly lower than the vines under FI in both pruning systems. The vine's physiological performance was affected by decreasing its stomatal conductance, transpiration, and photosynthesis. However, the lower physiological performance did not significantly affect yield and yield components.

The results showed that moderate water supplies during the ripening period for the region where the study was conducted (severe water deficits) increased water productivity and maintained quality.

The pruning system positively influenced the vine water status in all irrigation regimes. However, in this first year of study, it was not possible to verify the effect of this better water status on yield, yield components, and quality.

No significant differences were observed in total soluble solids and total acidity regarding the grape composition. However, there was an increase in anthocyanins and phenolic compounds (not statistically significant) in grapes with less irrigation.

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