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RESPONSE OF GRAPEVINE CV. "TINTA RORIZ" (*VITIS VINIFERA* L.) TO MODERATE IRRIGATION IN THE DOURO REGION, PORTUGAL

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ABSTRACT

The behaviour of cv. "Tinta Roriz" (*Vitis vinifera* L.), was studied when moderate drip irrigation was applied from veraison to harvest. Field studies were conducted during three growing seasons (2006-2008) in a commercial vineyard located in the Douro region, Portugal.

Experimental layout consisted in the measurement of physiological and agronomic parameters in vines submitted to three different irrigation treatments: 0R was non-irrigation, 2R and 4R were irrigated with a constant fraction of reference evapotranspiration of 0.2 and 0.4, respectively.

The results showed that moderate irrigation improved plant water status, leaf photosynthesis and transpiration. Yield components and pruning weights had a significant increase, only in the 2008 growing season, in 4R irrigated treatment. There were no significant differences between treatments in the accumulation of sugar, titratable acidity and pH in berries. The total phenols and the colour intensity showed a tendency, not significant, to decrease in irrigated treatments.

KEYWORDS

Vitis vinifera L. – deficit irrigation – grapevine – yield components – must composition

INTRODUCTION

A large proportion of vineyards are located in regions with seasonal drought (e.g. climate of the Mediterranean type) where soil and atmospheric water deficits, together with high temperatures, exert a large constraints in yield and quality (Chaves *et al.*, 2007). In the hot and dry Douro Region, limitations in water supply have a great impact on grape production as the annual rainfall is not adequate to provide grapevines with their water requirements, and water deficits usually develop gradually during summer causing important crop losses (Malheiro, 2005).

Regulated Deficit Irrigation (RDI) is one of the most frequently used drip-irrigation strategies in vineyards with the aim to balance grapevine vegetative and reproductive growth by applying less than the full vineyard water use at specific periods of the growing season (Dry *et al.*, 2001, McCarthy *et al.*, 2002). 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. There is still some controversy in the literature concerning the positive and negative effects of irrigation of the vines on must and wine quality (Esteban *et* *al.*, 2001) and the question of when and how much water should be applied in a given environment and variety is still standing (Chaves *et al.*, 2007).

The objective of this study was to determine the effect of different irrigation amounts in physiology, production and grape composition of Portuguese grapevine variety Tinta Roriz, growing in Douro region.

MATERIALS AND METHODS

The research was conducted during three seasons (2006-2008) in a commercial vineyard, located near Torre de Moncorvo (41º11′ W, 7º6′ N, elevation 116 m) in the Douro Region.

The vineyard was planted in 1999, grafted onto 110 R, at a spacing of 2.2 m by 1.1 m (4132 vines ha^{-1}). The vines were trained as unilateral cordon. Rows were NW-SW oriented.

Irrigation water was applied with drip emitters (2.3 L h^{-1}). The water (*R*) was supplied according to the daily reference evapotranspiration (ETo) using the following equation: $R = (K \times ETo - P)$, where *P* represents effective rainfall and *K* a constant coefficient. Three irrigation treatments were established: 0R was not irrigated; 2R was irrigated with a constant fraction of the ETo (*K*=0.2) and 4R was irrigated with a constant fraction of the ETo (*K*=0.4). Reference evapotranspiration (ETo) was calculated using modified FAO Penman-Monteith equation (Allen *et al.*, 1998).

Each treatment had four replicates in a randomized complete block design. Each plot consisted of four rows with six vines per row and the surrounding perimeter vines were used as buffers. The beginning of water supplied was determined by the threshold value (-0.4 MPa) of pre-dawn leaf water potential (Malheiro, 2005) and the frequency of water applications was the same for all treatments and varied from 2 to 3 days per week applied continuously until harvest. The dates of first and last irrigation and total water applied for the three treatments are shown in Tab. 1.

Climatic data were automatically collected from a weather station located near the vineyard. Fig. 1 shows the monthly rainfall and the mean air temperature at the experimental site during the three growing seasons.

Leaf water potential was measured in fully expanded leaves at predawn (Ψ_{pd}) (1 h before sunrise) with a pressure chamber (Model 1000, PMS Instrument Company, Albany, USA) according to the method of Scholander *et al.* (1965).

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

Three 100-berry samples per treatment were collected after pea size was reached. Samples were put into plastic bags, placed in a portable cooler and taken to the laboratory. They were weighed immediately and processed to determine berry composition.

At harvest, yield components were assessed, following manual harvesting and weighing the production on-site.

At winter, pruning weight per vine was recorded and crop load (yield/pruning weight) was calculated.

Tab. 1 Dates of first and last irrigation and total water applied for the three treatments.

Growing season	Dates		Water applied (L $vine^{-1}$)		
	First irrigation	Last irrigation	0R	2R	4R
2006	07/Jul	05/Sep	0	37.5	75.0
2007	19/Jul	04/Sep	0	24.6	49.2
2008	14/Jul	08/Sep	0	31.7	63.4

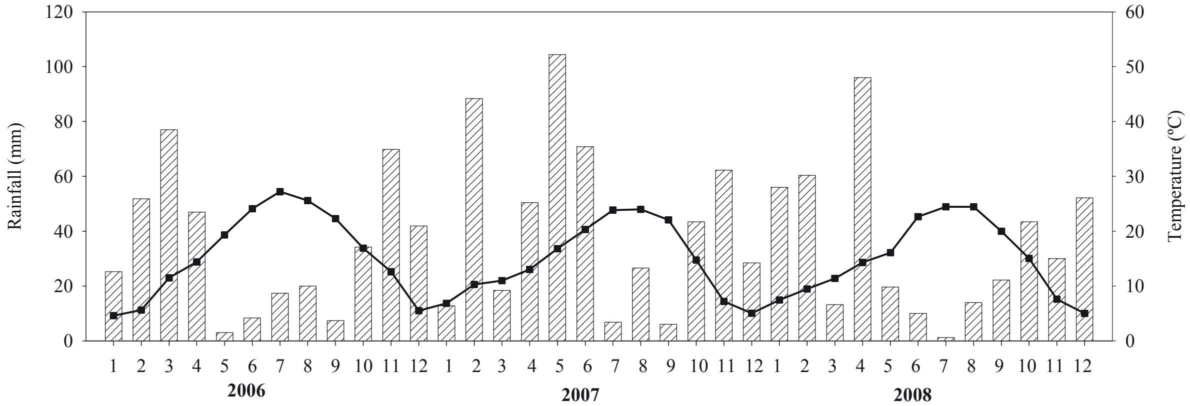

Fig. 1 Total rainfall (bars) and monthly mean air temperature (line) at the experimental vineyard during 2006, 2007 and 2008 growing seasons.

RESULTS AND DISCUSSION

Seasonal evolution of pre-dawn leaf water potential for the three treatments during 2006, 2007 and 2008 growing seasons is shown in Fig. 2. Leaf water potential (Ψ_{pd}) of non-irrigated vines (0R) showed a progressive decline from July onwards reached lower values at middle August. The lower values (~ -1.1 MPa) are indicative of a relatively severe water stress according to Deloire *et al.* (2004). Irrigated vines showed a slightly decrease of Ψ_{pd} throughout the growing season. The values reached by the irrigation treatment 2R were around -0.8 MPa in 2006 and -0.6 MPa in 2007 and 2008. The irrigation treatment 4R showed the highest values of Ψ_{pd} during ripening period.

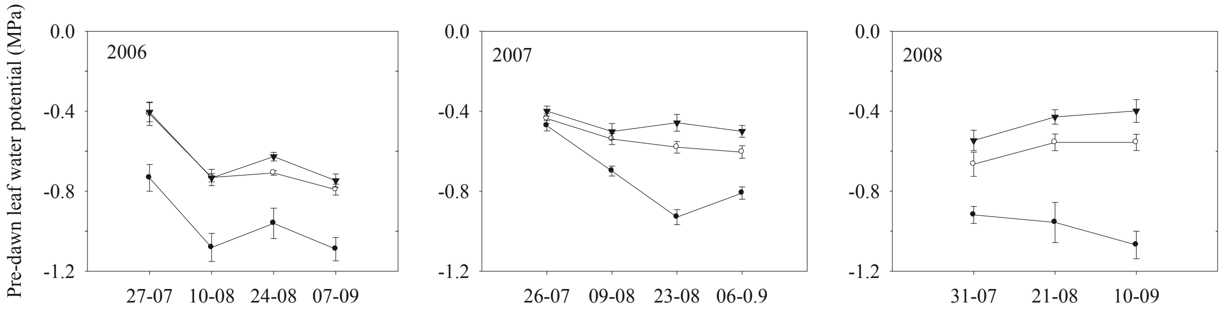

Fig. 2 Seasonal evolution of pre-dawn leaf water potential for the three treatments (●- 0R, ○-2R, ▼-4R) during 2006, 2007 and 2008 growing seasons. Each point represents the average of eight measurements with SE. Bars not visible indicate SE smaller than symbol

The results showed that, in generally, the water availability affected significantly the physiological parameters: transpiration rate (Tab. 2) and net CO_2 assimilation rate (Tab. 3) increased in the irrigated vines. These results are in agreement with Medrano *et al*. (2003). The vine growth was significantly affected only in 2008: the total pruning weight per vine was significantly lower in non irrigated vines (Tab. 4).

Tab. 2 Transpiration rate (E) measured during hot and clear days in the ripening period for the different water treatments in 2006, 2007 and 2008 growing seasons.

Year	Treatment	E (mmol m^{-2} s^{-1})			
		27 Jul	**10 Aug**	**24 Aug**	**7 Sep**
2006	0R	2.79[a]	2.39[a]	2.32[a]	2.26[a]
	2R	3.90[b]	3.84[b]	2.94[b]	3.28[b]
	4R	4.23[b]	3.80[b]	2.51[b]	3.50[b]
	Sig.	*	***	*	***
			9 Aug	**23 Aug**	**6 Sep**
2007	0R		1.83[a]	1.21[a]	1.23[a]
	2R		2.80[b]	2.28[b]	2.46[b]
	4R		4.62[c]	4.30[c]	4.32[c]
	Sig.		***	***	***
				21 Aug	**10 Sep**
2008	0R			1.47[a]	1.40[a]
	2R			4.46[b]	4.16[b]
	4R			7.62[c]	5.57[b]
	Sig.			***	***

Means within a column, for each date and season, flanked by se same letter are not significantly different at P ≤ 0.05 (Tukey HSD test). Significance of difference between treatments: ns – not significant; * 0.01< P≤0.05; ** 0.001< P≤0.01; *** P≤0.001

Tab. 3 Net CO_2 assimilation rate (A) measured during hot and clear days in the ripening period for the different water treatments in 2006, 2007 and 2008 growing seasons.

Year	Treatment	A (μmol m^{-2} s^{-1})			
		27 Jul	**10 Aug**	**24 Aug**	**7 Sep**
2006	0R	8,99	7,33	4,61	1,15[a]
	2R	11,92	9,13	4,93	4,91[b]
	4R	13,74	9,23	4,16	4,81[b]
	Sig.	*ns*	*ns*	*ns*	*
			9 Aug	**23 Aug**	**6 Sep**
2007	0R		4,15[a]	2,66[a]	2,34[a]
	2R		6,31[b]	5,51[b]	4,80[b]
	4R		11,32[c]	9,68[c]	8,19[c]
	Sig.		***	***	***
				21 Aug	**10 Sep**
2008	0R			0,52[a]	0,95[a]
	2R			1,48[b]	1,80[b]
	4R			2,38[b]	2,35[b]
	Sig.			**	***

Means within a column, for each date and season, flanked by se same letter are not significantly different at P ≤ 0.05 (Tukey HSD test). Significance of difference between treatments: ns – not significant; * 0.01< P≤0.05; ** 0.001< P≤0.01; *** P≤0.001

Yield and yield components were not significantly affected by irrigation treatments in 2006 and 2007 (Tab. 4). However, in 2008 the yield (kg $vine^{-1}$) and the mean weight per cluster were significantly higher in 4R treatment. The balance between vine supply capacity and crop demand expressed in terms of yield/pruning weight was not impaired by the irrigation applied in 2006 and 2007 what is in agreement with other authors (Intrigliolo and Castel, 2010). However, in 2008 this ratio was higher in irrigated vines confirmed the considerable differences among years, in this values (Bravdo *et al.*, 1985, Intrigliolo and Castel, 2010).

At the time of harvest no significant differences in must composition were found among treatments (Table 5). Similar results were obtained by Centeno *et al.* (2005), in Spain, for the variety Tempranillo and the same irrigation treatments. In 2008 season the total phenol content in berries from irrigated vines were significantly lower.

Tab. 4 Yield components at harvest, pruning weight and yield/pruning weight ratio for the different water treatments in 2006, 2007 and 2008 growing seasons.

Year	Treatment	Yield (Y) (kg vine^{-1})	Cluster Number per vine	Cluster Mean weight (g)	Pruning weight (Pw) (kg vine^{-1})	Y/Pw
2006	0R	2.7	14.5	183.3	0.58	5.3
	2R	2.7	15.8	169.7	0.55	5.2
	4R	3.0	15.0	193.8	0.53	6.2
	Sig.	*ns*	*ns*	*ns*	*ns*	*ns*
2007	0R	2.1	12.0	166.2	0.71	4.7
	2R	2.1	11.7	179.6	0.72	3.6
	4R	2.1	12.4	175.4	0.81	3.6
	Sig.	*ns*	*ns*	*ns*	*ns*	*ns*
2008	0R	1.9[a]	13.3	139.1[a]	0.50[a]	3.9[a]
	2R	2.7[a]	12.4	207.0[b]	0.64[a]	4.5[a]
	4R	4.3[b]	15.2	271.0[c]	0.66[b]	6.8[b]
	Sig.	***	*ns*	***	*	*

Means within a column, for each season, flanked by se same letter are not significantly different at P ≤ 0.05 (Tukey HSD test).
Significance of difference between treatments: ns – not significant; * 0.01< P≤0.05; ** 0.001< P≤0.01; *** P≤0.001

Tab. 5 Berry composition at harvest for the different water treatments in 2006, 2007 and 2008 growing seasons.

Year	Treatment	Total soluble solids (ºBrix)	Titratable acidity (g L^{-1} tartaric acid)	pH	Colour intensity	Total phenols
2006	0R	21.08	2.43	3.76	1.97[a]	62.87
	2R	20.87	2.19	3.67	3.43[a]	56.27
	4R	21.91	2.22	3.75	4.53[b]	61.22
	Sig.	*ns*	*ns*	*ns*	*	*ns*
2007	0R	20.57	3.21	3.98	5.33	76.53
	2R	21.10	3.68	3.84	3.43	63.07
	4R	21.53	4.05	3.79	3.33	65.23
	Sig.	*ns*	*ns*	*ns*	*ns*	*ns*
2008	0R	21.55	3.18	3.72	4.57	55.97[a]
	2R	21.87	2.86	3.60	4.17	44.17[b]
	4R	21.75	3.40	3.69	4.07	43.50[b]
	Sig.	*ns*	*ns*	*ns*	*ns*	*

Means within a column, for each season, flanked by se same letter are not significantly different at P ≤ 0.05 (Tukey HSD test).
Significance of difference between treatments: ns – not significant; * 0.01< P≤0.05; ** 0.001< P≤0.01; *** P≤0.001

CONCLUSIONS

The results showed that moderate water supplies during ripening period, for the region where the study was conducted (severe water deficits), did not benefit yield and fruit composition in two of the three seasons of experiments. The differences in yield between moderate water supplies and rainfed vines only occurred in the growing season with the driest summer (2008).

The moderate irrigation applied did not significantly affected berry sugar accumulation, titratable acidity and pH. The total phenols were significantly lower in musts from irrigated vines.

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