CAN SOIL WATER CONTENT BE USED AS A PREDICTOR OF PREDAWN LEAF WATER POTENTIAL FOR DEFICIT IRRIGATION SCHEDULING? A CASE STUDY AT ALENTEJO WINE REGION

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Context and purpose of the study: Water and heat stress impose new challenges to irrigation management in the Mediterranean areas. This reality has a major impact on the vineyard ecosystem, particularly on the scarce water resources of the Alentejo region (South Portugal). To mitigate this problem, irrigation management should focus on optimizing yield and fruit quality per volume of water applied. This work aims to discuss the use of predawn leaf water potential and soil water status relationships as a decision tool for irrigation management taking as basis data from a field trial where two deficit irrigation strategies were compared.

Material and methods: A deficit irrigation experiment was conducted from 2013-2015 at a commercial vineyard locatedat Reguengos de Monsaraz, Alentejo, Portugal (38°22' N 7°33' W) with the *V. vinifera* variety Aragonez (syn. Tempranillo). A sustained deficit irrigation (DI) strategy used by the farm consisting of a constant proportion of crop evapotranspiration (0.28) was applied along the irrigation period (DI_1) and was compared with DI_2, a similar strategy but with 48% lower water volumes than DI_1, using a randomized complete block design with four replications of 15 plants. Predawn leaf water potential (ψ_{PD}) was used to define the beginning of each irrigation event.Soil water content until one meter depth was assessed and the fraction of transpirable soil water (FTSW) was calculated. Yield, berry composition and pruning weight were assessed. This paper reports the first year (2013) results.

Results: The DI strategies induced a decrease of ψ_{PD} along the season. In parallel, the progressive water withhold decreased FTSW (accessed after each irrigation event) along the season from 80 to 20%, while atmospheric water demand was increasing. The strong correlation between ψ_{PD} and FTSW observed may support the use of FTSW as a robust predictor of ψ_{PD}. The stressful conditions imposed by this irrigation strategy had no significant effect on yield, berry composition and vigor. The crop WUE (amount of fruit produced per unit of water applied) was higher for DI_2 strategy and, at the same time, allowing water savings as compared to grower's irrigation strategy.

Keywords: Deficit irrigation, Water stress, Crop WUE, Yield and Berry quality

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A case study at Alentejo wine region

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ABSTRACT

Water and heat stress impose new challenges to irrigation management in the Mediterranean areas. This reality has a major impact on the vineyard ecosystem, particularly on the scarce water resources of the Alentejo region. To mitigate this problem, irrigation management should focus on optimizing yield and fruit quality per drop of water applied. This work aims to discuss the use of predawn leaf water potential and soil water status relationships as a decision tool for irrigation management from data obtained in a field trial where two deficit irrigation strategies were compared.

MATERIAL and METHODS

Location: Reguengos de Monsaraz (38º22' N 7º33' W), Alentejo appellation, South Portugal (Fig. 1);

Climate: Mediterranean climate, with very high Temperatures and water deficit from flowering to harvest;

Soil: Sandy to silty-clay-loam, diorite and granite derived, soils (pH=7-7.6, low OM, high P_2O_5 and K_2O);

Vineyard: 11 years-old grapevines cv. Aragonez (syn. Tempranillo), grafted onto 1103P rootstock, 2200 vines/ha (3.0 x 1.5 m). N-S oriented rows. spur-pruned with 15-16 nodes per vine on a bilateral Royat cordon, trained to a VSP trellis system with one pair of movable wires. Farm standard cultural practices were applied to all treatments;

Experimental layout: Complete randomized block design with 4 replications per treatment,15 vines per replication.

Treatments and measurements: DI1 - sustained deficit irrigation (DI) strategy used by the farm consisting of a constant proportion of crop evapotranspiration (0.28) applied along the irrigation period; DI2 - a similar strategy but with 48% lower water volumes than DI1.

Predawn leaf water potential (ψ_{PD}) was used to define the beginning of each irrigation event. Soil water content until 1 m depth was assessed and the fraction of transpirable soil water (FTSW), measured as a fraction of total available water (TAW) in the root zone, was calculated. Yield, berry composition and pruning weight were assessed.

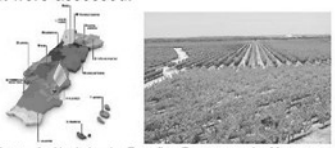

Figure 1. Herdade do Esporão, Reguengos de Monsaraz, Alentejo wine growing region of Portugal (38° 22' N, 7° 33' W).

REFERENCES

[1] Medrano H, Tomás M, Martorell S, Escalona J-M, Pou A, Fuentes S, Flexas J, Bota J, 2015. Improving water use efficiency of vineyards in semi-arid regions. A review. Agron. Sustain. Dev., 35: 499–517

RESULTS

	ARA				TNAC			
	1st January - Budburst	Budburst - Flowering	Flowering - Veraison	Veraison - Harvest	1st January - Budburst	Budburst - Flowering	Flowering - Veraison	Veraison - Harvest
Tmax (ºC)	15.2	22.3	32.3	36.7	15.2	22.3	31.3	36.4
Tavg (ºC)	9.8	15.0	22.9	26.3	9.8	15.1	22.1	26.1
Tmin (ºC)	5.2	8.5	14.1	16.2	5.2	8.6	13.4	16.2
Rain (mm)	223.8	123.6	3.4	0.0	223.8	117.4	9.6	10.0
ETo (accum) (mm)	112.9	238.6	412.1	183.4	112.9	207.3	443.4	210.9
VPD (accum) (kPa)	25.7	54.1	141.3	80.5	25.7	47.7	147.6	94.4

Table 1 – Mean maximum (Tmax), average (Tavg) and minimum (Tmin) air temperatures, accumulated rainfall, accumulated actual evapotranspiration (ETo) and vapor pressure deficit (VPD) during (ARA) Aragonez (syn. Tempranillo) and (TNAC) Touriga Nacional main phenological stages.

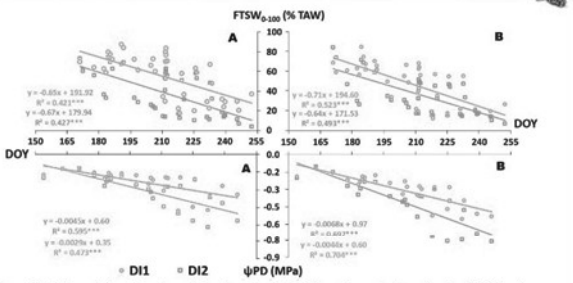

Figure 2 - Daily evolution of predawn leaf water potential (ψPD) and transpirable soil water ($FTSW_{0-100}$) as a fraction of total available water (TAW) in the root zone. **(A)** Touriga Nacional; **(B)** Aragonez (syn. Tempranillo). Deficit irrigation (DI1, 28% Etc) and DI2 (48% of DI1).

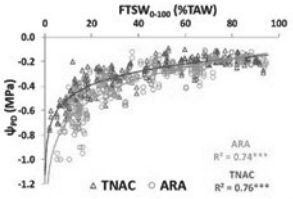

Figure 3 - Regression between predawn leaf water potential (Ψ_{PD}) and the transpirable soil water (FTSW) as a fraction of total available water (TAW) in the root zone. (○) Aragonez (syn. Tempranillo); (Δ) Touriga Nacional. Includes deficit irrigation (DI1, 28% Etc) and DI2 (48% of DI1) data.

Variety	Treat	Clusters / vine	Cluster weight (g)	Yield (Kg/vine)	Sugars (ºBrix)	Titr. acidity (g/L Tart.Acid)	Shoot number	Shoot weight (g)	Pruning weight (g)	WUEc (kg fresh grapes/m³ water applied) [1]
Aragonez	DI1	22.6	190.5	4.5	25.3	4.2	18.3	39.8	728.8	4.57
	DI2	21.6	167.1	3.8	25.1	4.2	17.2	39.7	682	4.62
	Sig	ns	ns	ns	ns	ns	n.s.	n.s.	*	
Touriga	DI1	29.6	137.3	4	22.3	5.9	18.6	39.5	732.6	3.78
	DI2	29.2	131.7	3.9	22.1	6.4	18.5	39.7	736.3	4.75
	Sig	ns	ns	ns	ns	*	n.s.	n.s.	n.s.	

Table 2 – Yield, yield components (number clusters/vine and cluster weight), berry composition (sugar content and titratable acidity), vigor (shoot number, shoot weight and pruning weight) and crop water use efficiency (WUEc) of Aragonez (syn. Tempranillo) and Touriga Nacional grapevines. Deficit irrigation (DI1, 28% Etc) and DI2 (48% of DI1). Values are means of 15 samples. ANOVA results of irrigation treatments comparison are presented for Aragonez and for Touriga Nacional.
(n.s. - no sig. differences; *, **, *** - sig. differences at p < 0.05, 0.01 and 0.001 respectively).

RESULTS

The DI strategies decreased ψ_{PD} along the season. In parallel, the progressive water withhold decreased FTSW (accessed after each irrigation event) along the season from 80 to 20%, while atmospheric water demand was increasing. The strong correlation between ψ_{PD} and FTSW observed may support the use of FTSW as a robust predictor of ψ_{PD}. The stressful conditions imposed by this irrigation strategy had no significant effect on yield, berry composition and vigor. The crop WUE (amount of fruit produced per unit of water applied) was higher for DI2 strategy and, at the same time, allowed to save water as compared to grower's irrigation strategy.

ACKNOWLEDGEMENTS

R. Egipto had a scholarship from FCT (SFRH/BD/128847/2017), Portugal.
We thank the estate "Herdade do Esporão" for the experimental vineyard facilities and all the Master students involved in the project.

This project has received funding from the EU's Seventh Framework Programme for research, technological development and demonstration under grant agreement nº 311775