DYNAMICS OF SOIL AND CANOPY TEMPERATURE: A CONCEPTUAL APPROACH FOR ALENTEJO VINEYARDS

Authors:Joaquim Miguel COSTA[1*], Ricardo EGIPTO[1,2], Carlos LOPES[2], Manuela CHAVES[2]

[1]*LEAF, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda Lisboa, Portugal*
[2]*INIAV, I.P., Pólo de Dois Portos, Quinta da Almoínha, 2565-191 Dois Portos, Portugal*
[3]*LEM-ITQB, Universidade Nova de Lisboa, Oeiras, Portugal*

*Corresponding author: *miguelcosta@isa.ulisba.pt*

Abstract:
Context and purpose of the study - Climate change imposes increasing restrictions and risks to Mediterranean viticulture. Extreme heat and drought stress events are becoming more frequent which puts in risk sustainability of Mediterranean viticulture. Moreover row crops e.g. grapevine for wine, are increasingly prone to the impact of more intense/longer exposure time to heat stress. The amplified effects of soil surface energy reflectance and conductance on soil-atmosphere heat fluxes can be harmful for leaf and berry physiology. Leaf/canopy temperature is a biophysical variable with both physiological and agronomic meaning. Improved comprehension of spatial and temporal dynamics of soil and leaf/canopy temperature (thermal microclimate) in irrigated vineyards can support improved crop and soil monitoring and management under more extreme and erratic climate conditions. In this work we propose a conceptual approach to integrate information on major soil-vine-atmosphere interactions under deficit irrigation. Ultimately a conceptual model based on temperature relations is proposed to support assessment of the impact of air and soil temperatures on canopy and berry temperatures, leaf senescence and gas exchange. This model may support Decision Support Systems (DSS) for canopy and soil management and irrigation scheduling in Mediterranean vineyards. In addition a set of temperatures (e.g. canopy, soil) are proposed to feed the conceptual models to support the DSS.
Material and methods – Location & plant material: South Portugal (38º22' N 7º33' W); cvs Touriga N. (TOU) & Aragonez (ARA) (syn. Tempranillo), 2,200 pl/ha, 1103-P rootstock, VSP, bilateral Royat Cordon training system, N-S ORIENTATION. Sandy to silty-clay-loam soil, pH=7-7.6, low OM; Irrigation treatments: DI_1 - sustained deficit irrigation strategy used by the farm consisting of an equal proportion of crop evapotranspiration (ET_c) (0.28 in 2014 and 0.36 in 2015) applied along irrigation period; DI_2 - similar to DI1 but with reduced volume applied (0.18 in 2014 and 0.24 in 2015). Measurements: Diurnal courses (8-20h, every 3h) of leaf water potential (Ψ_{PD}, Ψ_{leaf}), leaf gas exchange (Licor 6400, Licor, USA) and canopy T_C (B20, Flir Systems, 7-13 µm, ε=0.96) and T_{berry} (thermocouples) were determined. Statistics: Randomized complete block design (2 irrigation treat., 4 blocks). Pearson correlations between variables (T_C, ψ, g_s, An), measured on the west exposed side of the canopy, and between the variables and T_S, T_C and T_{berry} were done (Statistix 9.0 software).
Results - The strong correlations between T_{leaf} and water status in grapevine support the parameter T_c as good predictor of plant water status (Garcia-Tejero et al. 2016; Costa et al. 2019). In parallel, T_S was shown to positively influence T_C especially at the cluster zone and at the warmest conditions of the day (Costa et al., 2019). Therefore, T_S can used as another variable to model and predict thermal stress in vineyards. Better comprehension of thermal and water fluxes in the vineyard mat be predicted on the basis of temperature. Thermal variables such as T_{air}, T_C, T_{berry} and T_S can be used in models and DSS to support water and canopy management.
Keywords: Mediterranean viticulture, temperature, DSS, water and heat stress, soil and canopy temperature, irrigation

1. Introduction

Dynamics of soil and canopy temperature: a conceptual approach applied to Alentejo vineyards

J. Miguel Costa[1,*], R. Egipto[1,2], C.M. Lopes[1], M.M. Chaves[3]

[1]LEAF, Linking Landscape, Environment, Agriculture and Food, Instituto Superior de Agronomia, U. Lisboa, Lisboa, Portugal; [2]INIAV, I.P. Pólo de Dois Portos, Quinta da Almoínha, 2565-191 Dois Portos, Portugal; [3]ITQB-NOVA, Univ. NOVA de Lisboa, Oeiras, Portugal;
** miguelcosta@isa.ulisboa.pt*

INTRODUCTION

Climate change imposes increasing risks to Mediterranean viticulture e.g. in South Portugal. Row crops like grapevine are more vulnerable to heat stress due to amplified effect of soil surface on vineyard's heat fluxes. This can be negative for leaf and berry physiology especially under extreme and more erratic dry and warm climate conditions. Canopy temperature (T_C) is a robust biophysical variable with physiological/agronomic meaning (Costa et al., 2013). Therefore, characterization of spatial/temporal variation of T_C in individual vines and/or vineyards together with soil T can support more precise water and soil management and predict yield losses. We are interested in using simple thermal parameters as indicators/predictors of vine's performance with potential use to feed models and optimize decision support systems in modern viticulture.

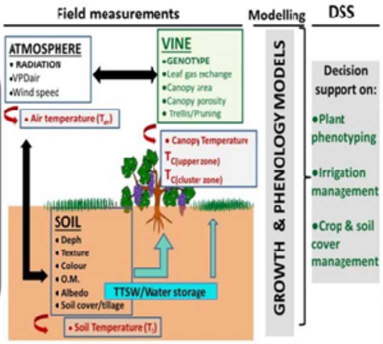


Fig. 1. Relational diagram showing the major water/heat relations in a vineyard to predict water balance and the role of internal/external variables influencing heat relations and exchanges.

O.M.: Organic Matter; TTSW: tot. transpirable soil water; DSS: decision support system.

MATERIAL & METHODS

Location & plant material: South Portugal (38°22' N 7°33' W); cvs Touriga N. (TOU) & Aragonez (ARA) (syn. Tempranillo), 2,200 pl/ha, 1103-P rootstock, VSP, bilateral Royat Cordon training system. Sandy to silty-clay-loam soil, pH=7-7.6, low OM; **Irrigation treatments:** DI_1 - sustained deficit irrigation strategy used by the farm consisting of an equal proportion of crop evapotranspiration (ETc) (0.28 in 2014 and 0.36 in 2015) applied along the irrigation period; DI_2 - similar to DI_1 but with reduced volume applied (0.18 in 2014 and 0.24 in 2015); **Measurements**: Diurnal courses (8-20h, every 3h) of leaf water potential (Ψ_{PD}, Ψ_{leaf}), canopy T (T_C) leaf gas exchange (Licor 6400, Licor, USA) and T_C (B20, Flir Systems, 7-13 µm, ε=0.96) (Fig.1) were determined. **Statistics:** Randomized complete block design (2 irrigation treat., 4 blocks). Pearson correlations between variables (Tc and ψ, gs, An) and between Ts and Tc were done (Statistix 9.0 software).

RESULTS

Climate and irrigation (2014-2015)

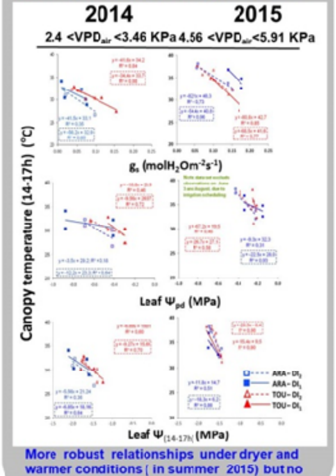
Solar radiation was similar in both years but 2015 was warmer and drier, requiring the longest irrigation period and the larger amount of water (163 mm)(Tab.1): The year 2014 had lower VPD_{air} and T_{air} which resulted in the lower cumulative ET0 than in 2015 **(Tab.1)**.

Tab. 1. Average T_{air}, rainfall, cumulative ET0 and irrigation water use

YEAR	Mean/ Max Tair (Jun - Aug) (°C)	Rainfall dormancy (Oct - Feb) (mm)	Rainfall bud-burst to harvest (Mar - Aug) (mm)	Cumulative ET0 (Mar - Aug) (mm)	SDI Irrigation [*May/Jun - Aug) (mm)
2014	23.2/32.8	321	157	776	67
2015	24.9/34.6	288	95	940	163*

T_C *vs* vine's water status

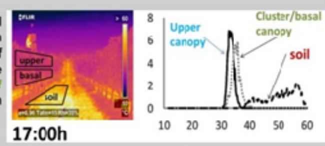
Fig. 2. $T_{C(14-17h)}$ is a simple thermal indicator of grapevine performance



More robust relationships under dryer and warmer conditions (in summer 2015) but no differences between genotypes .

T soil (T_S) vs canopy temperature (T_C)

Fig. 3. Thermogram (left) and relative pixel frequency of a given temperature taken from thermal images of two contiguous vine rows of Aragonez at 17 h on 8 Jul. 2015 and showing the mean T of the upper canopy and the basal part of canopy (cluster zone) and soil. ROIs selected on the sunlit area (facing West at 14:30-24h).



Tab. 2. Pearson correlation coefficients for the relationships between T_C (upper and basal part - cluster zone) and T_s for both the sunlit (facing East at 5h–11 h and West at 14:30-20h) and at the shadow side (facing West at 5 –11h and East at 14:30-20h). Data from treatments and varieties was combined (***-sig. dif. at p<0.001).

	T_C upper canopy sunlit	$T_C$cluster -zone sunlit		T_C upper canopy shadow	$T_C$cluster-zone shadow
$T_s$sunlit	0.80	0.87	$T_s$shadow	0.92	0.94
sig.	***	***	*sig.*	***	***

CONCLUSIONS

T_C is a proxy of leaf gas exchange and can support grapevine phenotyping and stress monitoring in field conditions. T_S had a positive influence on T_C at the cluster zone and under the warmest conditions of the day (Costa et al., 2019). Therefore, T_S is another thermal parameter with relevance to model and predict thermal stress in vineyards. Better comprehension of thermal and water fluxes in the vineyard can be predicted on the basis of temperature. The combined use of variables such as T_{air}, T_C, T_S and T_{berry} can be used in models and Decision Support Systems to manage water management and reduce risks due to climate.

REFERENCES: Costa JM et al. (2013). Thermography to monitor plant-environment interactions. J Exp. Bot. 64,3937-3949; Costa JM et al. (2019). Canopy and soil thermal patterns to support water and heat stress management in vineyards. Agric. Water Manag. 216, 484-496

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