Thermal patterns in the vineyard to support management

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ABSTRACT

Irrigated viticulture expanded fast in Southern European countries to optimize yield and quality and to promote vine longevity. However, intensive irrigation practices increase pressure over the already scarce water resources. In addition, row crops such as grapevine, are more vulnerable to heat stress due to the effects of soil heat fluxes which can influence canopy and berry thermal condition. Therefore, a better understanding of grapevine responses (diurnal and seasonal) to environmental factors (air temperature, VPD, soil water) and agronomic practices (deficit irrigation, soil management) are still required. Ground based thermography was used to monitor canopy and soil temperature patterns along the day and season as a tool to assess vine water status and predict risks of heat stress damage. In the frame of the EU-INNOVINE project, field trials were carried in 2014 and 2015 in South Portugal. We examined the diurnal and seasonal response of two *V. vinifera* varieties Aragonez (syn. Tempranillo) and Touriga Nacional subjected to sustained deficit irrigation (SDI), and regulated deficit irrigation (RDI, about 50% of the SDI). Diurnal canopy (T_C), and soil surface (T_{soil}) temperatures were assessed by thermography. Punctual measurements of leaf temperature with thermal couples, leaf water potential and leaf gas exchange were also done. T_C values were above the optimal temperature for leaf photosynthesis during the day light period (11-14h to 17h), especially under high VPD and high Tair conditions and in RDI vines. T_{soil} was on average about 10-15ºC higher than T_C. We found good correlation between T_C retrieved by thermography and eco-physiological parameters in both years. In turn, the good correlation between T_C and thermal couple temperature data supported robustness of the thermal imaging approach.

INTRODUCTION

Extreme air temperatures combined with dry soils, and an increasing frequency of heat waves, represent a major threat to South European Mediterranean viticulture (Medrano et al., 2015; Costa et al, 2016). In addition, row crops such as grapevine, can be more exposed to heat stress due to the effects of soil heat fluxes (latent and sensible). Therefore, studies on drought and heat responses in grapevine together with improved knowledge on heat and water fluxes in the vineyard are highly relevant to minimize risks for the crop due to extreme climate events. Remote sensing is one of the pillars of precision viticulture but it still needs optimization for open-field applications (e.g. crop and soil monitoring, genotype characterization). This applies to thermal remote sensing, which can support characterization of vine's water status (Garcia-Tejero et al., 2016) and detection of energy and moisture fluxes at the land surface (Soliman et al., 2015).

MATERIAL AND METHODS

Field trials were located in South Portugal (38º22' N 7º33' W) under typical Mediterranean climate conditions. We used 11-year old vines of the cvs Touriga Nacional (TOU) and Aragonez (ARA) (syn. Tempranillo) grafted on the 1103-P rootstock (2,200 pl/ha), trained on a vertical shoot positioning and pruned on a bilateral Royat Cordon system. The soil has a silty-clay-loam texture, with pH=7-7.6, low O.M., high P_2O_5 and K_2O. Vines were subjected to two irrigation treatments: 1) Sustained Deficit Irrigation (SDI, control), watered since pea size berry (about 30% ETc, done according to farm's schedule) and 2) Regulated Deficit Irrigation (RDI), subjected to early imposed water deficit (pea size – veraison) and late deficit (ripening) (about 65% of the SDI). Diurnal courses of leaf water potential (Ψ), canopy (T_C) and soil temperature (T_{soil}) and individual leaf gas exchange were implemented. T_C was determined by thermography (B20, Flir Systems, 7-13 µm, ε=0.96). Thermal IR imaging was followed by RGB imaging and individual leaf gas exchange (Licor 6400, Li-cor, USA). Thermal images were analysed with the ThermaCAM Researcher software (Flir Systems, USA). We used a randomized complete block design (2 irrigation treatments with 4 replications/blocks). Pearson correlations between variables (T_C, g_s, ψ_{pd}) were done (Statistix 9.0 software).

RESULTS AND DISCUSSION

Inter-annual climate variation resulted in different irrigation requirements and different T_C patterns in the vineyard. T_C values derived from thermography (sunlit side of the canopy) and individual leaf temperature values were well correlated indicating that ground based thermography provides robust information on T_C, in a faster way and for a larger monitored area. Thermography enabled to assess T_{soil} and T_C variation patterns along the day (and night). T_{soil} often exceeds canopy temperature, on average 10-15ºC, and the largest differences between T_{soil} and T_C occur at 14h, when sun is at its zenithal position and sun beams are more perpendicular to the soil. Results from the two years, indicate that canopy temperature can be a simple but robust thermal indicator to assess vine's performance (Fig. 1). Correlations between gs and Ψ_{pd} and the T_C measured between 14.00h and 17.00h ($T_{C14-17h}$) were particularly strong in 2015 (Fig. 1), when climatic conditions were more stressful (dryer and hotter) than in 2014 (data not shown). Differences between genotypes were not evident under the tested growing conditions. The strong correlation between $T_{C14-17h}$ and major eco-physiological parameters suggest that canopy temperature can be explored as a simple but robust thermal indicator for irrigation management and eventually as a parameter to feed growth models for grapevine.

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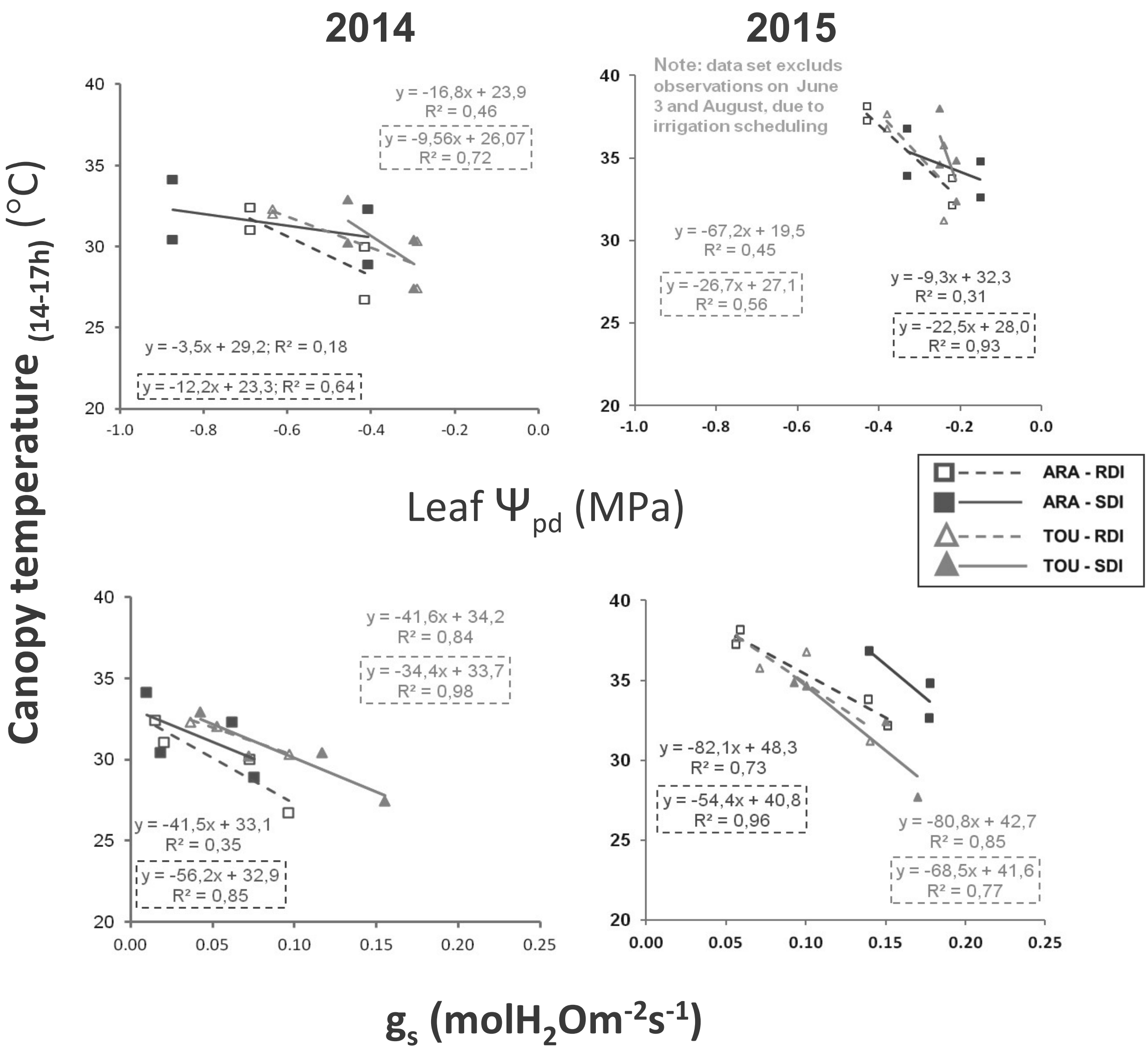

Figure 1. Correlation between sunlit canopy temperature measured between 14 and 17 hours ($T_{C\ 14\text{-}17h}$), and two major eco-physiological parameters (leaf water potential at predawn -Ψ_{pd}, and leaf stomatal conductance to water vapour - gs, measured for ARA and TOU vines subjected to two deficit irrigation strategies (RDI e SDI), in the years of 2014 and 2015.