LOW-COST SENSORS AS A SUPPORT TOOL TO MONITOR SOIL-PLANT HEAT EXCHANGES IN MEDITERRANEAN VINEYARDS

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BACKGROUND and AIMS:

In vineyards, row distribution and canopy geometry favor a high sunlight exposure of vines and soil. As a result, soil contribution to vineyards energy balance is very considerable (Costa et al., 2018; 2019; Kool et al., 2021). This is particularly marked for extreme dry and warm conditions of Mediterranean regions during ripening. The "cooling effect" of irrigation on soil and vines is known but the impact of irrigation on heat convection from soil to the canopy, and to the cluster zone, remains less characterized. The use of low-cost sensors (e.g. low cost infrared thermal cameras) offer new opportunities to monitor and support decision in viticulture. However, they must be tested and validated under field conditions. Here we present preliminary results of low-cost thermal cameras to characterize soil-canopy vertical thermal profiles in Portuguese vineyards.

MATERIAL and METHODS:

A study was carried in an irrigated vineyard, in Herdade do Esporão (HE) (Alentejo, south Portugal), and in a non irrigated vineyard in Quinta da Almoínha (QA), INIAV, Dois Portos (Lisbon region). Soil at HE has a sandy to silty-clay texture while QA's soil has a loam texture. We used two thermal cameras (FLIR One, 80x60 pixels and FLIR C5, 160x120pixels, 8-14 μm, FLIR systems, USA, ε=0.96) (Fig.1) to monitor canopy temperature (Tc) and soil surface temperature (Ts). Air temperature (Tair) and wind speed (U) were measured 0.3 m above soil and 1.0 m above the canopy with two thermohygrometers (CS215-PWS, Campbell Scientific, Logan USA) and two ultrasonic anemometers (Windsonic GILL instruments, UK) (Fig.2), respectively, connected to a datalogger (CR1000, Campbell Scientific, Inc.) (Fig.3). IR images were taken along rows on the sunlit side of canopies. Images were analysed with Flir Tools software, using square ROIs (3000 pixels).

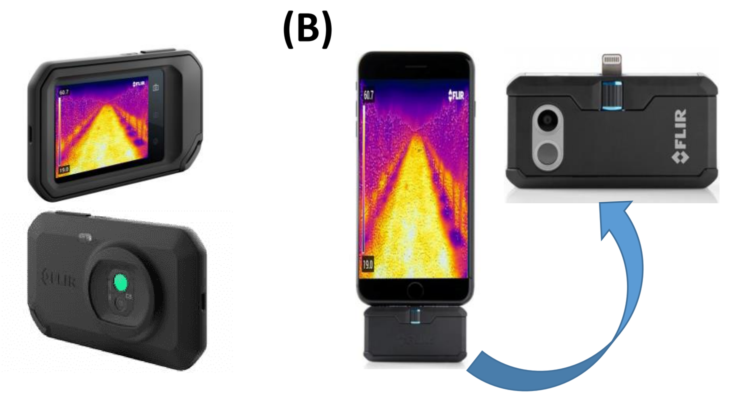


Figure 1. Low-cost thermal cameras.
(A) FLIR One, 80x60 pixels, 8-14 μm,
(B) FLIR C5, 160x120pixels , 8-14 μm

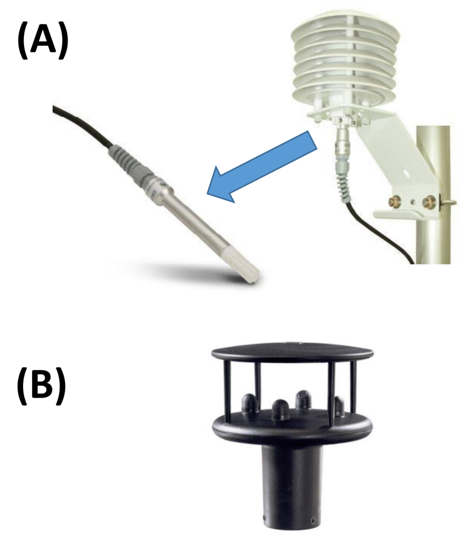


Figure 2. Air temperature and wind speed sensors.
(A) Campbell CS215-PWS thermohygrometer, (B) GILL Windsonic ultrasonic anemometer.

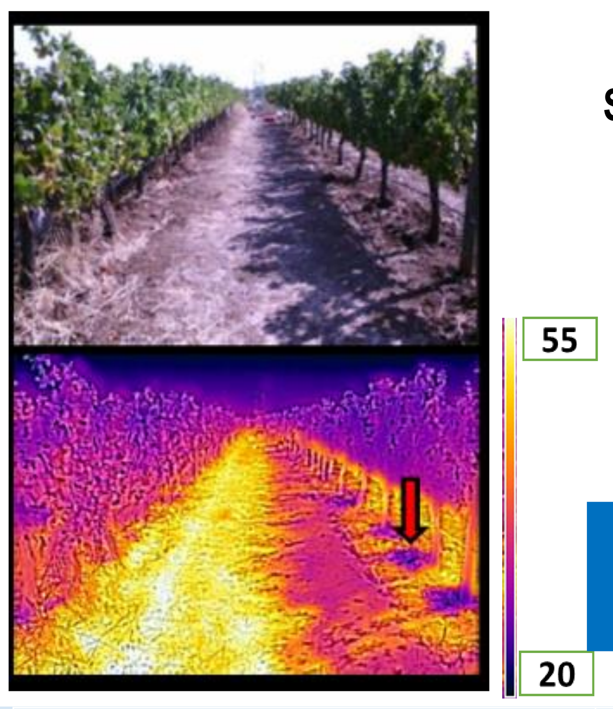
Figure 3. Campbell CR1000 datalogger.

RESULTS:

Flir One measurements descriminated differences between Tc and Ts under Alentejo conditions as well between irrigated and non irrigated vines (data not shown). Data from Flir C5 show that irrigation decreased Ts and Tc at cluster zone by 6 ºC and 1.9 ºC, respectively. Moreover, the daylight time cumulative effect showed less 80 ºC and less 24.4 ºC between the wet and dry soil surfaces, and the related reference Tair above canopy.

15/08/2021

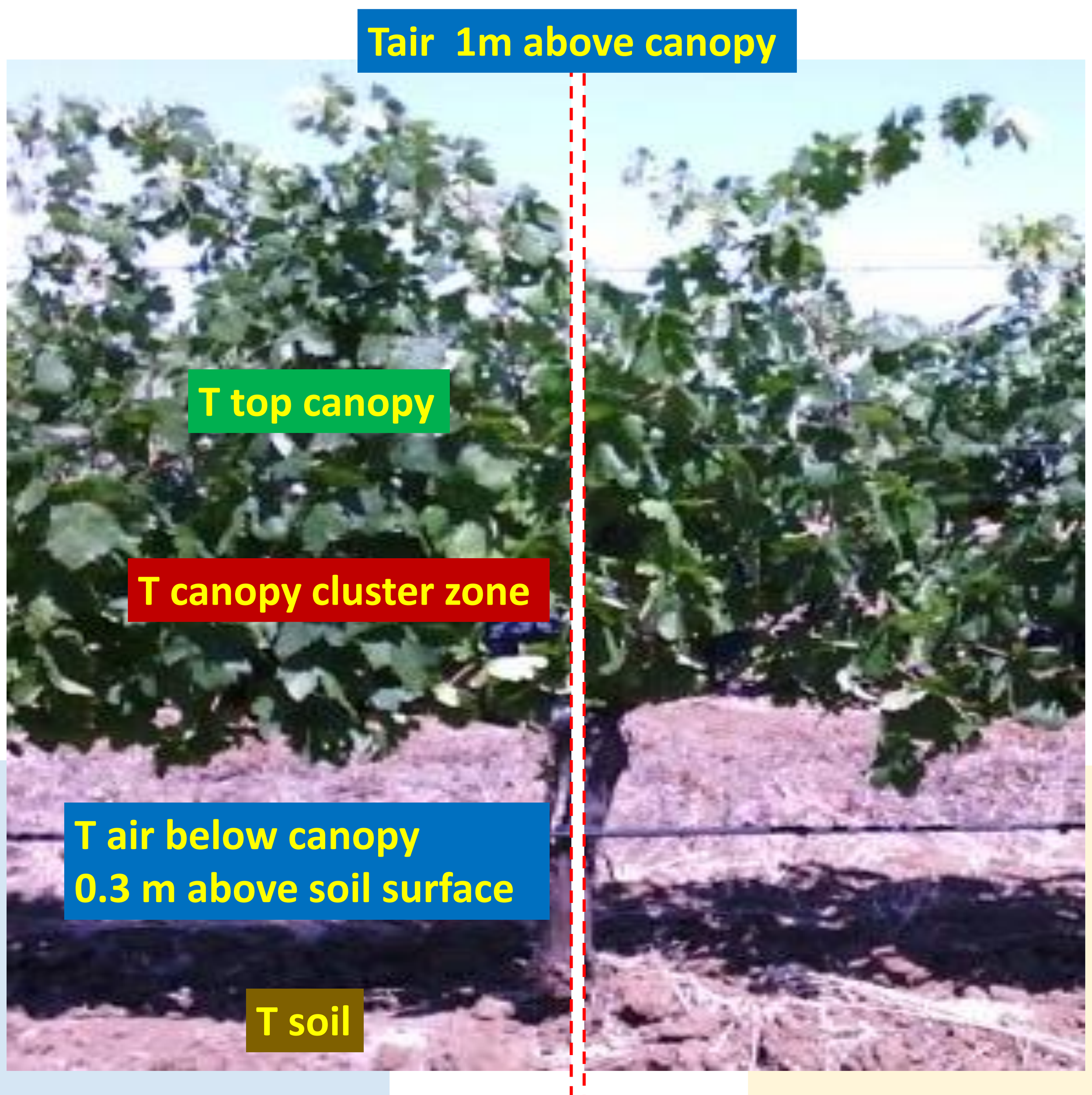
Sunrise	Sunset	Daylength
06:44	20:23	13:39:07



WET surface (AFTER IRRIGATION)

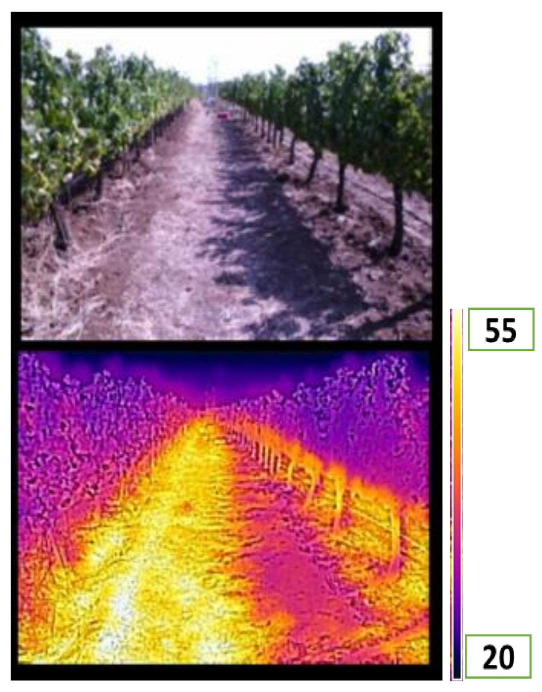
	Daylight time	
	Avg (ºC)	Accum (ºC.day)
ΔT (top canopy - air)	0.8	11.3
ΔT (canopy cluster zone - air)	1.3	17.6
ΔT (air below canopy - air)	0.6	8.9
ΔT (soil - air)	- 3.0	- 41.2

	Tair (ºC) (Above Canopy)	Tsoil (ºC) (Below Canopy)	Tsoil (ºC) (InterRow)	U (m.s-1) (Below Canopy)	U (m.s-1) (InterRow)
max	39.9	34.4	43.7	1.53	1.55
avg (Daylight time)	33.4	30.4	35.9	0.79	0.80
min	20.0	26.5	28.0	0.10	0.09



25/08/2021

Sunrise	Sunset	Daylength
06:53	20:10	13:16:36



DRY surface (BEFORE IRRIGATION)

	Daylight time	
	Avg (ºC)	Accum (ºC.day)
ΔT (top canopy - air)	2.8	36.7
ΔT (canopy cluster zone - air)	3.2	42.0
ΔT (air below canopy - air)	1.4	18.5
ΔT (soil - air)	3.0	39.3

	Tair (ºC) (Above Canopy)	Tsoil (ºC) (Below Canopy)	Tsoil (ºC) (InterRow)	U (m.s-1) (Below Canopy)	U (m.s-1) (InterRow)
max	31.9	34.5	41.6	1.35	1.54
avg (Daylight time)	27.9	30.9	34.8	0.80	0.92
min	19.5	27.5	28.4	0.18	0.14

CONCLUSIONS & FUTURE:

The use of low-cost thermal cameras and thermohygrometers can detect vertical T differences/gradients in vines in response to wet and dry soil conditions. These thermal parameters can be relevant for DSS applications for vineyard management. Future development and data validation is needed to incorporate thermal data in real time DSS.

REFERENCES:

Costa et al. (2019). *Canopy and soil thermal patterns to support water and heat stress management in vineyards.* Agricultural Water Management, 216: 484-496; **Costa et al. (2018).** *Water and heat fluxes in Mediterranean vineyards: indicators and relevance for management*. In: Garcia-Tejero, IF; Durán-Zuazo, VH (Eds.). Water Scarcity and Sustainable Agriculture in Semiarid environment: Tools, Strategies and Challenges for Woody Crops. Academic Press, Elsevier.;**Kool et al. (2021).** *Energy partitioning between plant canopy and soil, performance of the two-source energy balance model in a vineyard*. Agricultural and Forest Meteorology, 300: 108328.

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INTERPHENO - UMA APROXIMAÇÃO INTERDISCIPLINAR À FENOTIPAGEM DE ALTO DÉBITO EM PLANTAS
PDR2020-101-031010 – WINECLIMADAPT – SELEÇÃO E CARACTERIZAÇÃO DAS CASTAS MAIS BEM ADAPTADAS A CENÁRIOS DE ALTERAÇÕES CLIMÁTICAS - WINECLIMADAPT