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Short communication

Thermal sensing of crop: An insight on water stress

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With the global issue of water scarcity on the rise, the need for precise irrigation scheduling strategies has become essential for effective crop management. Irrigation management is crucial to optimize crop yield and also conserving limited water resources. The crop water status indicates the current condition from sufficiently watered to severely stressed. Plant physiological parameters like stomatal conductance and leaf water potential have been used as indicators to evaluate the crop water stress. Traditionally, irrigation scheduling has relied on the physiological indicators such as evapotranspiration and soil moisture measurements (Fernández-Novales *et al.,* 2018). However, these conventional approaches are labour intensive and require skilled personnel to handle the instruments effectively (Gutiérrez *et al.,* 2018). To enhance irrigation management, there is a growing need for rapid, non-destructive methods to monitor crop water stress. In this context, infrared thermal imagery has emerged as a convenient and efficient tool for detecting and quantifying water stress in crops (Meron *et al.,* 2010; Pineda *et al.,* 2020; Soni *et al*., 2023; Payares *et al.,* 2025).

Temperature plays a crucial role in regulating various physiological processes in plants. The advancement of infrared thermal sensing technology provides a precise and efficient approach for detecting and quantifying crop water stress (Patel *et al.,* 2001; Zhou *et al.,* 2021). Ground-based thermal imaging can serve as a primary decision-support tool for optimizing irrigation scheduling. Given the strong and direct correlation between canopy temperature and plant water status under specific solar positions and atmospheric conditions, irrigation strategies based on canopy temperature closely align with real-time water stress monitoring. This approach offers a more responsive and adaptive alternative compared to conventional calendar-based or meteorological-driven irrigation scheduling methods.

Canopy temperature, can be defined as the average temperature of multiple leaf assemblages aggregated from individual branches up to whole crowns. It strongly influences, and is influenced by ecosystem - atmosphere exchanges of water, energy, and carbon (Fig. 1).

Spatial variability of canopy temperature is closely related to irrigation management practices, irrigation application uniformity, and more directly to water deficit. Canopy temperature is related to plant water stress because the evaporative cooling involved in transpiration may cool leaves below ambient air temperature. If soil water is limiting, plant water stress develops, transpiration decreases and the canopy temperature rises. This phenomenon can be observed in Fig. 2 where decrease in volumetric water content (VWC) during June month resulted in higher canopy temperature in comparison to the July month. Plants with adequate supply of water maintained their canopy temperature below the air temperature, whereas the plants with inadequate supply of water exhibited their

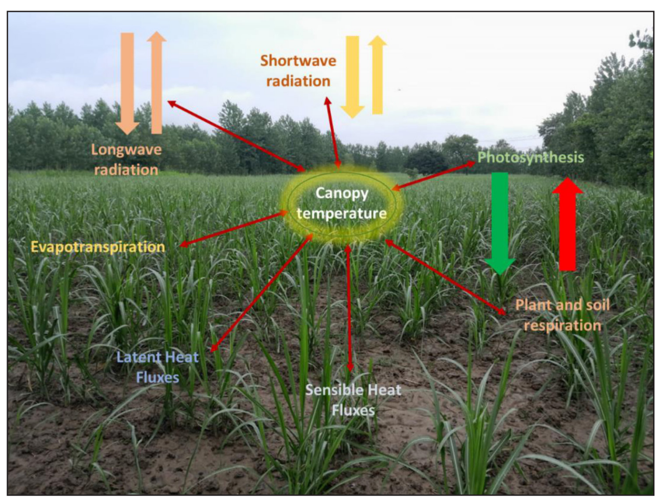

Fig. 1: Energy, water, and carbon fluxes influenced by and influencing canopy temperature

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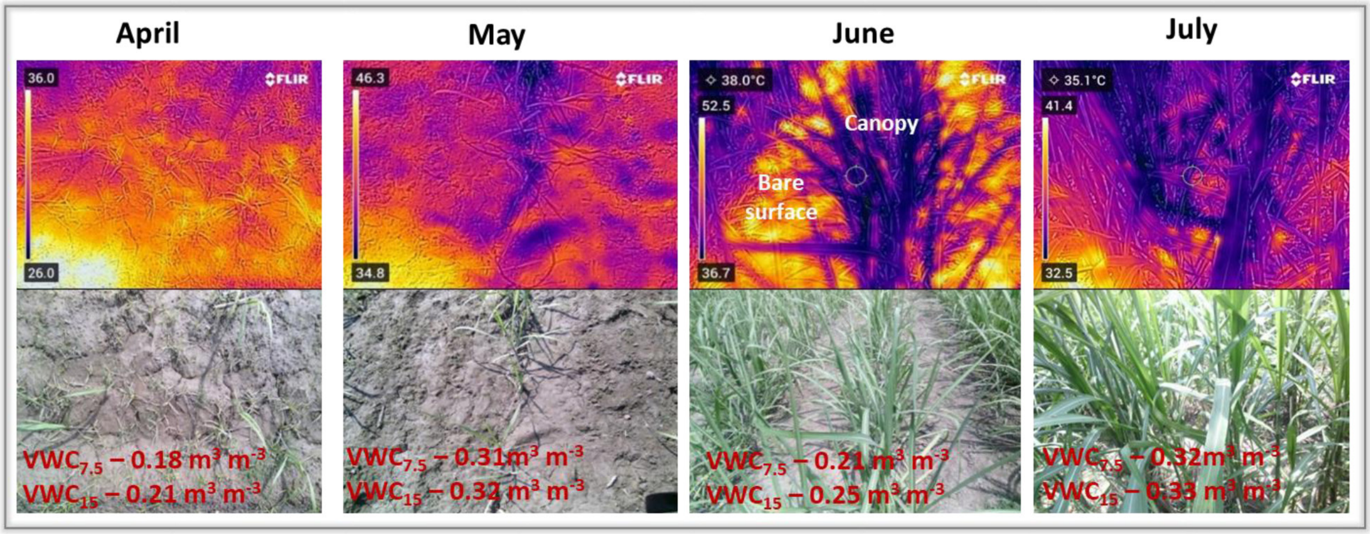

Fig. 2: Thermal imaging of sugarcane crop in year 2023

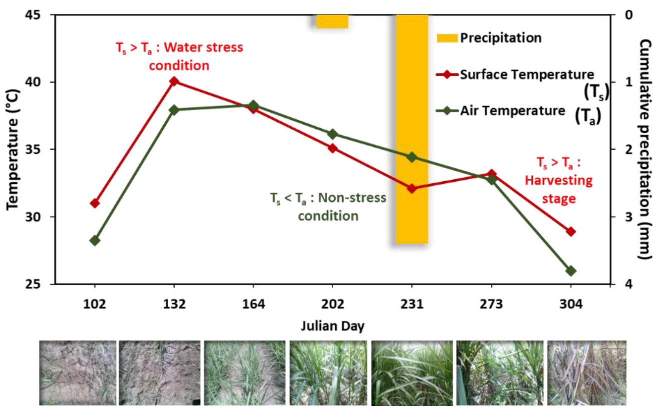

Fig. 3: Pattern of surface temperature, air temperature and precipitation during the sugarcane growing period in year 2023

canopy temperature above the air temperature.

Infrared thermography presents distinct advantages over traditional gas-exchange measurements in plant phenotyping, particularly for assessing stomatal responses under varying environmental conditions. Stomatal closure, a key physiological response to abiotic stressors such as soil moisture deficits and elevated atmospheric vapor pressure deficit (Pokhariyal *et al.,* 2023), directly influences the thermal gradient between air temperature (Ta) and canopy or surface temperature (Ts), making it a reliable proxy for water stress assessment (Fig. 3). During the early growth stages of the sugarcane crop, Ts exhibited higher values than Ta, indicative of plant water stress. Conversely, during the grand growth stage, adequate irrigation and precipitation contributed to a significant reduction in Ts relative to Ta, signifying optimal water availability and non-stress conditions. Furthermore, the Ts-Ta differential serves as an indicator of crop developmental stages.

In the initial phases of growth, young plants with underdeveloped root systems exhibit heightened susceptibility to water stress, leading to reduced transpiration and an increase in canopy temperature above ambient air temperature. A comparable pattern is observed during senescence, where aging or water-deficient plants experience a decline in transpiration efficiency, causing Ts to rise above Ta.

During periods of vigorous vegetative growth, such as the grand growth phase in sugarcane, a well-established root system facilitates efficient water uptake, enhancing transpiration rates and consequently reducing Ts below Ta. Sufficient irrigation and precipitation further contribute to the maintenance of lower canopy temperatures, reflecting optimal physiological function and a non-stressed state. If the Ts remains consistently higher than the Ta, it can be a strong indicator of ongoing water stress regardless of the growth stage. This could signal the need for irrigation or other management interventions.

Canopy temperature therefore provides direct insight into plant eco-physiological processes including rates of photosynthetic carbon dioxide assimilation and transpiration (Pineda *et al.,* 2020; Farella *et al.,* 2022). Thermal imagery could also be applied for disease detection, mapping soil properties, tillage mapping, drainage tile mapping, crop maturity mapping, and leaf water potential mapping. With the rapid advancements in imaging acquisition technologies and deep learning methodologies for canopy segmentation in thermal imagery and crop water stress prediction models, the integration of infrared thermal imaging for water stress assessment is poised to become increasingly prevalent in precision agriculture. Its widespread adoption in agricultural practices is expected in the near future, offering enhanced accuracy and efficiency in monitoring plant water status.

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REFERENCES

Farella, M. M., Fisher, J. B., Jiao, W., Key, K. B. and Barnes, M. L. (2022). Thermal remote sensing for plant ecology from leaf to globe. *J. Ecol.*, 110(9): 1996-2014.

Fernández-Novales, J., Tardaguila, J., Gutiérrez, S., Marañón, M. and Diago, M. P. (2018). In field quantification and discrimination of different vineyard water regimes by on-the-go NIR spectroscopy. *Biosyst. Eng.*, 165: 47-58.

Gutiérrez, S., Diago, M. P., Fernández-Novales, J. and Tardaguila, J. (2018). Vineyard water status assessment using on-the-go thermal imaging and machine learning. *PLoS One*, 13(2): e0192037.

Meron, M., Tsipris, J., Orlov, V., Alchanatis, V. and Cohen, Y. (2010). Crop water stress mapping for site-specific irrigation by thermal imagery and artificial reference surfaces. *Precis. Agric.*, 11: 148-162.

Patel, N. R., Mehta, A. N. and Shekh, A. M. (2001). Canopy temperature and water stress quantification in rainfed pigeonpea (*Cajanus cajan* (L.) Millsp.). *Agric. For. Meteorol.*, 109(3): 223-232.

Payares, L. K., Gomez-del-Campo, M., Tarquis, A. M. and García, M. (2025). Thermal imaging from UAS for estimating crop water status in a Merlot vineyard in semi-arid conditions. *Irrig. Sci.*, 43(1): 87-103.

Pineda, M., Barón, M. and Pérez-Bueno, M. L. (2020). Thermal imaging for plant stress detection and phenotyping. *Remote Sens.*, 13(1): 68.

Pokhariyal, S., Patel, N. R., Danodia, A. and Singh, R. P. (2023). Heat wave characterization and its impact on carbon and water vapour fluxes over sugarcane-based agroecosystem. *J. Agrometeorol.*, 25(3): 375-382. https://doi.org/10.54386/jam.v25i3.2239

Soni, A. K., Tripathi, J. N., Ghosh, K., Sateesh, M. and Singh, P. (2023). Evaluating crop water stress through satellite-derived crop water stress index (CWSI) in Marathwada region using Google Earth Engine. *J. Agrometeorol.*, 25(4): 539-546. https://doi.org/10.54386/jam.v25i4.2211

Zhou, Z., Majeed, Y., Naranjo, G. D. and Gambacorta, E. M. (2021). Assessment for crop water stress with infrared thermal imagery in precision agriculture: A review and future prospects for deep learning applications. *Comp. Electron. Agric.*, 182:106019.