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Better water use efficiency in vineyard by using visible and near infrared spectroscopy for grapevine water status monitoring

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Summary
Optimizing water consumption and improving its quality are considered central issues for the future also in the wine industry which places a significant demand on the world's water resources. Grapevine growing regions are mostly characterised by water stress conditions due to high evaporative demand and low water availability. In addition to this, recently the global warming has determined an increasingly use of irrigation. Consequently, a high efficiency of water use is required both by scheduling properly the irrigation system and by measuring the use of water. Nowadays irrigation scheduling in vineyards is performed through the measurement of soil moisture status using time consuming systems that are not easy to apply in field, may be affected by cumulative errors, may not be representative because of soil heterogeneity, and these methods increase moreover the irrigation costs.
The increasing water shortages are leading to develop new tools to better manage irrigation monitoring and scheduling for high water use efficiency. This results in a need of rapid water status monitoring systems in order to better manage crop and irrigation scheduling for a high water use efficiency. The objective was to predict the water status of grapevine in a rapid and non-destructive way using two portable optical devices (vis/NIR and NIR) for measurements directly on the leaves, in order to evaluate the feasibility of a compact-sized simplified handheld and low-cost optical device, based on a few wavelengths appropriately selected. The specific aims were (1) to obtain essential wavelength variables (EV) based on a variable selection method, correlating the vis/NIR and NIR spectra and the water status; (2) to choose a limited number of informative wavelengths; (3) to compare the prediction performance of the calibration models calibrated on the vis/NIR and NIR spectra and those obtained using only the selected wavelengths.
As references, a Scholander pressure chamber was used to measure the water potential (Ψ). Measurements were made during the night in pre-dawn conditions (pre-dawn leaf water potential, Ψ_{plwp}) (3.00 to 5.00 hours, solar time). The water potential (Ψ) was measured immediately after spectral acquisitions.
A variable selection methodology (partial least square regression coefficient analysis, PLS-RCA) was proposed to determine a reduction of variables set that are effective in the prediction of Ψ related to grapevine water status. Multiple linear regression (MLR) was applied to select the candidate wavelengths in order to validate the prediction ability, compared with the PLS models built using the full vis/NIR and NIR spectra. The overall prediction results of the MLR models were satisfactory.
These individual fingerprint wavelengths and simply equations could be used for the design of a simplified LED technology based handheld device which would allow real-time assessment of Ψ directly in field. This envisaged device could be employed for the estimation of the three leaf water potentials (pre-dawn leaf water potential, Ψ_{plwp}; stem water potential, Ψ_{swp}; leaf water potential, Ψ_{lwp}), depending on the measurement timing across the day and the leaf sampling methodology.
The simplified, low-cost, and easy-to-use device proposed allow to avoid specific chemometric analyses and trained personnel, in order to support or replace the tedious and time consuming conventional techniques in the water status assessment of the vineyard providing information useful for a better management of the irrigation scheduling.

Keywords: water stress; irrigation; vis/NIR and NIR spectroscopy; chemometrics; wavelengths selection.