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Assessing plant water relations based on hidden in formation in the hyper-spectral signatures: Parameterization of olive leaf P-V curve and estimation of water potential components

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The Soil Plant Atmosphere Continuum (SPAC) is characterized by complex structures and biophysical processes acting over a wide range of temporal and spatial scales. Additionally, in olive grove systems, the plant adaptive strategies to respond to soil water-limited conditions make the system even more complex. One of the greatest challenges in hydrological research is to quantify changing plant water relations. A promising new technology is provided by the advent of new field spectroscopy detectors, characterized by very high resolution over the spectral range between 300 and 2500 nm, allowing the detection of narrow reflectance or absorptance peaks, to separate close lying peaks and to discover new information, hidden at lower resolutions.

The general objective of the present research was to investigate a range of plant state function parameters in a non-destructive and repeatable manner and to improve methodologies aimed to parameterize hydrological models describing the entire SPAC, or each single compartment (soil or plant). We have investigated the use of hyperspectral sensing for the parameterization of the hydraulic pressure-volume curve (P-V) for olive leaf and for the indirect estimation of the two principal leaf water potential components, i.e. turgor and osmotic potentials.

Experiments were carried out on an olive grove in Sicily, during the mature phase of the first vegetative flush. Leaf spectral signatures and associated P-V measurements were acquired on olive leaves collected from well-irrigated plants and from plants maintained under moderate or severe water stress.

Leaf spectral reflectance was monitored with a FieldSpec 4 spectro-radiometer (Analytical Spectral Device, Inc.), in a range of wavelengths from VIS to SWIR (350-2500 nm), with sampling intervals of 1.4 nm and 2.0 nm, respectively in the regions from 350 to 1000 nm and from 1000 to 2500 nm. Measurements required the use of contact probe and leaf clip (Analytical Spectral Device, Inc.), specifically designed for plant leaves. Immediately after each spectral acquisition, water potential was measured on the same leaf with a Scholander pressure chamber (Skye, Powys, UK), by following the standard procedure usually adopted to detect leaf P-V curves (Vilagrosa et al. 2003). The relationship between pressure and volume was represented by means of the Höfler diagram (Richter, 1978) and modeled following an analytical approach.

In order to parameterize the the P-V curve and to estimate the leaf water potential components, spectral indices were then examined, considering the features of water absorption in SWIR domain, sensitive to changes in leaf water content, and in NIR domain of the spectrum, sensitive to changes in leaf internal structure. A number of spectral indices were found to be related to patterns in the Höfler diagram, for leaves collected under different intensities of crop water stress. Moreover, results show that a fundamental characteristic point of the Höfler diagram, the turgor loss point, can be identified when indices accounting for both SWIR and NIR domains are considered.

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