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Seasonal variation in canopy reflectance and its application to determine the water status and water use by citrus trees in the Western Cape, South Africa

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Abstract

This study describes the diurnal and seasonal dynamics of the canopy reflectance, water use and water status of Midknight Valencia citrus trees under semi-arid conditions. Hyperspectral canopy reflectance data was collected on 30 trees at monthly intervals over a period of 16 months in a commercial orchard in South Africa. The mean canopy reflectance in the wavelength range 350–2500 nm followed a clear seasonal trend influenced by environmental conditions and tree phenology. Mean monthly reflectance peaked in summer (~22%) while the lowest value (~15%) was reached in winter with the seasonal changes in the sun's position accounting for a significant proportion of the variations. A sensitivity analysis of a Penman–Monteith transpiration model showed that water use by individual trees changed by up to 13% when the canopy reflectance was varied over the seasonal range of measured values. This suggested that the seasonal changes in tree water use influenced the seasonal trend of the canopy reflectance. Thus monitoring the canopy reflectance of citrus trees could

offer information on the tree water status. To test this, sap flow data of water uptake and loss by the trees were compared with the canopy spectra. Sap flow data showed a heavy reliance by the citrus trees on the internally stored water with up to 25% of the daily total transpiration withdrawn from the trees' internal water storage pools when soil water was limited. This depletion of internally stored water, and hence the change in tree water status, was detected using spectral indices based on the first order derivatives of the canopy reflectance centered at two and, at most, four spectral bands. We conclude that even if citrus trees are evergreen, their canopy reflectance changes significantly throughout the year with a considerable impact on tree energy balance and water use. In addition, the contribution of the internally stored water to daily transpiration is a possible indicator of drought stress for citrus trees detectable from changes in canopy reflectance and it has potential applications in irrigation scheduling using canopy level spectral information.

Keywords

- Drought stress;
- Hyperspectral remote sensing;
- Internal water use;
- Sap flow;
- Transpiration model

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