NITROGEN ESTIMATION IN ALMOND ORCHARDS FROM DESIS IMAGING SPECTROMETER ONBOARD THE INTERNATIONAL SPACE STATION

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ABSTRACT

Accurate nitrogen (N) assessment is crucial for precise and sustainable agricultural management. Understanding crop nutrient status in a timely manner is essential to improve the efficiency of fertilizer application throughout the growing season across the entire farm. Standard remote sensing methods for N assessment are built upon empirical relationships with structural and chlorophyll-sensitive vegetation indices derived from multispectral sensors. In contrast, hyperspectral imagers can collect detailed spectral signatures resulting from the combination of all biochemical constituents and canopy structure, which provides more physiological links for improved crop N quantification. In addition to the high spectral and temporal resolutions, hyperspectral sensors onboard satellite and airborne platforms can collect imagery over large areas allowing for the monitoring of nitrogen levels across entire farms. Nevertheless, unlike homogenous crops, the detailed assessment of tree orchards requires higher spatial resolutions to reduce the extensive effects of canopy structure and soil background. Therefore, it is important to understand the applicability of coarser-resolution satellite imagery with hyperspectral capabilities for the accurate prediction of N in heterogeneous orchards.

This study explores the feasibility and performance of N status assessment from the German Aerospace Center (DLR) Earth Sensing Imaging Spectrometer (DESIS) over a 1,200-hectare almond orchard, as compared to high-spatial resolution airborne hyperspectral imagery. The experiment was conducted throughout the almond growing season from Nov 2020 to Jan 2021 in Victoria, Australia. Two airborne campaigns were conducted at almond kernel-filling and pre-harvest stages. A hyperspectral VNIR camera (Headwall Photonics, Fitchburg, MA, USA) was installed on board an aircraft, collecting imagery at a 40 cm spatial resolution and 358 bands in the 400-1000 nm spectral range. DESIS hyperspectral sensor on board the International Space Station (ISS) was used to collect imagery with 235 spectral bands in the 400-1000 nm at 2.55 nm spectral resolution (FWHM) and 30 m spatial resolution. Work was carried out to cross-validate the DESIS reflectance spectra from the airborne imagery using field targets comprising dense canopy, soil, water body and mixed features. Results of the analysis carried out using the NIR and different spectral bands in the visible part of the spectrum will be discussed.

Previous work for N assessment at the orchard level enabled the generation of a nitrogen map using the airborne hyperspectral imagery from advanced spectral-based plant traits comprising Solar-Induced Fluorescence (SIF) and chlorophyll $a+b$ content estimated from FluSAIL radiative transfer model, validated against ground truth measurements ($r^2=0.95$; $p<0.001$). The methodology was applied to every tree in the entire orchard using the airborne hyperspectral mosaic, obtaining a high-resolution map of N distribution. Assessment of N estimates from DESIS hyperspectral imagery will be discussed, assessing the structural effects of non-homogeneous orchard canopies on the accuracy of parameter retrievals. This research will contribute to the evaluation of DESIS for precision agriculture applications, in particular for large-scale mapping of N in tree crops.

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