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Comparison between hyperspectral indices and traits derived from biophysical model for assessing winter wheat genotypes performance

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Nitrogen (N) is the nutrient most limiting in agricultural production around the world. However, this resource has been over-applied in agriculture for decades, increasing the environmental and economic costs. Remote sensing is a valuable tool to increase sustainability in farming systems; nevertheless, specific strategies to improve N fertilization should be better addressed. The main goal of this work is the assessment of nutritional status, and the detection of different genotypes performance by coupling radiative transfer models (RTM) with machine learning (ML) approaches in wheat (*Triticum aestivum* L.) crops. For that, two field experiments with barley–wheat and pea–wheat crop rotations, three wheat genotypes (Cellule, CH-Nara and Nogal) under two water levels and different N treatments were conducted in central Spain and west Switzerland over 3 years (2018-2020 and 2019-2021). We measured leaf chlorophyll content with SPAD® or Dualex® leaf-clip sensors. Whilst we performed the canopy reflectance (400-1000 nm) with a handheld spectroradiometer at three different wheat growth stages. Additionally, at harvest stage, we estimated the grain yield (GY) and grain N concentration (GNC). We used a hybrid ML method, which combines the simulated reflectance derived from PROSAIL model with ML algorithms, for retrieving chlorophyll (Chl) and leaf area index (LAI). Additionally, different vegetation indices (VIs) were calculated through hyperspectral canopy reflectance. At the beginning of stem elongation, GY was better assessed by the canopy chlorophyll content index (CCCI) in most genotypes in both locations. At the end of stem elongation and flowering, all VIs and plant traits retrieved by the hybrid method obtained higher coefficient of determination (R^2) than SPAD® or Dualex® readings in both locations (except Nogal genotype at flowering the first experimental year in Spain). However, we highlight that the relationships between traits and VIs with GNC showed great variability between years, locations and genotypes. Moreover, the Chl, LAI retrieved by the hybrid method and CCCI showed the best differentiation between genotype performance in both locations, showing the genotype Cellule higher response than Nogal (Spain) and CH-Nara (Switzerland). This study highlights the ability of plant traits retrieved by RT models through hybrid ML method and VIs to assess GY and detect different performances in winter wheat genotypes. However, for GNC assessment more research is necessary.

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