Canopy architectural and spectral phenotypes improve the prediction of radiation use efficiency in wheat canopies.

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October 30, 2023

Abstract

Feeding the world's population of 9 billion by 2040 is one of the major challenges of the agriculture sector. Wheat (*Triticum aestivum* L.) is the second most important staple crop, with a global production of 773 million tonnes per year, but the expected yields need to increase by 60% to ensure future food security. Achieving this requires the development of new cultivars with heightened expression of yield-associated traits, such as radiation use efficiency (RUE), which is fundamental to enhancing plant performance and yield. Recently, plant architectural phenotypes involving leaf inclination angle have shown promising traits in improving RUE at the canopy level. Specifically, the erectophile leaf arrangement exhibits a higher yield potential, receiving more even light distribution than the planophile arrangement, which is susceptible to light saturation on the top layer. This study used a mobile robotic phenotyping system with 3D-multispectral laser scanners and hyperspectral cameras. In 2022 and 2023, data were collected from 100 spring wheat canopies at the heading/anthesis and booting/anthesis stages, respectively. Using 3D data, we estimated canopy tangency angles, identified two architectural phenotypes, and incorporated them into one-dimensional (1D) convolutional neural networks (CNN) to predict canopy-based RUE. Canopy architectural phenotypes in CNN models improved the prediction accuracy of RUE. These findings underscore the potential of canopy architectural traits derived from 3D images as a critical parameter for enhancing RUE predictions in wheat canopies. It could potentially be used in other cereal crops.

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Keywords: Radiation use efficiency, hyperspectral image, 3D plant architectural phenotype, Wheat *(Triticum aestivum*), High-throughput phenotyping