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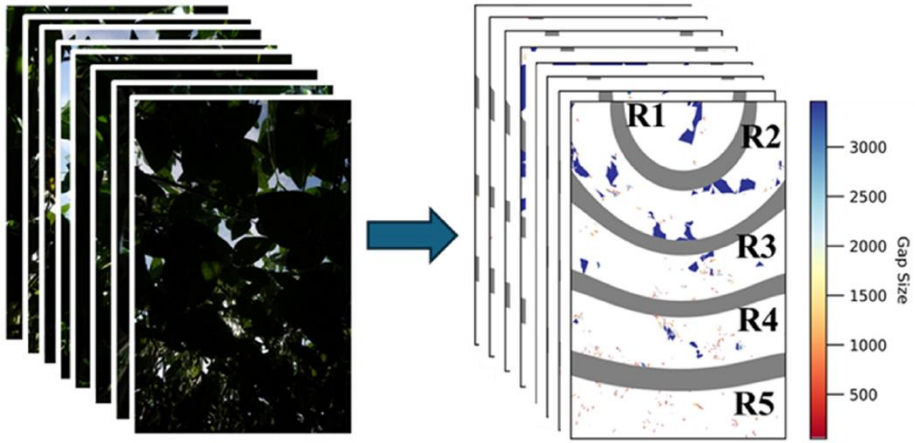
Clumping Index Estimation with 30°-Tilted Cameras in Row Crops: Evaluation of Methods and Segment Size Effects

Background/Objective

Clumping index (CI) quantifies the spatial distribution of foliage and is an essential variable for understanding vegetation canopy structure, radiative transfer processes, and photosynthesis. Existing methods for CI quantification have not been comprehensively evaluated in row crops and while digital cameras offer a cost-effective solution for canopy measurements in row crops, their application for CI quantification has not been thoroughly explored. This study applies a new approach using 30°-tilted digital cameras in conjunction with existing methods to quantify CI in corn and soybean fields.

Approach

Researchers evaluated CI estimates via three different methods: finite-length averaging (LX), gap size distribution (CC), and a combined approach of CC and LX (CLX). Performance was assessed for the three methods by combining field measurements from 30°-tilted cameras in corn and soybean fields with simulations using the LESS 3D radiative transfer model.



30° tilted camera images from a soybean field (left) and gap sizes of each ring determined after image classification (right). White, grey, and color bars represent plant components, the excluded view zenith angle range, and gap size, respectively.

Results

The 30°-tilted camera effectively captured CI variation across different angles and growth stages, making it a practical and robust instrument for row crop canopy structure analysis. The 30°-tilted camera effectively captured multi-angular gap fractions and gap size distributions in row crops, overcoming key limitations of traditional instruments in these environments. Each CI method showed distinct but internally consistent angular and seasonal trends, with CLX-whole (utilizing the whole image), CLX-45 (utilizing a 45° image segment), and LX-15 (utilizing a 15° image segment) being the most accurate across different segment sizes, crop types, and planting configurations.

Significance/Impacts

This work demonstrates that the CI methods tested, combined with digital cameras, offers a low-cost, accessible CI estimation alternative which may be used to enhance canopy structure monitoring accuracy for row crops.

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