BRC Science Highlight
November 2020

Unique Contributions of Chlorophyll and Nitrogen to Predict Crop Photosynthetic Capacity from Leaf Spectroscopy

Objective

The positive relationship between crop yield and CO_2-saturated photosynthetic rate (V_{max}) makes maximizing V_{max} and its related traits, Chl and N_{mass} (chlorophyll and nitrogen), an important management and engineering target for bioenergy crops. Spectroscopic methods have great potential for high-throughput trait measurement, but it is unclear which methods among radiative transfer modeling (RTM), partial-least squares regression (PLSR), and generalized PLSR (gPLSR) perform best. To address this issue, researchers in this study evaluated spectra-based methods for estimating V_{max}, Chl, and N_{mass} and sought to understand the relationships among these traits.

Approach

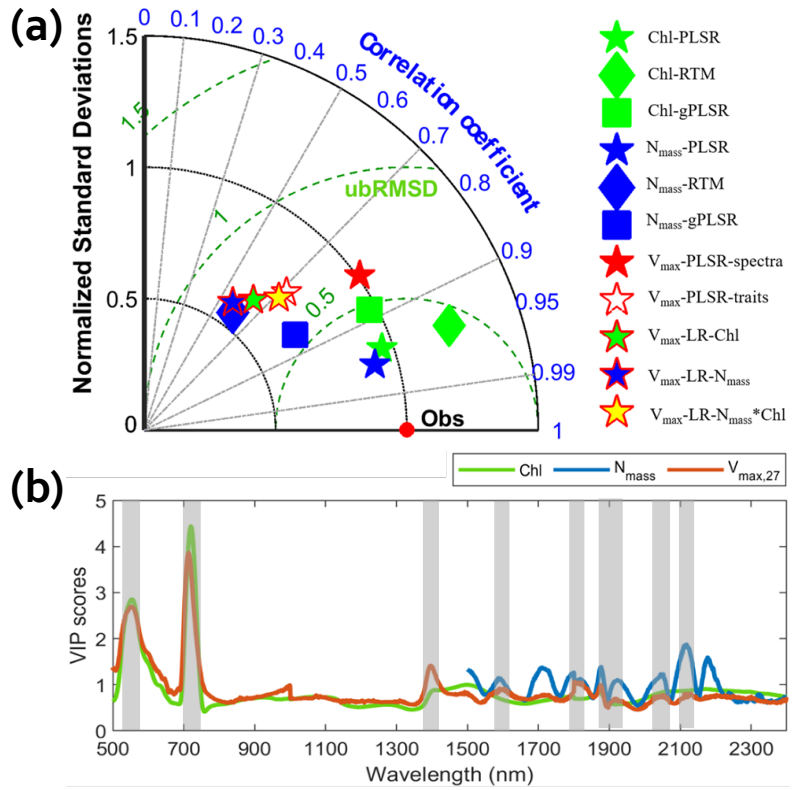
- Conducted field and laboratory experiments to measure leaf spectra and traits in maize
- Comprehensively evaluated RTM, PLSR and gPLSR for estimating Chl, N_{mass}, and V_{max} from spectra
- Performed RTM and PLSR-based spectral contributions to analyze the linkage of Chl, N_{mass}, and V_{max}
- Compared leaf trait-based regression models to predict V_{max}

Results

- Leaf RTMs considering bidirectional effects gave accurate estimates of Chl, while gPLSR had an added value to predict N_{mass}.
- When field measurements were used for model training, PLSR achieved the best V_{max} prediction.
- Chl and N_{mass} made complementary contributions to the prediction of V_{max}, and their combined use significantly improved V_{max} prediction over the use of either one individually.

Significance

Results of this study may be used to improve V_{max} prediction by incorporating both Chl and N_{mass} data across leaf and canopy scales. This strategy can be applied to other bioenergy crops and could improve crop yield and carbon cycling predictions in ecosystem-scale models of bioenergy cropping systems.



(a) Taylor diagram for evaluating spectroscopic methods. Points that appear closer to the observation point (red) indicate higher model predictive ability. (b) Variable Importance in Projection (VIP) scores for spectral contributions of trait predictions. V_{max} is close to Chl in 500-1500 nm but similar to N_{mass} in 1500-2400 nm.

*Wang, et al. 2020. "Unique Contributions of Chlorophyll and Nitrogen to Predict Crop Photosynthetic Capacity from Leaf Spectroscopy." **Journal of Experimental Botany.** DOI: 10.1093/jxb/eraa432*

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