Leaf-level functional trait predictions in maize crops using UAV-based hyperspectral imaging

Karoll Quijano[1], John Couture[2,3], Michael Mickelbart[4], Elisabeth Joll[3], Mitchell Tuinstra[5], and Melba Crawford[1,5,6]

[1]Department of Agricultural and Biological Engineering
[2]Department of Entomology
[3]Department of Forestry and Natural Resources
[4]Department of Botany
[5]Department of Agronomy
[6]School of Civil Engineering, Purdue University

October 31, 2023

Abstract

Plant functional traits capture essential morphological, physiological, or phenological characteristics of plants that influence growth, resource allocation, and survival. These traits can be used to identify plant adaptations to changes in the environment. Functional traits that are indicators of water status in plants can be used to identify adaptative mechanisms to overcome drought. Measuring functional traits using standard approaches is costly, time consuming, and destructive. Vegetation spectroscopy has been shown to estimate a wide variety of plant functional traits, but still can involve extensive field work. Using proximal spectral measurements as a training input for unpiloted aerial vehicle (UAV) collections can potentially bridge spatial gaps between point-based reference and proximal measurements and whole-field UAV measurements. This research proposes a non-destructive approach to transition from proximal spectroscopy to high resolution UAV imagery to predict photosynthetic and water relation traits in maize hybrids grown in two different environments under varying levels of water availability. Both proximal and UAV collected spectral measurements covered the visible, near infrared, and shortwave infrared regions. Partial least squares regression (PLSR) models were developed for both proximal spectra, using reference measurements, and UAV spectra, using proximal predictions as response variable. Many UAV-based PLSR models, including chlorophyll concentration, CO_2 assimilation, osmotic potential, and succulence, performed well with goodness of fit statistics over 0.60. These preliminary results highlight the opportunity to advance the capabilities of UAV-based hyperspectral imaging to rapidly and non-destructively predict leaf-level functional traits related to drought, improving breeding approaches and genotype selection.

NAPPN Annual Conference Abstract: Leaf-level functional trait predictions in maize crops using UAV-based hyperspectral imaging.

***Karoll Quijano*[1]**, *John Couture*[2,3], *Michael Mickelbart*[4], *Elisabeth Joll*[3], *Mitchell Tuinstra*[5], *Melba Crawford*[1,5,6]

[1]*Department of Agricultural and Biological Engineering*, [2]*Department of Entomology*, [3]*Department of Forestry and Natural Resources*, [4]*Department of Botany*, [5]*Department of Agronomy*, [6]*School of Civil Engineering*

Purdue University, West Lafayette, IN, USA

Corresponding author: couture@purdue.edu

ORCiD: 0000-0003-4968-7053

Keywords: Plant functional traits, Gas exchange, Hyperspectral imaging, Maize, Partial least squares regression, Remote sensing, Proximal sensing, Water absorption.

Plant functional traits capture essential morphological, physiological, or phenological characteristics of plants that influence growth, resource allocation, and survival. These traits can be used to identify plant adaptations to changes in the environment. Functional traits that are indicators of water status in plants can be used to identify adaptative mechanisms to overcome drought. Measuring functional traits using standard approaches is costly, time consuming, and destructive. Vegetation spectroscopy has been shown to estimate a wide variety of plant functional traits, but still can involve extensive field work. Using proximal spectral measurements as a training input for unpiloted aerial vehicle (UAV) collections can potentially bridge spatial gaps between point-based reference and proximal measurements and whole-field UAV measurements. This research proposes a non-destructive approach to transition from proximal spectroscopy to high resolution UAV imagery to predict photosynthetic and water relation traits in maize hybrids grown in two different environments under varying levels of water availability. Both proximal and UAV collected spectral measurements covered the visible, near infrared, and short-wave infrared regions. Partial least squares regression (PLSR) models were developed for both proximal spectra, using reference measurements, and UAV spectra, using proximal predictions as response variable. Many UAV-based PLSR models, including chlorophyll concentration, CO_2 assimilation, osmotic potential, and succulence, performed well with goodness of fit statistics over 0.60. These preliminary results highlight the opportunity to advance the capabilities of UAV-based hyperspectral imaging to rapidly and non-destructively predict leaf-level functional traits related to drought, improving breeding approaches and genotype selection.