

Foliar Reflectance and Fluorescence Responses for Plants Under Nitrogen Stress Determined with Active and Passive Systems

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Abstract- Vegetation productivity is driven by nitrogen (N) availability in soils. Both excessive and low soil N induce physiological changes in plant foliage. In 2001, we examined the use of spectral fluorescence and reflectance measurements to discriminate among plants provided different N fertilizer application rates: 20%, 50%, 100% and 150% of optimal N levels. A suite of optical, fluorescence, and biophysical measurements were collected on leaves from field grown corn (*Zea mays* L.) and soybean plants (*Glycine max* L.) grown in pots (greenhouse + ambient sunlight daily). Three types of steady state laser-induced fluorescence measurements were made on adaxial and abaxial surfaces: 1) fluorescence images in four 10 nm bands (blue, green, red, far-red) resulting from broad irradiance excitation; 2) emission spectra (5 nm resolution) produced by excitation at single wavelengths (280, 380 or 360, and 532 nm); and 3) excitation spectra (2 nm resolution), with emission wavelengths fixed at wavelengths centered on selected solar Fraunhofer lines (532, 607, 677 and 745 nm). Two complementary sets of high resolution (< 2 nm) optical spectra were acquired for both adaxial and abaxial leaf surfaces: 1) optical properties (350-2500 nm) for reflectance, transmittance, and absorptance; and 2) reflectance spectra (500-1000 nm) acquired with and without a short pass filter at 665 nm to determine the fluorescence contribution to "apparent reflectance" in the 650-750 spectrum, especially at the 685 and 740 nm chlorophyll fluorescence (ChlF) peaks. The strongest relationships between foliar chemistry and optical properties were demonstrated for C/N content and two optical parameters associated with the "red edge inflection point". Select optical properties and ChlF parameters were highly correlated for both species. A significant contribution of ChlF to "apparent reflectance" was observed, averaging 10-25% at 685 nm and 2-6% at 740 nm over all N treatments. Discrimination of N treatment groups was possible with specific fluorescence band ratios (e.g., F740/F525 obtained with 380EX). From all measurements assessing fluorescence, higher ChlF and blue/green emissions were measured from the abaxial leaf surfaces; Abaxial surfaces also produced higher reflectances in the 400-800 nm spectrum. Fluorescence information collected in Fraunhofer regions located on the shoulders of ChlF features compared favorably with peak emissions. This supports the potential capability of a future space-born interferometer sensor to capture plant canopy fluorescence.

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