TEMPORAL AND SPATIAL DYNAMICS OF SPECTRAL BIO-INDICATORS AND PHOTOSYNTHETIC ACTIVITIES IN A CORNFIELD

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INTRODUCTION

Canopy-level and leaf-level Spectral Bio-indicators indices derived from hyperspectral field data were examined for temporal dynamics in conjunction with carbon and energy fluxes and meteorological observations made from an instrumented tower. This was accomplished through intensive field-based campaigns conducted in an experimental cornfield at the USDA/Agricultural Research Service (ARS) in Beltsville, MD. During one day per week, diurnal measurements were made over a six week period in 2007 (see Hummerich *et al.*, 2008) and over a 14 week period in 2008 along a transect within the tower footprint. In 2009, daily spectrometer measurements were acquired over a five week period in the adjacent nitrogen treatment plots (supplemental N at 0%, 50%, 100% and 150% of the optimal N).

Define Terms: PRI = Photochemical Reflectance Index; SIF = Solar Induced Fluorescence; Fyield = Fluorescence Yield=SIF/PAR; FLD = Fraunhofer Line Depth; NEP = Net Ecosystem Production; PAR = Photosyntheically Active Radiation; LUE =Light Use Efficiency

METHODS

- **High resolution (~1 nm) canopy-level spectral measurements (USB4000 Miniature Fiber Optic Spectrometer, Ocean Optics Inc., Dunedin, Florida, USA) used to determine SIF and PRI.**
- **PRI = [ρ531 - ρ570] / [ρ531 + ρ570].**
- **SIF was derived using FLD retrieval approach centered on the two atmospheric oxygen bands at 688 (O_2-B; F@Red) and 760 nm (O_2-A; F@FarRed).**
- **NEP and PAR were tower-derived; LUE was calculated as NEP/PAR.**

RESULTS

- **Considerable within-day as well as day to day variation was observed for NEP, PAR, and LUE, and all declined over the 2008 growing season (Fig. 1).**

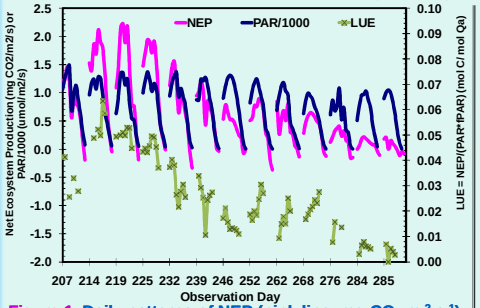

Figure 1. Daily patterns of NEP (pink line, mg CO_2 m^{-2} s^{-1}) and incident PAR (dark blue line, µmol m^{-2} s^{-1}) for the 14 Intensive Study Days in 2008 at the USDA/ARS cornfield. Note: values of PAR were scaled to fit the charting area (PAR/1000).

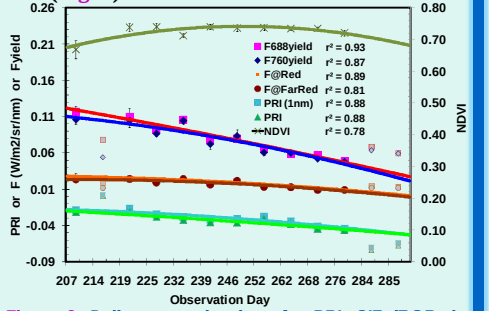

Figure 2. Daily-averaged values for PRI, SIF (F@Red, F@FarRed), Fyield (F688yield, F760yield) and NDVI are plotted against day of the year. Fyield (pink & blue) exhibits the strongest seasonal change for F688yield (r^2 = 0.93) and for F760yield (r^2 = 0.87). SIF values (browns) changed less seasonally. PRI values (green & aqua) also showed strong seasonal declines over the season (r^2 = 0.88).

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RESULTS

- **Daily averages for PRI, SIF and Fyield declined linearly across the growing season as the cornfield progressed through vegetative and reproductive stages, and senescence (Fig. 2).**
- **A linear relationship of between PRI and LUE was apparent over the 2008 growing season, there was considerable variation within each day (Fig. 3). These results are comparable with findings in 2007 (Huemmerich *et al.*, 2008).**
- **N treatment differences expressed in the Red/Far-Red F ratio [F@Red over F@FarRed], with values associated with physiological stress obtained at the low (0%, 50%) and high (150%) N treatment plots (Fig. 4).**

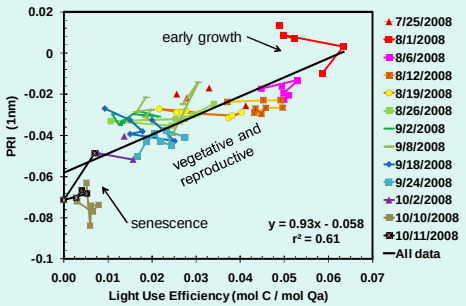

Figure 3. The PRI was determined from average transect reflectances measured with the Ocean Optics (1 nm resolution) versus LUE (mol C/mol Qa) from observations at the UDSA/ARS cornfield in 2008. Colored lines/symbols connect observations collected over the same day. Regression line (r^2 = 0.61, n = 81).

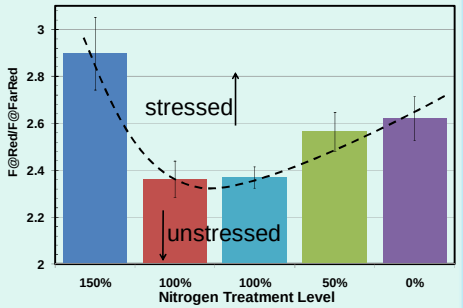

Figure 4. The Red/Far-Red Fluorescence ratio [F@Red/F@FarRed] was determined with the Ocean Optics (1 nm resolution) observations in the nitrogen treatment plots (supplemental N at 0%, 50%, 100%, and 150% of the optimal N) in the UDSA/ARS cornfield in 2009. Higher values indicate higher physiological stress, obtained at both deficient and over-fertilized N levels. Values are means ± S.E.

CONCLUSIONS

We found that canopy-level SIF, Fyield, and the PRI varied significantly throughout each field day, with the available PAR exerting a significant control on responses. The PRI and fluorescence parameter values tracked daily as well as seasonal changes in canopy level physiological stress. PRI successfully described seasonal declines in LUE for the cornfield. SIF showed a clear difference among different nitrogen treatment plots separating non-stressed and stressed plots. Our studies advocate the use of hyperspectral data with various bio-indicators to monitor, estimate and model vegetation physiological status and carbon-related activities.

REFERENCES

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