5.2 USE OF HYPERSPECTRAL REMOTE SENSING IN EVALUATING THE RATE OF NET PHOTOSYNTHESIS AND STRESSED AREAS OF AGRICULTURAL FIELDS

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1. INTRODUCTION

Crop growth and development is a function of various limitations imposed by soil properties and management practices coupled with transient conditions as presented by the weather within the growing season. One way to assess crop development is through the use of the current crop ecophysiological status which can be determined using micrometeorological methods from measurements over agricultural surfaces in an upwind area from an instrumented tower. In relating carbon and water exchanges over larger spatial areas, remote sensing is key. The advantage of hyperspectral reflectance (HR) is that individual pigments or physiological features can be identified and exploited. The work presented, examines the relationship between temporally discrete HR indices and continuous micrometeorological data.

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2. MATERIALS AND METHODS

Ground-based HR measurements were made in nadir orientation above the canopy of a cropped field over three years of corn and two years of wheat. A portable spectroradiometer (GER1500, SVC, Millbrooke, NY) was used with a Spectralon white reference to obtain reflectance between 350-1050 nm. In each year, reflectance measurements were made from areas of the field that either had an imposed N amendment (starter only, sub-optimal N, or recommended N) or was within an area of increased slope/compaction or textural difference. Co-incident with the HR measurements, biomass and other variables were (destructively) sampled from the same sub-areas.

For the HR data, we focused on the photochemical reflectance index (PRI; Gamon *et al*., 1992; 1997) as it has been shown previously to be correlated with radiation use efficiency (Strachan *et al*., 2002) and gross photosynthesis (GP) (Rahman *et al*., 2001). PRI is found from the normalized index:

$$PRI = \frac{R_{531} - R_{570}}{R_{531} + R_{570}}$$

where R_{xxx} is the reflectance from an individual waveband centred at this wavelength. Rahman *et al*. (2001) suggested that PRI should be scaled to avoid negative values as:

$$sPRI = \frac{PRI + 1}{2}$$

They further suggested that the product of sPRI and NDVI was correlated with GP.

At three times during 2001 (wheat) and four times during 2000 (corn) CASI images were acquired thus spanning the range of growing conditions for these crops. These images were atmospherically, radiometrically and geometrically corrected. All images were brought to a common georeferenced master such that separate images could be compared in space.

Throughout each growing season, continuous measurements of CO_2 uptake (net ecosystem exchange) were made using the eddy covariance technique from a tower located in the optimum-N region of the field. Measurements of soil respiration were made such that canopy gross photosynthesis (GP) was the residual from net ecosystem exchange as measured through eddy covariance (Pattey et al., 2001). These data were used in combination with HR to develop relationships which could be mapped at the field scale.

Final harvest yield was measured using a combine harvester equipped with a yield monitor and GPS system. A yield map was created from these data and was smoothed using a 3x3 pixel maximum value filter.

3. RESULTS AND DISCUSSION

Strong relationships (r^2=0.77; n=20) were found between sPRI*NDVI and GP for the wheat and corn data both by crop and combined. Maps of GP (e.g. Figure 1) were produced using these relationships through the use of CASI imagery at each date of acquisition. A summation of the GP maps indicated areas of the field which were performing poorly throughout the growing season. In our study field, maps of GP successfully identified the starter only and sub-optimal areas as well as the areas of compacted soil and textural difference. These areas correlated well with low yield as determined by the final harvest yield map.

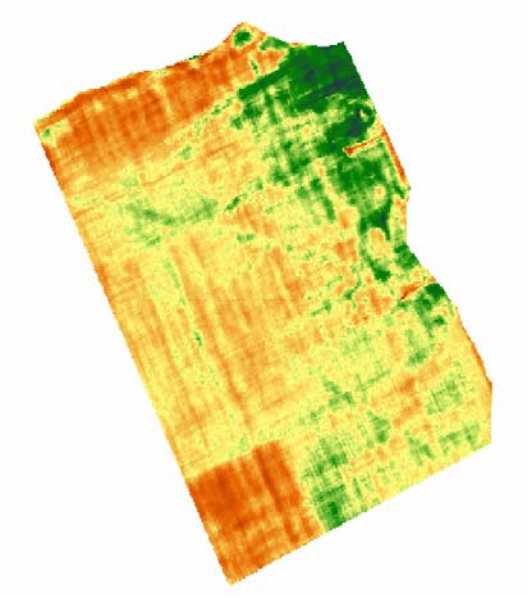

Figure 1. Summed gross photosynthesis (GP) for wheat based on three CASI images. GP was derived from a relationship between eddy covariance CO_2 uptake and sPRI*NDVI from a ground-based spectroradiometer.

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