Estimating canopy-level photosynthetic capacity using reflectance spectra and solar-induced fluorescence

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Improving photosynthesis has been considered critical to increasing crop yield to meet food demands from a growing population. To achieve this goal, high-throughput phenotyping techniques are highly needed to explore both natural and genetic variation in photosynthetic performance among crop cultivars. Due to the non-invasive nature of hyperspectral imaging, there is an increasing use of hyperspectral imaging for phenotyping of photosynthesis or photosynthetic physiology. The use of hyperspectral sensors has resulted in the accumulation of large amounts of data, shifting the research efforts into efficiently mining spectral information for high-throughput phenotyping. In this presentation, we will introduce data pipelines developed to leverage proximal sensing platforms and data sources including both reflectance spectra and solar-induced fluorescence (SIF) for quantifying photosynthetic performance at the canopy level. Photosynthetic performance was represented by the maximum carboxylation rate (V_{cmax}) and the maximum electron transport rate (J_{max}). The experiments were conducted using eleven tobacco cultivars grown in field conditions during 2017 and 2018 at Energy Farm at University of Illinois. Time-synchronized hyperspectral images from 400 to 900 nm and irradiance measurements of sunlight under clear-sky conditions were collected for capturing reflectance spectra and SIF (and SIF related parameters). Within 30 minutes of spectral measurements, ground-truth V_{cmax} and J_{max} were obtained from portable leaf gas exchange system. Our results suggested both reflectance spectra and SIF can provide accurate estimations of V_{cmax} and J_{max}. The presented data pipelines have potential to relieve bottleneck in phenotyping of photosynthesis for breeding cultivars of enhanced photosynthesis.