University of Bayreuth

Linking Canopy Reflectance to Photosynthetic Physiology, Canopy Structure, and Yield of Rice with Variable Nutrient Availability

Wei Xue[1], Bhone Nay Htoon[1], Hyojung Kwon[1], Jonghan Ko[2], and John Tenhunen[1]

[1] University of Bayreuth, [2] Chonnam National University

24

1. Problem Statement:

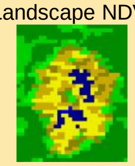
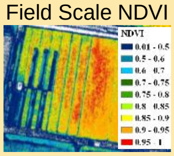
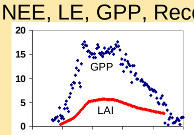
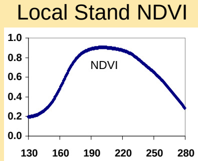
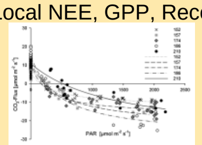
Rice is a staple food in more than 95 countries. Large increases in rice production are promoted by FAO to keep pace with population growth. Nevertheless, intensive fertilization to levels above those which enhance production, impacts water quality in many Asian countries including South Korea. Understanding optimal fertilization is important for food production and water management.

This project is designed to provide better understanding of spatial variations in current rice production, e.g., to identify climate and management factors that reduce production via their influences on crop canopy structure, physiology and gas exchange. Canopy reflectance is examined as an integrated measure of rice performance, and we attempt to interpret reflectance changes measured locally, hundreds of meters above the crop and via satellite in terms of observed ecosystem, plant stand and leaf characteristics. The results will be used in model scenarios focused on estimating agricultural yields with varying levels of fertilization.

2. Coordinated Research Scheme:

The research of this project is embedded in a coordinated scheme for observing crop physiology and growth at different scales as shown below:

Conceptual Linking and Interpretation | Spatial Generalization

Data Collection	Derived Products	Results and Outputs
MODIS @ 700 km 	Landscape NDVI 	Landscape Level Production Estimates, Spatial Extrapolation
Multicopter @ 300 m 	Field Scale NDVI 	Field Scale Reflectance and Yield in Relation to Climate and Management Gradients
Eddy Covariance Field Scale 	Field Scale NEE, LE, GPP, Reco 	Field Scale Estimation of Carboxylation Capacity to Relate to NDVI
Crop Scan @ 3 m 	Local Stand NDVI 	True Local Seasonal NDVI Patterns Free of Atmospheric Influence
Community Fluxes 	Local NEE, GPP, Reco 	Local Carboxylation Capacity as Related to Leaf Mean Physiology Characteristics
Leaf Physiology 	Leaf Parameters: Carboxylase Capacity, Reduction Capacity, Quantum Efficiency, Stomatal Regulation	Key Parameters for Growth Simulator Sub-models

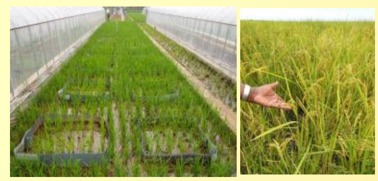
4. Conclusion and Outlook:

Measurements of gas exchange are conducted to define parameters used in production simulation models and to relate these to canopy reflectance. Also, we will develop understanding of spatial variations in rice production, and the changes in processes responsible, e.g., those controlling production levels.

The results will be used to improve and apply the simulation models CERES-Rice and PIXGRO. The applications will focus on assessing crop production within Soyang Watershed, but also to consider future rice production across large geographical regions of Asia in the context of climate change.

3. Specific Project Work:

For paddy and upland rice with differing nutrient availability, as well as in large rice paddies under normal management:



►► Measure seasonal changes of biomass, its allocation pattern, LAI and leaf chlorophyll

►► Measure daily and seasonal gas exchange and fluorescence intensity of leaves as follows below, use the photosynthetic parameters to simulate gas exchange of leaves,

►►Obtain temperature dependent values of photosynthetic model parameters (*Vcmax*, *Pml*, α, *Rd*) at different growing stages,

►► Obtain values of N_A and N_M through the growing season and canopy N pool,

►► Obtain canopy reflectance locally with CropScan instruments and derive the vegetation indexes (NDVI, EVI, REP), and build relations with *Vcmax* and *Pml*),

►► Measure seasonal and diurnal fluorescence intensity (Fyield), compare it with daily leaf gas exchange,

►► Measure daily and seasonal net ecosystem exchange (NEE) and ecosystem respiration (Reco) with chambers, calculate carboxylase capacity of the rice stand ($V_{cuptake}$) via inversion of a physiologically-based model (compare with eddy-derived values),

►► Structure the relationships between vegetation indices (VIs) and $V_{c\ uptake}$ as well as leaf parameters,

►► Bridge the relations between VIs deduced locally with those derived from hyperspectral data (multi-copter) and MODIS to predict vegetation response in carbon exchange, growth and yield over large areas.

Important Reference:

Kim H-Y, Kang S, Tenhunen J, Ko J-H 2012 Impacts of climate change on paddy rice yield in a temperate climate. Global Change Biology, doi: 10.1111 / gcb.12047

Contact: xuewei8341@yeah.net