Plant production studies in Haean in 2010
Steve Lindner

Introduction:

Dark chamber:

Soil respiration $R_{\text{soil}}$ = CO$_2$ release from the bare soil
Ecosystem respiration $R_{\text{eco}}$ = CO$_2$ release from the soil ($R_{\text{soil}}$) + plant ($R_{\text{plant}}$)

Light chamber:

Net ecosystem exchange NEE = GPP + Reco

Gross primary production (GPP): rate at which an ecosystem's producers capture and store a given amount of chemical energy as biomass in a given length of time.
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Introduction

Methods: Portable closed chamber system 
$CO_2/H_2O$ porometer CQP-130 
Pressure chamber 
Ech2o logger

Results

Conclusions & Outlook
Introduction:

- 5 crops / 1 field per crop in 2009
- Up to 9 plots per field:
  - 4 crop plots / replicates
  - 3 weed plots (not so successful)
  - 2 bare soil plots
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Methods: Portable closed chamber system

- Detailed information of plant reaction to environmental factors in small scale (1-2 plants enclosed)
- Up scaling of CO₂ fluxes up to landscape level
  TERRECO-02: Spatial assessment of atmosphere-ecosystem exchanges via micrometeorological measurements, footprint modelling and mesoscale simulations Peng Zhao, Johannes Lüers, Thomas Foken, Chong Bum Lee
- Validation of the Pixgro model
  TERRECO-15: Comparisons of net ecosystem CO₂ exchange, carbon gain, growth and water use efficiency of agricultural crops in small catchments in Korea Bora Lee, John Tenthunen, Sinkyu Kang

- Daily courses
- At least 3 times/growing season and crop
- Intensified measurements on the Radish field with different fertilizer treatments
- NEE, Reco, Rsoll
- Microclimate
- Biomass leaves/ stem/ roots
- C/N content

Figure 1: Applied light and dark gas exchange chambers for measuring the NEE and Reco
Figure 2: Installed soil frames (38 x 38 cm²) as a base for the gas exchange chambers
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Methods: CO$_2$/H$_2$O porometer CQP-130, Fa. WALZ, Effeltrich, Germany

- Measuring leaf gas exchange (photosynthesis or respiration of the leaf can be measured)
- In relation to microclimate
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Methods: Pressure Chamber & Ech2o logger

- Plant water relations will be accessed using the scholander pressure chamber

- Soil moisture content and soil temperature
- Automatic Weather Station for continuous recording of climate parameters (air temperature, relative humidity, solar radiation, wind speed and direction, rainfall)
Results from 2009:

Reco = Rsoil + Rplant

NEE = GPP + Reco

Daily course of NEE from a conventional potato field
Results:

Seasonal course of CO₂ fluxes from cabbage
Hyperbolic light response model  
(Michaelis-Menten type model)

- Used Michalis - Menten / rectangular hyperbola model to estimate model parameters for ecosystem/ leaf level gas exchange

\[ NEE = -\frac{\alpha \cdot \beta \cdot PAR}{\alpha \cdot PAR} + \beta + \gamma \]

Gilmanov et al, 2003

**Physiological parameters:**

- \(\alpha\) is the initial slope of the light response curve and an approximation of the canopy light utilization efficiency
- \(\beta\) is the maximum NEE of the canopy
- \(\gamma\) is an estimate of the average ecosystem respiration (Reco) occurring during the observation period
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Results:

- Estimated parameters to describe gas exchange capacity of potato
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Results: Daily courses of NEE

Radish DOY 197

Cabbage DOY 198

Bean DOY 203

Rice DOY 204
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Results:

- **Cabbage**

- **Rice**

- **Radish**

- **Potato**

*CO$_2$ flux [µmol m$^{-2}$ s$^{-1}$]*

*Day of year*
Results:

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Results:

radish

\[ y = 10.27 + 0.0175x \]

\[ a = -0.10 \]

\[ b = 3.87 \]

coefficient / Std. Error

Cabbage

\[ y = 28.01 + 0.0071x \]

\[ a = -0.15 \]

\[ b = -46.51 \]

coefficient / Std. Error

Bean

\[ y = 9.60 + 0.0407x \]

\[ a = -0.52 \]

\[ b = 1.9052 \]

coefficient / Std. Error

Rice

\[ y = 6.00 + 0.0047x \]

\[ a = 0.06 \]

\[ b = 21.55 \]

coefficient / Std. Error
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University of Bayreuth

Conclusions & Outlook:

- One place, one season, gives standardized abiotic conditions for all crops
- Gain basic understanding of how these crops interact with their physical environment
- Use the data for model parameterization using e.g. light response curves, physiological carboxylase - based process model
- Compare the differences in CO$_2$ exchange rates among crops

→ Why?
Identify the determinants of crop CO$_2$ exchange rates =
e.g. type of crop, LA, biomass, C/N content, light use efficiency, soil properties

\[ \text{NEE} = \text{GPP} + \text{Reco} \]

In order to:
→ Identify the most constraining factors on crop production & carbon exchange in Haean
→ Understand and quantify the processes of agro- ecosystem functioning
Flux Regulation, N Balances and Production in Agroecosystems of Haean Catchment

Objective
Understand ecosystem fluxes and measure their impact on:
1) Environmental sustainability
2) Ecosystem service provision

Main assumption
Ecosystem processes & fluxes both impact functioning and interact with each other

➔ Separate measurements of each process cannot account for such interactions
➔ In order to fully apprehend the set of parameters that influence production and sustainability, an interdisciplinary approach is necessary

Integrated approach to the measurement of ecosystem processes
Use of an identical field setup with coordinated measurements by multiple disciplines
Flux Regulation, N Balances and Production in Agroecosystems of Haean Catchment

I. Nutrient cycling: N fluxes and N balances J. Kettering, S. Berger
II. CO₂ fluxes and plant production S. Lindner, B. Lee
III. Herbivory and pest control E. Martin

Randomized block designs:
16 plots = 4 * 4 fertilizer levels → 50 - 150 - 250 - 350 kg N/ha
Flux Regulation, N Balances and Production in Agroecosystems of Haean Catchment

What are we measuring?

1. N balances
   - N\textsubscript{2}O emissions
   - Atm. N deposition
   - Soil retention
   - N leaching and seepage
   - Plant nutrient uptake

2. Carbon dioxide fluxes & plant production
   - Soil & Plant respiration
   - CO\textsubscript{2} fixation
   - Biomass production and nutrient allocation

3. Herbivory & biological pest control
   - Crop plant: Radish
Experimental setup

- 16 plots = 4 * 4 fertilizer levels
  → 50 - 150 - 250 - 350 kg N/ha

- Harvest of subplots after 25, 50 and 75 days

- Fertilizer application: reproduce as closely as possible the practices of local farmers

- granulate mineral fertilizer

Recommendation of Korean Agricultural Center: up to 400 kg N/ha
Usual amount in Germany: 50-150 kg N/ha

1st fertilizer application

Ploughing, Disking, Black cover, Planting (seeds), Harvest 25, Harvest 50, Harvest 75

- Planting (seeds)
- Harvest 25
- Harvest 50
- Harvest 75

- 15N + biomass
- CO₂ exchange
- N emissions
- Herbivory + monitoring

May June July August
Biodiversity studies in Haean 2010

Thank you!
I appreciate your questions.