Variations in Carbon Dioxide Gas Exchange and Productivity of the Major Crops of the Haean Catchment, South Korea

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Introduction:

The Asian region is a major contributor to global atmosphere / biosphere exchange of energy, water, carbon dioxide and other trace gases. Furthermore, it accounts for ca. 20% of the world's agricultural land (Fan 2005). Agricultural production over large parts of Asia and under the common farming practices carried out in South Korea is input-intensive with respect to fertilizer, pesticides, and machinery use. The objectives of the current study were to evaluate the outputs from such management practices, e.g., to:

- 1. Quantify the diurnal and seasonal CO_2 exchange of the dominant agricultural crops within the Haean landscape,
- 2. Quantify biomass production and its partitioning in the major crops throughout the growing season,
- 3. Identify key drivers of agro-ecosystem CO_2 exchange and productivity, and
- 4. Relate plot level CO_2 exchange to landscape level exchange fluxes, biomass development and total farm yields.

Hypothesis: Yield of the agricultural crops raised in Haean Catchment is determined by seasonal changes in carbon uptake capacity, the duration of carbon uptake and the patterns occurring in carbon partitioning.

Materials and Methods:

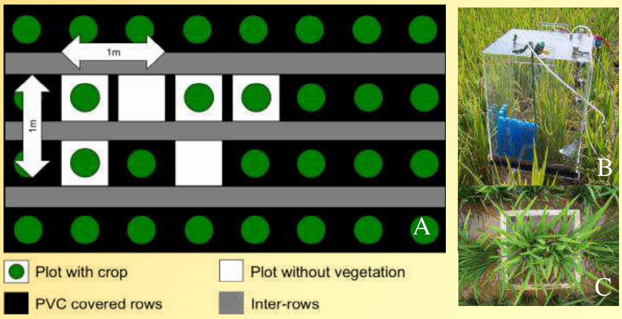

Figure 1: A) Experimental set up for the CO_2 chamber measurements in the crop fields. B) Installed light chamber during the CO_2 exchange measurements in the rice field. C) Top down detail picture of a rice plot.

Net ecosystem CO_2 exchange (NEE) and ecosystem respiration (R_{eco}) of the dominant crops in the Haean Catchment were observed during 2009 and 2010 with a systematic rotation over 6 plots (Figure 1A) using manually-operated, closed light (see Figure 1B and 1C) and dark gas exchange chambers (cf. Otieno et al. 2012). A set of 6 soil frames were inserted 20 cm into the ground as bases for CO_2 measurement chambers. After CO_2 measurements, all of the biomass within each of the 40 cm by 40 cm soil frames was harvested to determine dry weight of plant organs and leaf area. The samples were also analyzed for N and C contents. Average yield of the catchment was estimated from harvests in 32 randomly selected fields distributed over the entire catchment. Empirical description of the measured NEE fluxes was performed with a non-linear least squares fit of the data to a hyperbolic light response model (Owen et al. 2007).

Results and Conclusions:

Table 1: Dry weight of biomass in 2009

	Day of Year 2009	Leaves Dry weight [kg/m²]	SD	Stems Dry weight [kg/m²]	SD	Root Dry weight [kg/m²]	SD	Grains/ Tuber Dry [kg/m²]	SD
Radish	163	0.00	0.00	0.00	0.00	0.00	0.00		
	176	0.01	0.00	0.00	0.00	0.00	0.00		
	196	0.04	0.00	0.02	0.00	0.03	0.00		
	213	0.07	0.01	0.06	0.01	0.24	0.03		
	247	0.11	0.02	0.07	0.01	0.32	0.08		
	253	0.06	0.01	0.07	0.02	0.35	0.07		
Cabbage	148	0.00	0.00			0.00	0.00		
	162	0.04	0.02	0.02	0.01	0.00	0.00		
	177	0.16	0.05	0.11	0.04	0.01	0.01		
	197	0.27	0.05	0.26	0.06	0.02	0.01		
Potato	159	0.10	0.03	0.05	0.02	0.03	0.02	0.09	0.04
	174	0.08	0.06	0.07	0.07	0.02	0.01	0.32	0.21
	189	0.09	0.03	0.04	0.02	0.03	0.01	0.62	0.19
	220							1.44	0.22
Rice	147	0.01	0.00			0.02	0.00		
	155	0.00	0.00			0.03	0.03		
	156	0.01	0.00	0.00	0.00	0.01	0.01		
	164	0.02	0.00	0.01	0.01	0.03	0.00		
	175	0.05	0.01	0.01	0.01	0.16	0.11		
	203	0.27	0.05	0.37	0.12	1.17	0.54		
	260	0.25	0.02	0.84	0.15	0.54	0.08	0.91	0.10
Bean	169	0.01	0.01	0.01	0.00	0.01	0.00		
	179	0.03	0.01	0.02	0.01	0.01	0.00		
	202	0.11	0.06	0.12	0.07	0.03	0.01		
	235	0.35	0.06	0.49	0.14	0.07	0.02	0.10	0.03

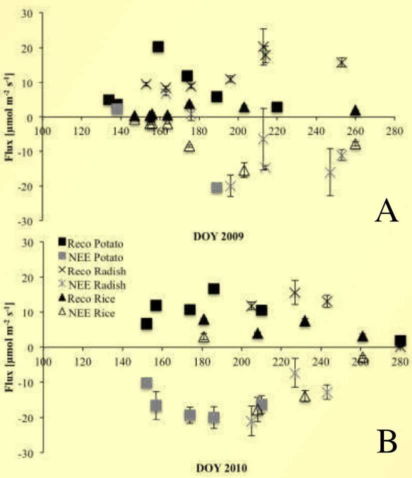

Figure 2: Seasonal course of Reco and NEE in (A) 2009 and (B) 2010.

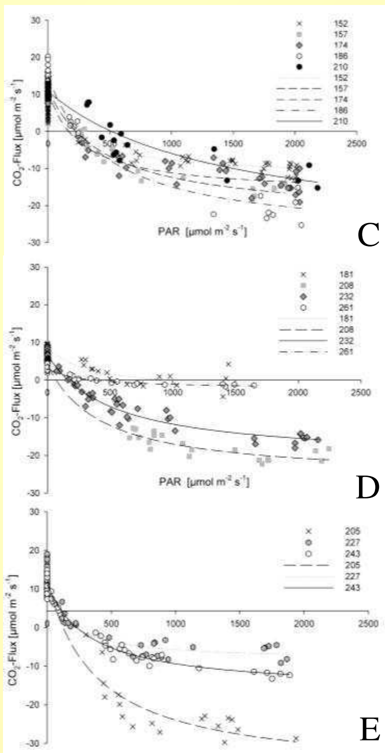

Figure 3: Fitted light curves from the daily courses for CO_2 exchange measurements with (C) potato, (D) rice and (E) radish in 2010.

Results of CO_2 exchange as observed during 2009 and 2010 are shown in Figure 2 A and B and biomass development in Table 1 for the most important annual dryland crops (potato, radish, cabbage, bean) and rice in the Haean Catchment. The main determinants of CO_2 exchange and biomass development in the catchment were radiation and temperature. Peak rates of NEE and GPP during the season were dependent on the developmental stages of the crops, daily flux rates were influenced by the time course for PAR (see Fig. 3). Local farmers played a strong role by determining the planting dates. Upscaling from plot to landscape level is planned, using eddy covariance data and the PIXGRO-model (Lee et al. 2010).

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