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Introducing non-flooded crops in rice-dominated landscapes: Impact on carbon, nitrogen and water budgets

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Rice production consumes about 30% of all freshwater used worldwide and 45% in Asia. Turning away from permanently flooded rice cropping systems for mitigating future water scarcity and reducing methane emissions, however, will alter a variety of ecosystem services with potential adverse effects to both the environment and agricultural production. Moreover, implementing systems that alternate between flooded and non-flooded crops increases the risk of disruptive effects.

The multi-disciplinary DFG research unit ICON aims at exploring and quantifying the ecological consequences of altered water regimes (flooded vs. non-flooded), crop diversification (irrigated rice vs. aerobic rice vs. maize), and different fertilization strategies (conventional, site-specific, and zero N fertilization). ICON particularly focuses on the biogeochemical cycling of carbon and nitrogen, green-house gas (GHG) emissions, water balance, soil biotic processes and other important ecosystem services. The overarching goal is to provide the basic process understanding that is necessary for balancing the revenues and environmental impacts of high-yield rice cropping systems while maintaining their vital ecosystem services. To this aim, a large-scale field experiment has been established at the experimental farm of the International Rice Research Institute (IRRI, Philippines). Ultimately, the experimental results are analyzed in the context of management scenarios by an integrated modeling of crop development (ORYZA), carbon and nitrogen cycling (MoBiLE-DNDC), and water fluxes (CMF), providing the basis for developing pathways to a conversion of rice-based systems towards higher yield potentials under minimized environmental impacts.

In our presentation, we demonstrate the set-up of the controlled large-scale field experiment for simultaneous assessment of carbon and nitrogen fluxes and water budgets. We show and discuss first results for:

- Quantification and assessment of the net-fluxes of CH_4, N_2O and CO_2 from rice-rice and rice-maize rotations. The conversion of flooded to non-flooded cropping systems resulted in pollution swapping of greenhouse gas emissions, shifting from CH_4 under wet conditions to N_2O under dry conditions.

- Quantification and assessment of water budgets and nutrient loss in rice-rice and rice-maize rotations. Switching from rice-rice dominated growing systems to upland rice or maize-rice cropping systems resulted in reduced water use efficiency and increased nitrogen loss.

- Quantification and assessment of soil functions affected by soil fauna community structure in flooded and non-flooded cropping rotations. In contrast to temperate soils, earthworms reduced the peaks of microbial C and N decomposition depending on soil water content.