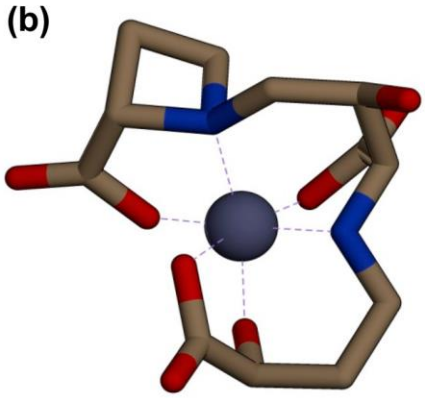
Micronutrient cycling in submerged soils and uptake into rice

Field experiments conducted at the International Rice Research Institute



Structure of the Zn-DMA complex we study

Micronutrient (i.e., trace metals including zinc) deficiency in rice has only recently been proposed as a major factor contributing to malnutrition in countries relying on rice as a major crop. Breeding rice strains that are efficient in taking up micronutrients or the application of fertilizers have been proposed as possible solution. The success of both approaches, however, requires a thorough understanding of the mechanism how the rice plants accesses the micronutrients in the soil, how the micronutrients are cycled within the soil and in what form they are eventually taken up. Our knowledge of the biogeochemistry of submerged soils, however, is very limited due to the significant experimental challenges associated with the anoxic and alkaline conditions and the very low trace element concentrations typically associated with paddy soils.

Our research aim is to develop a comprehensive understanding of the micronutrient cycling in paddy soils and uptake in rice.

To this end, we identify and quantify the chemical forms of the micronutrients in the soils and pore waters and we constrain spatial and temporal variations during an entire growth season. This is achieved by determining the speciation of the trace elements in the soil solution and in the solid phase using an array of different field (pipers, lysimeters) and analytical (i.e., voltammetry, XAS, sequential extraction, micro beam analysis and microscopy) techniques. Major soil chemical processes are tested in detail in well-constrained laboratory experiments, including complexation with organic and inorganic ligands, dissolution and precipitation of organic and inorganic phases, and mineral water and other surface processes. Labile soil pool and the dynamics of uptake and translocation are studied using stable isotopes and high precision isotope ratio measurements.

We also study the possible role of complexing organic ligands in the mobilization of micronutrients from the soil and the subsequent uptake of the metal complex into the rice plant. The importance of this process as a major process-controlling uptake under micronutrient deficient condition is strongly debated. We study in particular the coordination chemistry of trace metals with the mugineic acid family of phytosiderophores. Mugineic acid and its derivatives are either isolated from plants or synthesized in the laboratory. The reactivity and structure of the complexes are characterized using spectroscopic, potentiometric and spectrometric techniques. The goal is to obtain a detailed picture of the reactivity and structure of metal complexes of the micronutrients with this family of acids. Possible uptake mechanisms of the metal-ligand complexes are tested using novel isotopic and imagining techniques using various forms of labelling.

Contact:

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Literature:

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