Geochemical patterns and microbial contribution to iron plaque formation in the rice plant rhizosphere

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1. Background

Wetland plants - especially Rice - developed strategies to **counteract toxification** at elevated levels of Fe^{2+} in the rhizosphere:

Aerenchymatous tissues contrive gas exchange between the atmosphere and water-saturated anoxic soils.

Radial oxygen loss from roots increases redox potential around roots. Fe^{2+} gets oxidized and precipitates as **Fe(III)-minerals** along the roots.

These precipitates have been described as **iron plaques** (Fig.1):

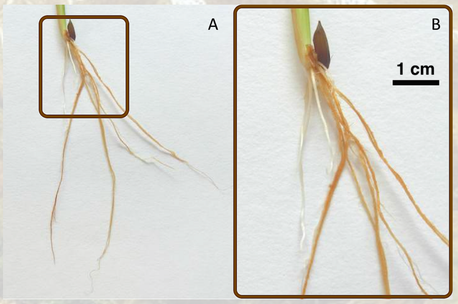

Fig. 1: Roots of rice plants grown on 1mM Fe^{2+} Hoagland solution

Microbially driven iron redox cycling can control the formation and dissolution of ferriferrous minerals along the roots (Fig. 2).

But it is **currently unknown** whether microbial activity triggers or inhibits iron plaque formation.

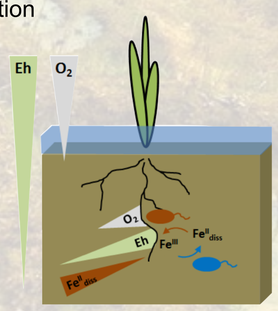

Fig. 2: Schematic representation of major geochemical fluxes in the rhizosphere root zone

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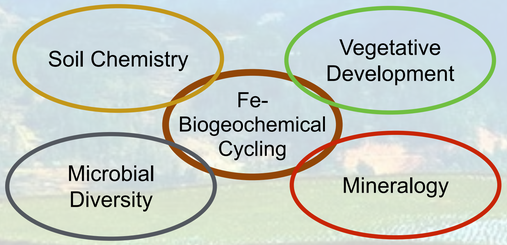
2. Goals & Concepts

Our **goal** is a comprehensive study that combines vegetative development of the rice plant and its effects on the rhizosphere soil geochemistry, mineralogy and microbial diversity with respect to iron biogeochemical cycling.



Our **concept** will involve the correlation of microbial, geochemical and mineralogical small scale variations as a function of plant and root development.

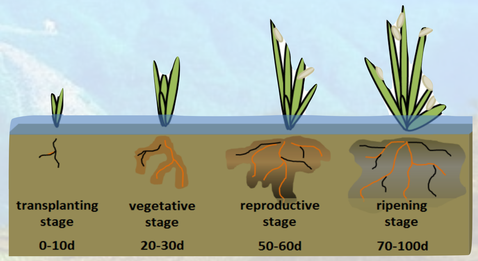
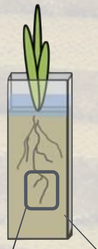


Fig. 3: Schematic representation of the growth stages, roots iron plaque and redox development during the growth of rice plants.

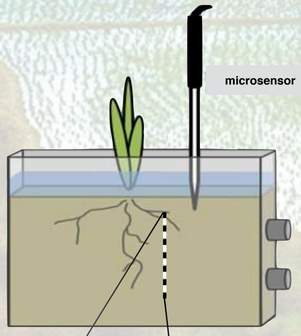
(Orange color represent iron oxide accumulation)

3. Methods & Preliminary Results

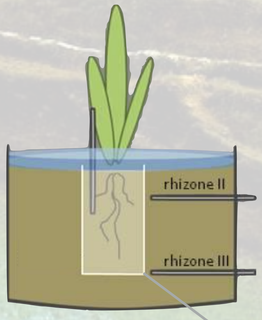
Rice Plant Growth



Glass Containers were used to cultivate rice plants (*Oryza sativa*) on phytoagar to visually follow growth of the roots and iron plaque development.



Rhizotrons filled with phytoagar were used to visually follow sampling and microsensor use, as well as redox indicative color changes within the rhizosphere.



Rice Pots are filled with soil sampled from the field to simulate an environmental setting. Porewater samplers (rhizons) are installed to draw samples directly from the soil water.

SEM-Imaging

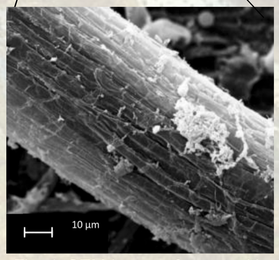


Fig. 4: SEM-image of a root with iron plaque from a 2 month old rice plant

Iron-minerals found on root surface

Radial Oxygen Loss

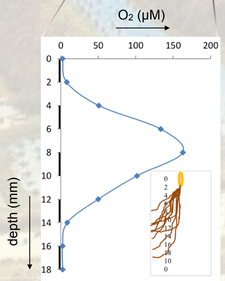


Fig. 5: Oxygen concentration after 34 days in anoxic phytoagar (0.5 mM Fe^{2+})

significantly higher Oxygen release from roots in set-ups amended with 0.5 mM Fe^{2+}

Vercelli Field Samples

Fig. 6: Location of sampling site: Vercelli, Italy

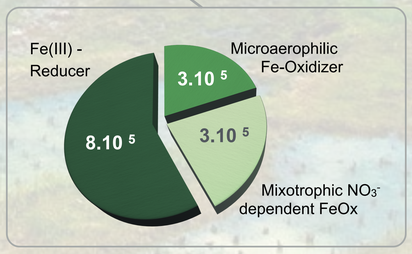
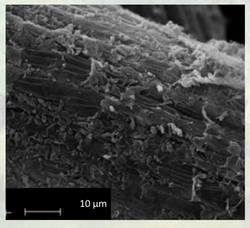


Fig. 7: Preliminary results on the microbial abundance of iron(II)-oxidizing and iron(III)-reducing bacteria (MPN-method)

4. Open Questions & Outlook

- Dynamic **geochemical** and **iron-microbial patterns** following vegetative development of the rice plant *Oryza sativa.*
- **Quantification** and **identification** of iron(II)-oxidizing and iron (III)-reducing microorganisms in native rice paddy soil.



- **Connections** between oxidizing and reducing processes at redox interfaces and relevance for Fe-mineral formation?
- Geochemical **characterization** and mineralogical **identification** of *in-situ* iron plaque formation.

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