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Iron Lung: How Rice Roots Induce Iron Redox Changes in the Rhizosphere and Create Niches for Microaerophilic Fe(II)-Oxidizing Bacteria

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Abstract:

Although water-logged rice paddies are characterized by anoxic conditions, radial oxygen loss (ROL) from rice roots temporarily oxygenates the soil rhizosphere. ROL not only triggers the abiotic oxidation of ferrous iron (Fe(II)) but also provides the electron acceptor for microaerophilic Fe(II)-oxidizing bacteria (microFeOx). Both processes contribute to the formation of ferric (Fe(III)) iron plaque on root surfaces. Redox interactions at single roots have been studied intensively. However, temporally resolved spatial changes of ROL in the entire rhizosphere and the impact on redoximorphic biogeochemistry are currently poorly understood. Here, we show how ROL spatiotemporally evolves and correlates with Fe-redox transformations. Applying noninvasive measurements in a transparent artificial soil, we were able to visualize opposing O_2 and Fe(II) gradients that extend from the root surface 10 – 25 mm into the rhizosphere. The microoxic zone expanded exponentially in size throughout the entire rhizosphere creating niches for microFeOx. Following iron mineral formation and pH, we show that root-related ROL induces iron redox transformations on and around roots and correlates with rhizosphere acidification. These findings highlight the dynamic nature of roots in the rice plant rhizosphere, and our approach spatiotemporally resolved their impact on iron redox chemistry and microbial niche formation in the rice plant rhizosphere.

Keywords: radial oxygen loss (ROL), rhizosphere, Fe(II)-oxidizing bacteria, microoxic zone, iron redox transformation, rhizosphere acidification