Evaluation of Fe uptake and transport mechanism of rice plants in a paddy field using Fe isotope fractionation

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Two distinct mechanisms for Fe uptake and transport by plants have been developed, which are known as strategy I (Fe(III) reduction) and strategy II (Fe(III)-ligand complex chelation). The mechanism of Fe uptake and transport in rice plants is still not well understood. Fe isotope fractionation analysis is a promising approach for the assessment of Fe uptake and transport in the soil-rice system of the paddy field. Here, Fe isotopic compositions of different tissues (including roots, stems, leaves, panicles, husks, and seeds) of rice plants during jointing and maturity stages in the soil-rice system were determined. The rice plants were enriched in heavier Fe isotopes by about 0.6‰ compared to soil. Five leaves or four stems at different heights exhibit limited Fe isotope variations. While Fe accumulation in the mature stage was higher than that in the jointing stage, Fe isotopic compositions of different tissues of rice plants were identical within error. These findings indicated that the mechanism for Fe uptake and transport for rice plants in the paddy field was Fe(III)-ligand complex chelation in the absence of Fe(III) reduction. The Fe(III)-ligand complex was converted from Fe(III)-phytosiderophore (PS) into Fe(III)-citrate during Fe transport from roots to stems. Fe isotope fractionation between roots and stems ($\Delta^{56}Fe_{root-stem}$) was −1.6‰, which was consistent with that between Fe(III)-citrate and Fe(III)-PS from previous *Ab initio* calculations. In addition, the Fe isotopic compositions of soil, porewater, and Fe plaque of rhizosphere were measured. The HCl extraction for soil did not lead to Fe isotope fractionation, indicating proton-promoted dissolution of Fe (oxyhydr)oxides in soil. This study confirms that the Fe isotope fractionation analysis is a powerful tool for investigating the mechanism of Fe uptake and transport for rice plants, and would be helpful for understanding plant physiological processes.