【Grant-in-Aid for Scientific Research (S)】

Broad Section F

Title of Project： **Studies on nitrogen fixation of iron reducing bacteria as a key process supporting sustainable nitrogen fertility of rice paddy soil : towards low nitrogen agriculture**

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Keyword：nitrogen fixation, iron-reducing bacteria, rice paddy soil, nitrogen fertility, low-nitrogen input

【Purpose and Background of the Research】

Soil nitrogen fertility is essential for crop production. Rice paddy soil has the ability to sustain nitrogen fertility autonomously, however, its mechanism remains largely unknown. Microbial nitrogen fixation is the major route for supplying nitrogen to paddy soil, which must be a key process supporting soil nitrogen fertility. Our recent comprehensive survey showed that most nitrogen fixation genes and their transcripts in paddy soil were derived from iron-reducing bacteria. The nitrogen-fixing ability of iron-reducing bacteria isolated from paddy soils was also verified. These findings strongly suggest that iron-reducing bacteria are previously overlooked nitrogen-fixing bacteria that play a pivotal role in paddy soils.

Nitrogen fertilizers have revolutionized modern crop cultivation; however, excessive application promotes the release of nitrogen loads from agricultural fields to the natural environment. This can lead to unavoidably aggravating environmental problems including global warming and nitrate pollution in groundwater. The environmental issues caused by the nitrogen fertilizer input have provoked public concern and increased expectations for developing new methods to achieve both increased rice production and decreased environmental burden.

The principal purpose of this study is to establish the academic base of nitrogen fixation of iron-reducing bacteria in rice paddy soil. Based on the obtained information, we will propose and test novel paddy soil management strategies to increase nitrogen fixation of iron-reducing bacteria and to increase soil nitrogen fertility.

【Research Methods】

To reveal the ecology of nitrogen-fixing iron-reducing bacteria in paddy soils in detail, we will further isolate iron-reducing nitrogen-fixing bacteria from paddy soils, obtain their genomic information, and perform soil metagenomic analysis. To investigate the contribution of iron-reducing nitrogen-fixing bacteria to soil nitrogen fertility, amount of nitrogen fixation by the bacteria will be examined in both laboratory and field soils. Environmental factors regulating nitrogen fixation of iron-reducing bacteria will be analyzed; carbon compounds derived from rice plant residue decomposition and rice root exudates. Rice gene and rice plant response closely related to nitrogen-fixing activity of iron-reducing bacteria in soil will be clarified. Ferric iron compounds in soil utilized by iron-reducing bacteria as electron acceptors and generated ferrous iron compounds will be identified through several instrumental analyses. Finally, we will propose novel paddy soil management strategies to increase nitrogen fixation of iron-reducing bacteria and examine their validity by laboratory soil microcosm and field studies.

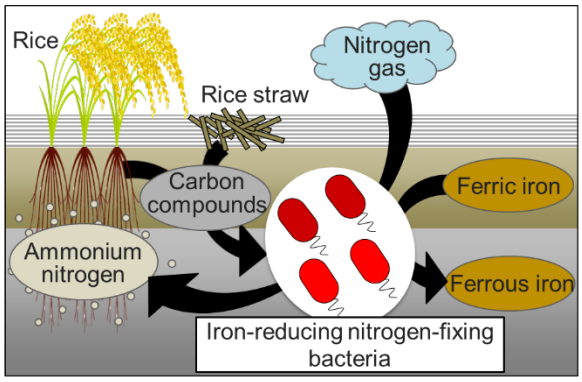

Fig. Nitrogen fixation of iron-reducing bacteria in paddy soil

【Expected Research Achievements and Scientific Significance】

The whole picture of nitrogen fixation of iron-reducing bacteria in rice paddy soil, and its contribution to sustainable soil nitrogen fertility will be figured out. This may lead to novel agricultural practices to increase soil nitrogen fertility and to ensure rice yields with reduced nitrogen fertilizer input and a lower environmental nitrogen burden.

【Publications Relevant to the Project】

・ Masuda Y, Itoh H, Shiratori Y, Isobe K, Otsuka S, Senoo K. Predominant but previously-overlooked prokaryotic drivers of reductive nitrogen transformation in paddy soils, revealed by metatranscriptomics. Microbes Environ., 32, 180-183 (2017)

・ Masuda Y, Yamanaka H, Xu Z-X, Shiratori Y, Aono T, Amachi S, Senoo K, Itoh H. Diazotrophic Anaeromyxobacter isolates from soils. Appl. Environ. Microbiol., 86, e00956-20 (2020)

【Term of Project】 FY2020- 2024

【Budget Allocation】 152,400 Thousand Yen

【Homepage Address and Other Contact Information】

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