Thirty-years long-term rice-rice-rape rotation optimizes 1,2-benzenediol concentration in rhizosphere paddy soil and improves nitrogen use efficiency and rice growth

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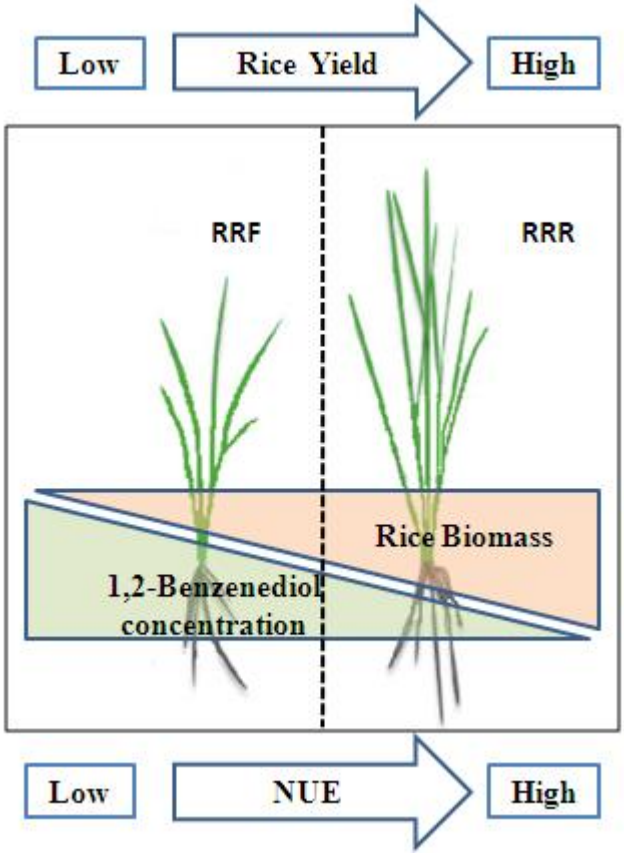
Abstract

Differences in soil metabolites from the rice root rhizosphere and the effects of 1,2-benzenediol on nitrogen use efficiency and rice growth were examined under 30-years long-term rice-rice-fallow and rice-rice-rape rotations. The metabolite composition of rice rhizospheres was analyzed using the gas chromatography mass spectrometry. A range of 0.2, 2.0 and 200 μmol L^{-1} concentrations of external 1,2-benzenediol were applied to examine their effects on rice growth, nitrate reductase and glutamine synthetase activities, and physiological nitrogen-use efficiency. The metabolite composition of rhizospheres differed significantly between rice-rice-fallow and rice-rice-rape rotations. Soil total nitrogen and 1,2-benzenediol concentrations during the early rice season were significantly lower under rice-rice-rape than under rice-rice-fallow rotations. Rice growth and nitrogen use efficiency significantly enhanced at 0.20 μmol 1,2-benzenediol L^{-1}, but inhibited at 2.0 μmol 1,2-benzenediol L^{-1} or higher. Changes in root morphology and uptake associated with 1,2-benzenediol possibly had contributed to a higher nitrogen use efficiency of the early season rice under rice-rice-rape rotations. The activity of nitrate reductase and glutamine synthetase in rice roots were significantly higher with external 0.2 μmol 1,2-benzenediol L^{-1} application than without 1,2-benzenediol treatment. Crop rotation significantly affected rice rhizosphere metabolites. An optimal soil 1,2-benzenediol concentration under 30-years long-term rice-rice-rape rotation may be associated with an enhanced nitrogen use efficiency and root nitrogen uptake and assimilation, resulting in an increased rice growth and yield.

Keywords: Allelochemical metabolite, *Brassica napus*, Glutamine synthetase, Nitrate reductase, *Oryza sativa*



A conceptual model for the effects of 1,2-benzenediol on nitrogen utilization and rice growth. Thirty-years long-term crop rotation changed the metabolite composition in rhizosphere paddy soil of the early rice season, and an optimal 1,2-benzenediol concentration is associated with a higher nitrogen utilization and improved growth of rice. The 1,2-benzenediol concentration was significantly lower under rice-rice-rape than under rice-rice-fallow rotations. A lower 1,2 benzenediol concentration was significantly associated with an increased nitrogen utilization and growth of the early rice. Therefore, an optimized 1,2-benzenediol concentration in the rhizosphere soil under the rice-rice-rape rotation might be associated with an increased rice growth and yield.

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