Rice increases phosphorus uptake in strongly sorbing soils by intra-root facilitation

Christian W. Kuppe[1,2], Guy J D Kirk[3], Matthias Wissuwa[1,4], and Johannes A Postma[1]

[1]Institute of Bio-and Geosciences -Plant Sciences (IBG-2), Forschungszentrum Jülich GmbH
[2]RWTH Aachen University
[3]School of Water, Energy and Environment, Cranfield University
[4]Crop, Livestock and Environment Division, International Research Center for Agricultural Sciences, Correspondence Christian Kuppe

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Abstract

Upland rice (Oryza sativa) is adapted to strongly phosphorus (P) sorbing soils. The mechanisms underlying P acquisition, however, are not well understood, and models typically underestimate uptake. This complicates root ideotype development and trait-based selection for further improvement. We present a novel model, which correctly simulates the P uptake by a P-efficient rice genotype measured over 48 days of growth. The model represents root morphology at the local rhizosphere scale, including root hairs and fine S-type laterals. It simulates fast-and slowly reacting soil P and the P-solubilizing effect of root-induced pH changes in the soil. Simulations predict that the zone of pH changes and P solubilization around a root spreads further into the soil than the zone of P depletion. A root needs to place laterals outside its depletion-but inside its solubilization zone to maximize P uptake. S-type laterals, which are short but hairy, appear to be the key root structures to achieve that. Thus, thicker roots facilitate the P uptake by fine lateral roots. Uptake can be enhanced through longer root hairs and greater root length density but was less sensitive to total root length and root class proportions.

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