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Phosphorus Acquisition Efficiency in Rice: Does Carbon Supply Limit Root Growth under Extreme P Deficiency?

Alejandro Pieters, Stuerz Sabine, Folkard Asch

University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany

Abstract

Phosphorus (P) acquisition efficiency (PAE) depends largely on a large root system. For high PEA varieties, enlarging the root system under P deficiency requires increased carbon partitioning towards the roots under conditions that also limit photosynthesis. Thus, root growth under P deficiency could be carbon limited. To test this hypothesis, we grew four rice genotypes (DJ123, Kasalath, Santhi Sufaid, high PAE, and IR64 a low PAE check), in hydroponics under glasshouse conditions and provided them with either high (0.32 mM) or low (0.0032 mM) P in the nutrient solution for 50 days. Photosynthetic rate was measured, plant dry weight and carbohydrate concentrations in leaves and roots were determined. Under high P supply shoot and root dry weight was different amongst varieties ($p < 0.001$). P deficiency decreased total and organ biomass but the impact was genotype specific as depicted by a significant PxG interaction ($p < 0.001$). P deficiency increased the root to shoot ratio and high PAE genotypes showed the largest increases compared to IR64. At high P supply photosynthesis rate differed amongst varieties and decreased under P deficiency ($p < 0.001$), the most affected variety was Kasalath and the least affected was Santhi Sufaid, both high PAE varieties. Sucrose concentrations in leaf blades and roots were lower in P starved plants than in high P plants. Starch concentrations in leaves increased under P deficiency but decreased in roots. Root dry weight was hyperbolically related to photosynthesis and linearly related to starch concentration in roots. Our results suggest that root growth under P deficiency could be limited by carbon supply, as leaf sucrose concentrations decreased importantly under P deficiency. However, whether the increase of leaf starch under P deficiency represents unused carbon due to restricted growth or contributes to maintain P homeostasis within the chloroplast allowing photosynthesis to continue, remains to be elucidated. Under these circumstances, selecting for high photosynthetic rates under P deficiency, coupled to an efficient translocation of assimilates to roots could contribute to breeding for high PAE in rice.

Keywords: Carbohydrates, carbon partitioning, IR64, *Oryza sativa*, photosynthesis

Contact Address: Alejandro Pieters, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Garbenstr. 13, 70599 Stuttgart, Germany, e-mail: alejandro.pieters@uni-hohenheim.de