Imbalanced Regulation of Fungal Nutrient Transports According to Phosphate Availability in a Symbiocosm Formed by Poplar, Sorghum, and Rhizophagus irregularis

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In arbuscular mycorrhizal (AM) symbiosis, key components of nutrient uptake and exchange are specialized transporters that facilitate nutrient transport across membranes. As phosphate is a nutrient and a regulator of nutrient exchanges, we investigated the effect of P availability to extraradical mycelium (ERM) on both plant and fungus transcriptomes and metabolomes in a symbiocosm system. By perturbing nutrient exchanges under the control of P, our objectives were to identify new fungal genes involved in nutrient transports, and to characterize in which extent the fungus differentially modulates its metabolism when interacting with two different plant species. We performed transportome analysis on the ERM and intraradical mycelium of the AM fungus Rhizophagus irregularis associated to Populus trichocarpa and Sorghum bicolor under high and low P availability in ERM, using quantitative RT-PCR and Illumina mRNA-sequencing. We observed that mycorrhizal symbiosis induces expression of specific phosphate and ammonium transporters in both plants. Furthermore, we identified new AM-inducible transporters and showed that a subset of phosphate transporters is regulated independently of symbiotic nutrient exchange. mRNA-Sequencing revealed that the fungal transportome was not similarly regulated in the two host plant species according to P availability. Mirroring this effect, many plant carbohydrate transporters were down-regulated in P. trichocarpa mycorrhizal root tissue. Metabolome analysis revealed further that AM root colonization led to a modification of root primary metabolism under low and high P availability and to a decrease of primary metabolite pools in general. Moreover, the down regulation of the sucrose transporters suggests that the plant limits carbohydrate long distance transport (i.e. from shoot to the mycorrhizal roots). By simultaneous uptake/reuptake of nutrients from the apoplast at the biotrophic interface, plant and fungus are both able to control reciprocal nutrient fluxes.
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