Phylogenetic, structural, and functional characterization of AMT3;1, an ammonium transporter induced by mycorrhization among model grasses

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In the arbuscular mycorrhizal (AM) symbiosis, plants satisfy part of their nitrogen (N) requirement through the AM pathway. In sorghum, the ammonium transporters (AMT) AMT3;1, and to a lesser extent AMT4, are induced in cells containing developing arbuscules. Here, we have characterized orthologs of AMT3;1 and AMT4 in four other grasses in addition to sorghum. AMT3;1 and AMT4 orthologous genes are induced in AM roots, suggesting that in the common ancestor of these five plant species, both AMT3;1 and AMT4 were already present and upregulated upon AM colonization. An artificial microRNA approach was successfully used to downregulate either AMT3;1 or AMT4 in rice. Mycorrhizal root colonization and hyphal length density of knockdown plants were not affected at that time, indicating that the manipulation did not modify the establishment of the AM symbiosis and the interaction between both partners. However, expression of the fungal phosphate transporter FmPT was significantly reduced in knockdown plants, indicating a reduction of the nutrient fluxes from the AM fungus to the plant. The AMT3;1 knockdown plants (but not the AMT4 knockdown plants) were significantly less stimulated in growth by AM fungal colonization, and uptake of both (15)N and (33)P from the AM fungal network was reduced. This confirms that N and phosphorus nutrition through the mycorrhizal pathway are closely linked. But most importantly, it indicates that AMT3;1 is the prime plant transporter involved in the mycorrhizal ammonium transfer and that its function during uptake of N cannot be performed by AMT4.
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