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Arbuscular mycorrhiza and nitrification: Competition for free ammonium ions?

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Arbuscular mycorrhiza (AM) is ancient and widespread inter-kingdom symbiotic relationship being established by a majority of terrestrial plant species and specialized fungi, which interconnect plant roots with surrounding soil. By doing so, this symbiosis can greatly increase acquisition of multiple mineral nutrients such as phosphorus, nitrogen (N), and copper by the plants from the soil, in exchange for reduced carbon supplied by the plant host. Supposedly, this is mainly due to extending the soil volume accessible for nutrient acquisition by the fungal hyphae compared to roots alone. Both the plants and the AM fungi require N for construction of their bodies. This can potentially result in different effects of AM symbiosis establishment on plant N nutrition ranging from positive to negative. Yet, the demand for and efficiency of mineral N uptake from the soil by a mycorrhizal plant is usually higher than that of a nonmycorrhizal plant. This may exert important feedbacks of AM symbiosis on soil processes in general and N cycling in particular. Here we asked what role does the symbiosis play in acquisition of N by a model plant, Andropogon gerardii, from an organic source (i.e., plant litter labeled with 15N) supplied in a soil zone beyond the direct reach of roots. Further, we tested whether this process of N acquisition by plant from the soil via mycorrhizal hyphae could be affected by supplying various synthetic nitrification inhibitors (DCD, nitrapyrin, or DMPP) along with the litter. We observed efficient acquisition of N to mycorrhizal plants via mycorrhizal pathway irrespective of the nitrification inhibitor supplied or not along with the plant litter. These results were strongly contrasting with 15N uptake (but not total N content of the plants or the plant biomass) of the nonmycorrhizal plants, which generally received much less 15N than the mycorrhizal plants, and this was further suppressed by nitrapyrin or DMPP supplementation of the organic N source as compared to DCD or the control (i.e., no inhibitor) treatment. Quantitative real-time PCR analyses of the microbial communities indicated that microbes involved in the rate-limiting step of nitrification, i.e., the ammonia oxidizers, were suppressed similarly by AM fungi as they were by nitrapyrin or DMPP amendments. These results suggest that mycorrhizal fungi successfully outcompeted the prokaryotic ammonia oxidizers, and this was most likely by accessing and efficiently utilizing/removing free ammonia ion pool in/from the soil via their extensive hyphal networks.