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Contrasting effects of mycorrhizal association on rhizosphere priming on soil C and N mineralization

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It has been increasingly recognized that tree-mycorrhizal associations, such as arbuscular mycorrhizal (AM) and ectomycorrhizal (ECM) fungi, influence soil carbon (C) and nitrogen (N) cycling in distinct ways. However, rhizosphere priming effects (RPE) on soil C and N mineralization caused by these two contrasting mycorrhizal associations remain largely unknown. Here we report the RPE of five tree species associated with AM or ECM with a mesh system where tree seedling roots, hyphae or exudates only could access a C4 soil.

We selected two AM trees (Cunninghamia lanceolata and Juglans mandshurica) and three ECM trees (Picea koraiensis, Larix kaempferi and Quercus mongolica), and grew these tree seedlings with sand inside of meshes for up to 150 days (∼ a growing season). We separated soil-derived CO_2 from root-derived CO_2 using a natural abundance 13C method, and investigated gross N mineralization using a 15N dilution method, and then determined the RPE on soil C (primed C) and N mineralization (primed N) as the differences in soil-derived CO_2 and gross N mineralization between planted and unplanted pots. We detected the microbial community structure using a phospholipid fatty acid (PLFA) analysis method. We also measured seven extracellular enzyme activities (EEAs) involved in the decomposition of C, N and phosphor (P)-containing compounds.

We found that the magnitude of primed C and N varied widely, ranging from +33% to +114%, and from +9% to +56%, respectively. Primed C was significantly influenced by mycorrhizal association ($P < 0.001$), with almost 1.2 times higher for AM than ECM. There was a marginally significant interaction between mycorrhizal association and mesh on primed N ($P = 0.06$), with the highest primed N induced by the access of AM hyphae only. These results indicated that compared to ECM, AM seedlings tended to cause a priming with a higher C to N ratio ($P < 0.0001$). Moreover, this ratio was significantly positively related with the C to nutrient (N plus P) stoichiometry of EEAs that was regulated by shifts in the microbial community structure. AM seedlings favored fungi and gram positive bacteria over actinomycete ($P = 0.03$); but ECM seedlings recruited gram negative bacteria more than saprophytic fungi ($P = 0.003$).

Overall, these findings indicate that tree-mycorrhizal associations could enhance soil C and N mineralization by selecting for microbial groups with different enzyme function, and AM tree species may have stronger RPEs than ECM, especially on C decomposition.