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The tree species matters: Belowground carbon input and utilization in the myco-rhizosphere

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ABSTRACT

Rhizodeposits act as major carbon (C) source for microbial communities and rhizosphere-driven effects on forest C cycling receive increasing attention for maintaining soil biodiversity and ecosystem functions. By *in situ* $^{13}CO_2$ pulse labeling we investigated C input and microbial utilization of rhizodeposits by analyzing ^{13}C incorporation into phospholipid fatty acids (PLFA) of beech- (*Fagus sylvatica*) and ash-associated (*Fraxinus excelsior*) rhizomicrobial communities. Plant compartments and soil samples were analyzed to quantify the allocation of assimilates. For 1 m high trees, ash assimilated more of the applied $^{13}CO_2$ (31%) than beech (21%), and ash allocated twice as much ^{13}C belowground until day 20. Approximately 0.01% of the applied ^{13}C was incorporated into total PLFAs, but incorporation varied significantly between microbial groups. Saprotrophic and ectomycorrhizal fungi under beech and ash, but also arbuscular mycorrhizal fungi and Gram negative bacteria under ash, incorporated most ^{13}C. PLFA allowed differentiation of C fluxes from tree roots into mycorrhiza: twice as much ^{13}C was incorporated into the fungal biomarker 18:2ω6,9 under beech than under ash. Within 5 days, 30% of the fungal PLFA-C was replaced by rhizodeposit-derived ^{13}C under beech but only 10% under ash. None of the other microbial groups reached such high C replacement, suggesting direct C allocation via ectomycorrhizal symbioses dominates the C flux under beech. Based on $^{13}CO_2$ labeling and ^{13}C tracing in PLFA we conclude that ash allocated more C belowground and has faster microbial biomass turnover in the rhizosphere compared to beech.

1. Introduction

The total forest area of the world in 2005 was estimated to be about 4 billion ha or 30% of the total land area [1]. Forests store 80% of the terrestrial aboveground biomass and thus determine the C balance of terrestrial ecosystems [2]. An estimated 73.5 t ha^{-1} of carbon (C) are stored in the soils (0–30 cm) of the world's forests, which is more than in the living tree biomass (71.5 t ha^{-1}) [1]. The C stock in the litter horizon of European forests is estimated to be 6.1 t ha^{-1} and the C stock in mineral soil 113 t ha^{-1} [1]. Beech is the most common deciduous tree in Germany, covering an area of 1.68 million ha, which is 15.4% of the entire forest area [3]. Beech therefore is of great economic value and ecological importance in Central Europe [4]. Ash makes up ca. 10% of the forest area in Germany and is seen as a promising species for the future forestry industry [5]. These two tree species therefore are major representatives of forests in Germany and taken as model species for investigating C allocation of trees belowground [6,7]. Notably, the link between tree species identity and soil microorganisms in mixed-species forests remains little studied [8].

C allocation to roots and into the rhizosphere has received little attention in trees [9–11]. Up to 90% of the net primary production of trees enters the soil as detritus [12], where fungi and bacteria subsist on rhizodeposits and show a high metabolic versatility. The amount, composition and dynamics of rhizodeposits and their ecological functions, especially those of trees, are poorly

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