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The role of Common Mycorrhizal Networks for nutrient allocation in Fagus sylvatica (European beech) trees

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Mycorrhizal fungi can connect multiple plants belowground forming Common Mycorrhizal Networks (CMNs). It has been suggested that CMNs facilitate mutualistic interactions between plants by providing channels to exchange carbon and nutrients. However, the terms of trade and mechanisms in which plants and their fungal partners interact are still not fully understood. Here, we investigated carbon and nitrogen transfer within a common ectomycorrhizal network between pairs of European beech trees. Our aim was to elucidate if there is C transfer between the root systems of plants connected via a CMN, and if CMNs amplify or alleviate belowground competition for nutrients.

Young beech trees collected from the Vienna Woods were transferred along with native soil and natural mycorrhizal inoculum to perforated pots which were wrapped in a fine pored (49μm) mesh allowing hyphae, but not roots to pass. Mycorrhiza-exclusive N sources, consisting of ^{15}N-labelled peat filled in 49μm mesh bags were buried in each pot. The pots were positioned in pairs of two at a distance of 6cm in plastic boxes filled with quartz sand, to allow CMNs to establish between them over a time period of 5 months. Two treatments were applied in a fully factorial design: 1) CMN (some pots were turned around at a regular interval to prevent the establishment of CMNs) and 2) equality of access to photoassimilated C (in part of the boxes one of the two plants was shaded). After the growing period, and four weeks before harvesting the plants, $^{13}CO_2$ labelling was started. Once a week, one of the plants (“donor”) in each box was exposed to a ^{13}C-CO_2 atmosphere for 8 hours. We subsequently traced 13C assimilated by the donor plants into belowground pools of both donor and ‘receiver’ plants (i.e. the unlabeled neighboring plants), as well as into the receiver plant itself, by isotope ratio mass spectrometry (EA-IRMS) and ^{13}C phospholipid fatty acid (PLFAs) analysis (GC-IRMS).

We did not find an effect of CMN on competition for N in the belowground resources. A high incorporation of ^{15}N from the labelled peat bags in the plant biomass indicates that the hosts relied mostly on their fungal partner to acquire nutrients. In addition, peat bags became highly enriched in ^{13}C compared to the surrounding soil. PLFA biomarkers (fungi and bacteria) in both the nearby (i.e. the peat bag buried under the donor plant) and the distant peat bags (i.e. the peat bag buried under the receiver plant) were significantly enriched in ^{13}C indicating a hyphal transfer of photoassimilated C not only in the belowground realm of their host plants, but also over longer distances into the realm of their neighbours. Fungal PLFA biomarkers extracted from the roots of the receiver plants were slightly, but significantly enriched in ^{13}C only when a CMN was present. This may indicate a translocation of photoassimilated C from the donor plant into the root system of the receiver plant. Whether this C stayed in the fungal tissue or was transferred into plant cells is however unknown.