More soil organic carbon is sequestered through the mycelium pathway than through the root pathway under nitrogen enrichment in an alpine forest

Xiaomin Zhu, Ziliang Zhang, Qitong Wang, Josep Peñuelas, Jordi Sardans, Hans Lambers, Na Li, Qing Liu, Huajun Yin, Zhanfeng Liu

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Abstract

Plant roots and associated mycorrhizae exert a large influence on soil carbon (C) cycling. Yet, little was known whether and how roots and ectomycorrhizal (ECM) extraradical mycelia differentially contribute to soil organic C (SOC) accumulation in alpine forests under increasing nitrogen (N) deposition. Using ingrowth cores, the relative contributions of the root pathway (RP; i.e., roots and rhizosphere processes) and mycelium pathway (MP; i.e., extraradical mycelia and hyphosphere processes) to SOC accumulation were distinguished and quantified in an ECM-dominated forest receiving chronic N addition (25 kg N ha−1 year−1). Under the non-N addition, the RP facilitated SOC accumulation, although the MP reduced SOC accumulation. Nitrogen addition enhanced the positive effect of RP on SOC accumulation from +18.02 to +20.55 mg C g−1 but counteracted the negative effect of MP on SOC accumulation from −5.62 to −0.57 mg C g−1, compared with the non-N addition. Compared with the non-N addition, the N-induced SOC accumulation was 1.62–2.21 and 3.23–4.74 mg C g−1, in the RP and the MP, respectively. The greater contribution of MP to SOC accumulation was mainly attributed to the higher microbial C pump (MCP) efficacy (the proportion of increased microbial residual C to the increased SOC under N addition) in the MP (72.5%) relative to the RP (57%). The higher MCP efficacy in the MP was mainly associated with the higher fungal metabolic activity (i.e., the greater fungal biomass and N-acetyl glucosidase activity) and greater binding efficiency of fungal residual C to mineral surfaces than those of RP. Collectively, our findings highlight the indispensable role of mycelia and hyphosphere processes in the formation and accumulation of stable SOC in the context of increasing N deposition.