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Carbon input increases microbial nitrogen demand, but not microbial nitrogen mining in boreal forest soils

Birgit Wild (1), Saeed Alaei (2), Per Bengtson (2), Samuel Bodé (3), Pascal Boeckx (3), Jörg Schnecker (4,5), Werner Mayerhofer (4), and Tobias Rütting (1)

(1) University of Gothenburg, Department of Earth Sciences, Gothenburg, Sweden, (2) Lund University, Department of Biology, Lund, Sweden, (3) Ghent University, Isotope Bioscience Laboratory, Gent, Belgium, (4) University of Vienna, Department of Microbiology and Ecosystem Science, Vienna, Austria, (5) University of New Hampshire, Department of Natural Resources and the Environment, Durham, NH, USA

Plant primary production at mid and high latitudes is often limited by low soil N availability. It has been hypothesized that plants can indirectly increase soil N availability via root exudation, i.e. via the release of easily degradable organic compounds such as sugars into the soil. These compounds can stimulate microbial activity and extracellular enzyme synthesis, and thus promote soil organic matter (SOM) decomposition ("priming effect"). Even more, increased C availability in the rhizosphere might specifically stimulate the synthesis of enzymes targeting N-rich polymers such as proteins that store most of the soil N, but are too large for immediate uptake ("N mining"). This effect might be particularly important in boreal forests, where plants often maintain high primary production in spite of low soil N availability.
We here tested the hypothesis that increased C availability promotes protein depolymerization, and thus soil N availability. In a laboratory incubation experiment, we added 13C-labeled glucose to a range of soil samples derived from boreal forests across Sweden, and monitored the release of CO_2 by C mineralization, distinguishing between CO_2 from the added glucose and from the native, unlabeled soil organic C (SOC). Using a set of 15N pool dilution assays, we further measured gross rates of protein depolymerization (the breakdown of proteins into amino acids) and N mineralization (the microbial release of excess N as ammonium).
Comparing unamended control samples, we found a high variability in C and N mineralization rates, even when normalized by SOC content. Both C and N mineralization were significantly correlated to SOM C/N ratios, with high C mineralization at high C/N and high N mineralization at low C/N, suggesting that microorganisms adjusted C and N mineralization rates to the C/N ratio of their substrate and released C or N that was in excess.
The addition of glucose significantly stimulated the mineralization of native SOC in soils where C availability was initially low, but this priming effect was not linked to increased gross protein depolymerization rates. Similarly, we found no connection to increased activities of enzymes targeting N-containing polymers such as proteins or chitin. Instead, glucose addition increased the microbial efficiency to use the N already available, as indicated by lower gross N mineralization rates and lower concentrations of inorganic N in the soil.
We emphasize that these findings do not generally preclude that higher C availability can induce microbial N mining and thus enhance soil N availability in some soils, but that such an effect cannot be universally assumed. In contrast, the changes in microbial N dynamics observed across our range of boreal forest soils suggest that higher C availability can at least in some soils increase N storage within microbial bio- and necromass, thus reducing N availability for plants, but also constraining soil N losses, e.g., by nitrate leaching and denitrification.