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Stabilization of labile carbon in soil microbial biomass and necromass – A question of nitrogen deficiency?

Nele Meyer[1,2], Outi-Maaria Sietiö[2], Sylwia Adamczyk[2], Christina Biasi[3], Per Ambus[4], Kevin Mganga[2], Rashmi Shrestha[2], Subin Kalu[2], Angela Martin[2], Bruno Glaser[5], and Kristiina Karhu[2]

[1]Department of Soil Ecology, University of Bayreuth, Bayreuth, Germany (nele.meyer@uni-bayreuth.de)
[2]Department of Forest Sciences, University of Helsinki, Helsinki, Finland
[3]Biogeochemistry Research Group, University of Eastern Finland, Kuopio, Finland
[4]Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark
[5]Institute of Agronomy and Nutritional Sciences, Soil Biogeochemistry, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany

It has been assumed for a long time that stable soil organic carbon (SOC) results from selective preservation of plant residues. Yet, a new paradigm points to a more active role of microorganisms in building SOC storage. In this context, even labile C, such as sugars, may persist in soil for a long time due to their incorporation into microbial biomass and ultimately necromass. The latter is considered as a relatively stable pool. However, little is known about the cycling of labile C through the microbial biomass and the turnover time of its residues. Unraveling the mechanisms and regulating factors would be critical for understanding SOC stabilization in soil.

We assume that the fate of labile C is mainly driven by microbial nitrogen (N) demand and supply. Specifically, we hypothesize that (1) high N demand forces microbes to decompose N-rich substances (“microbial N mining”), such as amino sugars, leading to a rapid turnover of microbial necromass, and that (2) labile C is stabilized in microbial necromass when N demand is met.

To investigate these hypotheses, we set up a greenhouse pot experiment including four treatments: (1) bare soil, (2) bare soil+N, (3) tree, and (4) tree+N. The soil is a sandy and nutrient poor forest soil from southern Finland. Trees are 1 m high pines (Pinus Sylvestris), which are supposed to induce microbial N deficiency by exuding easily degradable C compounds and by competing with microbes for mineral N. In order to follow to fate of labile C, we added trace amounts of ^{13}C labeled glucose to the soil (4 replicates per treatment). As a control to account for background variations in ^{13}C, we added ^{12}C glucose to another set of pots (4 replicates per treatment). Up to now, we sampled the soil 1 day, 3 days, 8 days, 1 month, 3 months, 6 months, 9 months, and 1 year after glucose addition. Measurements of the ^{13}C recovery in soil, microbial biomass, water extractable C, PLFA, amino sugars, and DNA are in progress.

First results indicate that the largest loss of ^{13}C tracer occurred in the unfertilized tree treatment, i.e., where N demand was high but N supply was low. Here, only 22% of the ^{13}C glucose remained after 3 month, whereas 40% remained in the fertilized tree treatment. Only small proportions of

the recovered ^{13}C were present in the pool of water extractable C (<1%) and in living microbial biomass (8±3%, 3 days after glucose addition). As protection by clay minerals and aggregates is likely not a relevant process in this sandy soil, we suspect the remaining ^{13}C to be stabilized in microbial residues, but depending on N demand. We assume that microbial necromass accounts for a considerable proportion to total SOC storage, especially under conditions of adequate nitrogen supply.