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Linking microbial carbon utilization with microbially-derived soil organic matter

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Soil microbial communities are fundamental to plant C turnover, as all C inputs eventually pass through the microbial biomass. In turn, there is increasing evidence that this biomass accumulates as a significant portion of stable soil organic matter (SOM) via physiochemical interactions with the soil matrix. However, when exploring SOM dynamics, these two processes are often regarded as discrete from one another, despite potentially important linkages between microbial C utilization and the fate of that biomass C as SOM. Specifically, if stable SOM is largely comprised of microbial products, we need to better understand the soil C inputs that influence microbial biomass production and microbial C allocation. Microbial physiology, such as microbial growth efficiency (MGE), growth rate and turnover have direct influences on microbial biomass production and are highly sensitive to resource quality. Therefore, the importance of resource quality on SOM accumulation may not necessarily be a function of resistance to decay but the degree to which it optimizes microbial biomass production.

To examine the relationship between microbial C utilization and microbial contributions to SOM, an ongoing 15-mo incubation experiment was set up using artificial, initially C- and microbial-free soils. Soil microcosms were constructed by mixing sand with either kaolinite or montmorillonite clays followed with a natural soil microbial inoculum. For both soil mineral treatments, weekly additions of glucose, cellobiose, or syringol are carried out, with an additional treatment of plant leachate to serve as a reference. This simplified system allows us to determine 1) if, in absence of plant-derived C, chemically complex SOM similar to natural soils can accumulate through the production of microbial residues and 2) how differences in C utilization of simple substrates, varying in energy yields, influence the quantity and chemistry of newly formed SOM. Over the course of the incubation, MGE, microbial activity and biomass, and SOM accumulation rates are monitored. Pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) is used to track the microbial transformation of added substrates into complex SOM and stability is measured biologically using 13C isotopes.

The first 6 mo of the incubation demonstrate a significant influence of both soil mineralogy and substrate quality on microbial physiology with subsequent effects on total newly formed soil C concentrations. However, treatment differences in total C changed when only the biologically stable fraction was considered. There was an interaction between mineralogy and substrate with soil respiration, enzyme activity and microbial biomass. Py-GC/MS results show a transformation of simple substrates into chemically complex SOM, rich in proteins, lipids, and phenolics. The abundances of proteins and lipids varied however, across soil and substrate treatments, suggesting divergent SOM chemistries due to substrate quality and organo-mineral interactions. Preliminary results from this long-term study demonstrate the microbial production of complex SOM where difference in accumulation and stability are influenced by the interactions between resources and the microbial community. From this work, we can develop a better understanding of the ecological context in which SOM is formed and how altering microbial community function and resource inputs may affect the development of stable SOM.