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Life and Death in the Soil Microbiome: How Cross-Kingdom Interactions Shape the Fate and Persistence of Soil Carbon

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Abstract

Soil surrounding plant roots, the 'rhizosphere', is a nexus of biological activity. Stimulated by exudates and root decay, rhizosphere organisms (bacteria, archaea, fungi, fauna, and viruses) interact to move carbon from root tissue to surrounding soil, and ultimately regulate how soil carbon is stabilized. While the concepts of soil food webs are well established, a quantitative and mechanistic understanding of how networks of organisms control dynamics of soil organic matter (SOM) and respond to changing precipitation patterns is only recently emerging. While some bio-interactions may be mutually beneficial, many others are the proximal cause of microbial death and turnover, producing microbial 'necromass' that plays a critical role in the persistence of soil organic matter (SOM). Several factors mediate microbial population dynamics, including top-down pressure from phage and soil microfauna, and environmental shifts in moisture or resource availability.

I will present evidence from studies where cross-kingdom responses to environmental drivers have follow-on effects for soil carbon—including shifts in resource availability around roots, fungal-bacterial interactions, and microbial community successional shifts during a post-drought wet-up. In all of these systems, stable isotope probing (SIP) helps us assess the active microbial and viral community and quantitatively track plant-derived carbon. These studies suggest that cross-kingdom interactions, involving bacteria, fungi, archaea, protists, microfauna and viruses, shape carbon availability and loss pathways and are differentially influenced by both soil habitat (rhizosphere, detritusphere, bulk soil) and natural fluctuations in the physicochemical environment.