Divergence in how roots and mycorrhizae affect microbial decomposition

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Soil microbes decompose organic matter and this is a critical process affecting fluxes of carbon from soil to atmosphere. To make reliable predictions of carbon fluxes it is imperative we understand drivers of microbial decomposition, but little is known about biotic drivers of decomposition. A prominent hypothesis is that roots facilitate decomposition activity. Plants benefit from facilitating decomposition as microbes increase available nutrients. Plants also host mycorrhizal fungi on their roots, yet few studies have investigated how mycorrhizae affect microbial activity. Mycorrhizae may also facilitate microbial activity, or they may compete with microbes for soil nutrients. In my study, I asked how roots and mycorrhizae affect microbial decomposition activity. Using a soil mesocosm field study, I examined effects of roots and mycorrhizae by progressively excluding them from microbes in soil. I used a 13C substrate to track microbial use of soil carbon into soil respiration. Additionally, I measured activity of enzymes that decompose labile and complex carbon, soil carbon pools, and microbial biomass. I found that roots promoted and mycorrhizae inhibited microbial decomposition of labile carbon. Microbes used the labeled substrate when roots and mycorrhizae were excluded, but used alternative carbon sources, potentially exudates, when roots and mycorrhizae had access. I found no effect of roots and mycorrhizae on microbial decomposition of complex carbon. My data suggest that mycorrhizae use oxidative enzymes to compete with microbes and reduce microbial biomass in soil far from roots, but that facilitation by roots overrides inhibitory effects of mycorrhizae when they are near roots. Overall, my work demonstrates there is spatial variation in microbial decomposition driven by ecological interactions. This becomes important as we use models to scale decomposition up to the ecosystem level.

Understanding effects of roots and mycorrhizae can improve mechanistic models of carbon dynamics. The Microbial Enzymatic Decomposition (MEND) model is calibrated with results from my experiment. The model simulates microbial production of two enzyme pools that decompose two respective carbon substrate pools, which vary in chemical and physical stabilization. Since the model lacks roots and mycorrhizae as mechanisms driving decomposition rates, data from exclusion treatments is used to calibrate the model. We test for importance of roots and mycorrhizae using data from mesocosms with root and mycorrhizal access and compare pool sizes predicted by the model to observed pool sizes in the study. Development of the MEND model with meaningful biological mechanisms represents the forefront of modeling biogeochemical processes.