EGU24-16663, updated on 26 Jan 2025
https://doi.org/10.5194/egusphere-egu24-16663
EGU General Assembly 2024

Nutrient and Water Availability Modulate the Destabilization of Mineral-Associated Organic Matter in the Rhizosphere

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Soils are the largest and most dynamic carbon reservoir in terrestrial environments, with most carbon stored as mineral-associated organic matter (MAOM). It has recently been shown that MAOM is effectively destabilized by reactive compounds released by plant roots and associated microbes. It is well known that quantity and quality of rhizodeposits dramatically change in response to nutrient or water stress, with unclear consequences for rates of plant root-driven MAOM destabilization. Here we show that altered rhizodeposition in response to environmental stressors affects rates of root-driven MAOM destabilization. Well-controlled growth chamber experiments with *Avena sativa* (common oat) allowed us to test the individual and interactive effects of nitrogen, phosphorus, and water limitations on the fate of 13C-labeled MAOM over a 10-week period. At the end of the experiment, total MAOM mineralization was strongly correlated with root biomass, which generally declined with nutrient and water limitations. However, under P limitations, root-driven MAOM mineralization was greatest during the initial growth stages (vegetative), whereas N limitations resulted in greater rates of MAOM mineralization during later growth stages (flowering). Drought treatments, when compared to their corresponding optimal watering treatments, produced the least MAOM destabilization. To test whether temporal changes in MAOM destabilization rates can be explained by differences in rhizodeposition intensity and composition, we analyzed rhizodeposits collected throughout the experiment via high-resolution mass spectrometry. This study demonstrates that MAOM mineralization is regulated not just by the inherent stability of MAOM against microbial attack, but also depends on plant water and nutrient availability within the whole plant-soil system as well as plant physiological and phenological stages. Through such feedback, changes in soil nutrient and water status (e.g. via altered precipitation or fertilizer application) can be expected to cause plant-induced alterations to the size of the otherwise stable, mineral-associated soil carbon reservoir.