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# Hillslope water-storage gradients alter drought-driven trajectories of dissolved organic matter transport and root exudation

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Soils are the largest terrestrial carbon reservoir, sustained in part by belowground plant carbon allocation through root growth and exudation. Yet varying root inputs to the subsurface in response to seasonal shifts in plant-accessible water—and how those responses shape soil organic-matter (SOM) processing and persistence—remains poorly constrained. We leverage a natural subsurface hydrologic contrast at the H.J. Andrews Experimental Forest (Oregon, USA) to study biotic and hydrologic controls on SOM processes. We sampled and monitored two adjacent Douglas-fir-dominated hillslopes that share similar soils and vegetation but differ in soil thickness, subsurface water storage capacity, and the persistence of plant-accessible water through summer drought. Previous work has shown that subsurface water storage capacity can alter SOM transformations, composition, and persistence across the landscape. To clarify the role of plants in driving seasonal SOM trajectories, we sampled in situ root exudates, rhizosphere-bound dissolved organic matter (DOM), and bulk DOM from zero-tension lysimeters (placed in A and B horizons) on approximately 6-week intervals between May and November 2024, and analyzed changes in SOM composition using Fourier-transform ion cyclotron resonance mass spectrometry. Organic matter composition varied seasonally for root exudates, and DOM in both rhizosphere-bound and bulk soil fractions. High water-storage hillslopes exhibited greater compositional variability across all pools. Rhizosphere-bound DOM differed sharply between hillslopes early in the growing season, then converged by winter toward more chemically complex, tannin-like signatures. In contrast, bulk DOM remained distinct between hillslopes throughout seasons: high-storage sites showed seasonal enrichment in organic S- and P-containing molecular formulas, whereas low-storage sites shifted toward more compositionally complex, lignin-like compounds. Depth patterns reinforced these differences—low-storage DOM was similar between A and B horizons, while high-storage sites exhibited pronounced stratification. Preliminary exudate results further suggest hillslope-dependent seasonal shifts in SOM inputs. These results suggest that plant inputs can synchronize SOM composition early in the season, but as drought intensifies, microbial processing and hydrologic connectivity increasingly governs hillslope organic matter trajectories. Accounting for plant-accessible water as a constraint on rhizosphere inputs, DOM transport, and depth-dependent processing may improve soil-carbon models in seasonally dry landscapes.