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Succession between living and dead roots drives the fate of soil carbon pools

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There is growing evidence that belowground plant carbon (C) inputs displays a major role for soil organic matter (SOM) dynamics. During the root life-cycle, there is a sequential shift from C inputs from living to dead roots, which might affect the conversion of these specific compound classes to SOM. However, this successional effect has yet not been investigated. In this study, we aimed to evaluate (i) the short-term impacts of living root-derived C on SOM formation and composition and (ii) how the succession between living and dead roots impacts their respective fate in soil. For this purpose, we set up a two-step experiment that simulated the shift between living and dead roots C inputs. In the first step, *Eucalyptus* spp. plants were cultivated in pots under controlled conditions for 66 days. In order to isolate the living root-derived C, we inserted in each pot 4 cylinders (0.5 cm high, 4.75 cm diameter) capped with a nylon membrane (pore size 5 μm) and filled with soil (clayey Rhodic Ferrasol) at the start of the experiment. Half of the pots were periodically pulse-labeled with ^{13}C-CO_2 (10 pulses of 10 h, 0.46 g of ^{13}C plant^{-1}), while the remaining ones were used as controls (unlabeled treatments). After 66 days, all pots were harvested, and one cylinder per pot was used to depict the living root effects on SOM pools. Those cylinders were separated in layers according to the distance from the roots (0-4, 4-8, 8-15 and 15-25 mm) and analyzed for organic carbon, nitrogen, as well as $\delta^{13}C$. We quantified and characterized the microbial communities using phospholipid fatty acid (PLFA), and extracted the pedogenic oxides (iron and aluminum) to highlight potential alterations in organo-mineral complexes and short-range order phases. Using density/size fractionation, we further gained elemental and isotopic information of specific SOM pools, i.e. particulate, occluded and mineral-associated organic matter. The remaining cylinders were incubated for 84 days in two treatments, with and without dead roots. Heterotrophic respiration rates were measured periodically together with the ^{13}C enrichment of the CO_2 produced. Carbon derived from living roots was mainly recovered in the first millimeters from the root source, as occluded or mineral-associated SOM. Close to the roots, we detected a shift in the microbial communities and a decrease of organo-mineral complexes and short-range order phases. Carbon derived from living roots was rapidly mineralized and the $\delta^{13}C$ from the respired CO_2 returned to natural abundance ranges after 84 days of incubation. The presence of dead roots did not affect the mineralization C derived from living roots. Our work

highlights the importance of C inputs from living roots for the formation of SOM. However, the compounds deposited by living roots exhibit also a transient nature which challenges the assumption that living root-derived C is necessarely a precursor of stable SOM formation.