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Soil texture determines the microbial processing from litter to POM and MAOM in the detritussphere

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Soil texture and microorganisms are key drivers controlling the fate of organic matter (OM) originating from decaying plant litter, and thus the stabilization of soil organic matter (SOM). However, the understanding of the mutual interactions between microbial litter decay and soil structure formation controlled by different soil textures remains incomplete. We monitored the fate of litter-derived OM (using ^{13}C isotopic enrichment) from decaying litter (shredded maize leaves) to microorganisms and SOM in two differently textured soils (sand and loam). The two soils were incubated with litter mixed in the top layer in microcosms for 95 days during which regular CO_2 and $^{13}CO_2$ measurements were conducted. After the incubation, each microcosm was divided in three to separate a top, center and bottom layer. Using a physical soil fractionation scheme, we assessed the fate of litter-derived OM to free and occluded particulate OM (POM), as well as mineral associated OM (MAOM). All SOM fractions were analysed with respect to their mass distribution, C, N, and ^{13}C contents, and for their chemical composition using compound-specific ^{13}C-CPMAS NMR spectroscopy. The effects of contrasting textures on the total microbial community structure were studied using phospholipid fatty acids (PLFA) and the incorporation of litter-derived C into individual PLFAs was assessed via ^{13}C-PLFA. Lastly, scanning electron microscopy and nano scale secondary ion mass spectroscopy (NanoSIMS) analysis of free POM of both textures enabled qualitative insights directly at the biogeochemical interface of the microbial hot spot of decaying plant litter.

We were able to clearly demonstrate higher contents of litter-derived OM still residing as free POM in the loamy textured soil after the 95 day-incubation, while higher contents were found in occluded and MAOM in the sandy textured soil. This indicated that the overall litter decomposition was refrained in the finer-textured soil, whereas microbial alteration and allocation of litter-derived compounds was promoted in the coarser textured soil. This was further corroborated by higher respiration and higher amounts of respired litter-derived CO_2-C in the sandy soil. The PLFA

analysis showed a coherent pattern between the textures, with similar community structures in all treatments and significant increases in microbial abundance in the top layers induced by litter addition. This increase was found most pronounced in fungal biomarkers, which was in line with the ^{13}C-PLFA measurements revealing over 90% of fungal biomarkers to be of litter-origin (compared to 30-40% in the other microbial groups). The labelled PLFA profiles also confirmed the importance of fungi as a vector for litter-derived OM into deeper layers of the soil columns, with significantly higher litter-derived fungal markers also in center and bottom layers. The NanoSIMS measurements verified the high ^{13}C enrichment in fungal hyphae and further revealed clay minerals embedded in enriched microbial-derived extracellular polymeric substances and intertwined with hyphae directly on top of the POM. Based on this comprehensive data, we highlight that regardless of the texture, plant litter in association with microbial-derived products represent a hot spot for soil structure formation by harbouring a core for aggregation and MAOM formation.