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Carbon storage in soil: how different land uses affect particulate organic matter composition. A molecular approach using nuclear magnetic resonance spectroscopy.

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The future soil carbon stocks in a climate change scenario is being closely monitored. However, the huge edapho-climatic variability impedes to disclose the mechanisms which underlie the cycle of accumulation/mineralization of soil organic matter (SOM). Soil environment could be described as a complex three phases matrix in which gases, liquids, and solids are not uniformly mixed, and in which microbes, fungi, vegetal residues, and roots are continuously interacting with the soil matrix and with each other. Molecular analyses on soil samples are crucial to estimate how stable those pools are and to predict which practices may accumulate larger C stocks. However, the study of land use impact through molecular characterization of a complex mixture like SOM is a challenge that requires a multidisciplinary approach. The present study applied a combination of soil physical fractionation (separation by density of the particulate organic matter (POM) within water stable aggregate fractions) followed by nuclear magnetic resonance (NMR) spectroscopy as a way to overcome spatial variability and to quantify the changes in the composition of SOM induced by land-use changes. The objective of the study was to assess, at a molecular level, the impact of different land managements, i.e. the introduction of temporary (ley) grassland into cropping cycles, on the chemical composition of SOM. Soil samples were collected at the long-term experimental observatory in Lusignan (http://www.soere-acbb.com/), in which control plots under permanent grassland, permanent cropland, and bare fallow are part of the experiment.

To improve the signal-to-noise ratio (especially in the aromatic-C region), samples were analyzed using a ramped cross polarization-single pulse/magic angle spinning (CPSP/MAS) experiment. Peak integrals of different spectral regions (indicating different compound classes) were compared between treatments and two different molecular mixing models, calibrated against standard compounds, were applied to characterize and quantify the impact of land uses on SOM. POM represents the most reactive fraction of SOM, reflecting the vegetal input returned to soil and the degradation rate of fresh litter. Carbohydrates and proteins tended to be more abundant in POM from larger aggregates, whereas finer fractions were richer in alkyl and aromatic compounds.

Bare fallow showed lower contribution of O-alkyl compounds and a higher contribution of aromatic-C in larger size fractions, due to the degradation of carbohydrates and the accumulation of condensed, hardly degradable structures. For finer fractions, differences between treatments were attenuated.

After 3 years of maize, ley grassland maintained a grassland "fingerprints" for most of the fractions, except for the largest one, richer in carbohydrates as for cropland samples, and for the finest one. In the latter, lower carbohydrates and higher alkyl-C contributions were found, probably due to microbial-C and/or persistence of aliphatic vegetal material. Those findings may validate other studies on the same area, which highlighted that short cropping periods might preserve grassland derived carbon and might not alter microbial preferences for grassland-derived litter. Thus, higher alkyl-C contribution reported for "older" grassland derived SOM (finer fraction) rather than newly derived one (larger macroaggregates) may be due to microbial proliferation driven by this preference.