

Lignin as a molecular marker of land management impacts on soil C storage and turnover

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Implementation of temporary grassland on cropped lands may be a sustainable option to enhance the carbon storage via the accumulation of soil organic matter (SOM). However, carbon storage is not only a matter of quantity, since higher inputs of labile carbon may stimulate soil microbial and fungal communities and induce the degradation of the formerly stabilized SOM, through the so-called priming effect. Therefore, targeted strategies for carbon storage need to consider the stability of newly added SOM at long term.

Recently, soil ecologists emphasized the huge spatial variability of soil structure and properties, and the fact that many ecosystem functions of SOM are only achieved if it decomposes. Thus, more attention must be paid to fluxes of carbon rather than to the quantities accumulated.

The present study aims to cope with the listed problems. The aim of the study was to use lignin as a molecular marker of plant C turnover, to assess carbon storage provided by a temporary (ley) grassland system situated at the long term experimental observatory in Lusignan (<http://www.soere-acbb.com/>). Our conceptual approach included plots under permanent grassland, permanent cropland and bare fallow as controls.

A soil fractionation into water stable aggregates has been chosen as a strategy to overcome spatial complexity, and compound specific analyses were focused on lignin phenols within the aggregates.

The hypothesis of this work is that lignin turnovers may be influenced by land uses, lignin localisation within soil compartments, the nature of litter input (above vs. belowground biomass), aggregate distribution, and plant cover characteristics (crop vs. grass). To test the hypothesis, cycles of storage and degradation of lignin were studied using compound specific stable isotope probing, taking advantage of in situ labelling provided by the switches from C3 to C4 plants (i.e. grassland to continuous maize) in the experimental area.

Lignin monophenols were extracted and purified with the CuO oxidation method, then their molecular isotopic content was analyzed with a gas chromatograph coupled with an isotopic ratio mass spectrometer. Turnover of each monomer was evaluated using the values obtained for maize and grass biomass as a reference. Results showed that for syringyl units, the acid monophenols had a faster turnover than their aldehydic form, whereas differences were less pronounced for vanillyl units. The fast degradation of cinnamyl units impeded a reliable determination of their turnover rates. Ley grassland reduced the turnover rates of lignin monophenols within macroaggregates and microaggregates, main contributors of total soil mass, and for vanillyl units of bulk soil. For finer fractions, similar turnover rates were detected under ley grassland and permanent cropland. A possible explanation is the preferential binding of lignin to silt in a first step, followed by a degradation of monophenols and their transformation into compounds that are not detected by the CuO oxidation method. Thus, turnover of SOM compounds constitutes a complex mosaic of different interactions and factors, such as litter origin, land use. Our molecular isotopic study also evidenced that spatial variability must be taken into account to evaluate carbon storage at long-term.