



Organic matter turnover in arable soils using ^{13}C natural abundance – bulk carbon, lipids and lignin

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The turnover of soil organic matter plays an important role in the global carbon cycle. Models describing CO₂ budgets therefore assume different rates of soil organic carbon (SOC) turnover, depending on the reactivity of plant-derived compounds. Lipids and lignin are assumed to represent a relatively stable fraction of soil organic matter (SOM) (e. g. Kögel-Knabner, 2002). A standard approach for assessment of SOM turnover rates uses natural isotopic labeling after switching from a C₃-plant to a C₄-plant monoculture. Replacing isotopically light C₃-biomass (e.g. rye) with isotopically heavier C₄-biomass (e.g. corn) incorporates biomass with heavier C-isotopic signature into SOM. This label allows to calculate proportions of new C₄-plant derived carbon (e.g. Lichtfouse et al., 1998). In this study, we simultaneously applied isotopic and biomarker analysis to obtain information on turnover times for bulk soils and individual components. We combine our results with already published data on 22 agricultural sites also using natural labeling.

Samples originated from experimental agricultural plots in Germany, Switzerland and France, and were taken 5. . . 40 years after introduction of a C₄-monoculture, with reference sites kept under C₃-monocultures. Total lipids were recovered by accelerated solvent extraction and separated into eight fractions of different polarity by automated liquid chromatography (Wiesenberg et al., 2004a, b). Lignin monomers were obtained via CuO-Oxidation followed by chromatographic clean-up (Heim & Schmidt 2005). Fractions of aliphatic hydrocarbons, carboxylic acids and lignin monomers were ana-

lyzed by GC-MS and GC-irmMS. Bulk SOC was analyzed by EA-IRMS after decarbonatization.

Results show that within 40 years new C4 plant biomass replaced 30...50% of the pre-existing C3 organic carbon following an exponential function with time, as expected. Typically, the amounts of new biomass were smaller in those soils with smaller biomass incorporation (silage cropping, no-till) than those for grain cropping and conventional tillage. Together with literature data on 22 field sites, we could, however, distinguish two subgroups of soils. In soils with mollic horizons (surface horizon with dark colour due to organic matter), the proportions of new C4 biomass carbon were always smaller than in the other soils, although carbon concentrations, stock and input all were similar. These proportions can be translated into apparent turnover times, given the time since conversion, and assuming steady state of the soil organic matter system and first order decay of the biomass. Arable soils with mollic properties had higher apparent turnover times (80 years) than the other soils (40 years). One possible explanation for that difference could be that soils with mollic properties have a larger fraction of slowly (centuries rather than decades) cycling soil organic carbon.

Compounds supposed to contribute to the relatively slow carbon pool were lignin and lipids. Our results on three sites, however, show that both lignin and lipids replaced pre-existing soil organic carbon at similar rates or even faster than bulk organic carbon, increasing in the order lignin (45...55%) < n-carboxylic acids (50...60 %) < n-alkanes (55...75 %). Thus, our data clearly demonstrated that lipids and lignin do not contribute to the long-term stable pool of soil organic matter, as previously suggested. Furthermore, these results add a new perspective to the still unanswered question, which compounds make up the long-term stable pool of SOM.

References

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