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Short-term turnover of soil organic matter after tillage proven by Pyrolysis-field ionization MS

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Knowledge about the composition and the turnover dynamics of soil organic matter (SOM) is crucial to the fertility of agricultural soils. Even short-term changes of SOM are of fundamental importance. Tillage changes the decomposition and the mineralisation of SOM. By disrupting macroaggregates, tillage induces an increased turnover and hampers the aggregation of SOM. As a consequence, mineralisation of SOM is stimulated which may imply an additional efflux of CO_2 and N2O from soil.

Pyrolysis-field ionization mass spectrometry (Py-FIMS) has been developed as a key method for SOM research. This powerful analytical tool allows a rapid, global and objective determination of the majority of chemical compound classes and is an appropriate method for the analysis of even small differences of biogeochemical matters. Hence, Py-FIMS may allow for a precise detection of the turnover of SOM and the involved compounds that are affected by tillage in the short-term. Py-FIMS measurements along with the determination of the CO_2 and N2O effluxes from soil after tillage at the same site may give new insights into the compounds of SOM which are mineralised and consequently contribute to fundamental processes such as respiration, nitrification and denitrification.

We applied Py-FIMS to soil samples from a stagnic Luvisol taken before and after tillage from a harvested maize field in Northern Germany. The samples were taken from two treatments amended with mineral fertiliser (MF) and biogas residues (BR), respectively, and also from an unfertilised control (UC). Tillage was conducted by disc harrowing, followed by mouldboard ploughing up to 30 cm. Simultaneously the soil efflux of CO_2 and N2O was measured with a dynamic chamber technique.

Before tillage, the mass spectra showed distinct differences in the relative ion intensities: the BR treatment showed much more volatilised matter during pyrolysis indicating an increased amount of SOM. Furthermore, in this treatment, the proportions of carbohydrates, peptides and N-heterocycles were smaller and those of lipids and sterols had larger values than in the other treatments, most likely attributable to the cattle manure used for the biogas feedstock and to relative enrichments during anaerobic fermentation. Only a few days after tillage significant changes in SOM composition were observed, especially in the BR treatment: the proportions of volatilised matter and the relative signal intensities of carbohydrates, phenols + lignin monomers, N-heterocycles and peptides increased, whereas those of lignin dimers, lipids and sterols decreased. In the MF treatment only an increase of lipid proportions at the expense of carbohydrates was observed. The decrease and the increase of carbohydrates in MF and BR, respectively, were reciprocally correlated with the cumulated CO_2 efflux. The N2O efflux increased in MF and BR after tillage, but not in UC.

Thus, we were able to show significant changes in the quality of SOM due to tillage confirming the sensitivity of Py-FIMS to detected even short-term changes in SOM composition that could be related to the release of gases from soil.