Long-term effects of inorganic and organic amendments on soil organic matter quality in a Swiss agrosystem

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Sustainable management of soil organic matter (SOM) is of great concern. The current study investigated how the addition of mineral and organic (green manure, wheat straw, farmyard manure and cattle slurry) amendments affected the quality of SOM in a 37-year field experiment in Changins, Nyon (VD), conducted by Agroscope-Changins. Firstly, a spectroscopic analysis of the organic amendments was performed using FTIR-KBr technique to study both their intrinsic molecular recalcitrance and wetting property. Secondly, the SOM quality affected by these amendments was investigated by (1) infrared spectroscopy (FTIR-KBr technique) using bulk soil, determining the aromaticity index (1630 cm-1: 2925 cm-1 absorbance band ratio) and by (2) particle size fractionation, investigating the organic carbon (Corg) allocation in size fractions. Finally, extracellular enzyme assays were conducted, using fluorogenically labeled substrates, concerning carbon (β-glucosidase), nitrogen (β-1,4-N-acetylglucosaminidase and leucine aminopeptidase), phosphor (phosphatase) and redox (phenol oxidase) cycles.

FTIR signatures of organic amendments indicated that both green manure and cereal straw were rich in organic acids. Straw, in addition, was particularly rich in aliphatic compounds (fats, wax, lipids), contributing to its water-repellent property (highest hydrophobicity), while green manure indicated the lowest hydrophobicity. Farmyard manure and cattle slurry, in contrast, contained more polysaccharides, lignin-derived phenol groups and aromatic compounds, indicating generally a greater inherent recalcitrance in terms of their molecular structures. In general, 50% of the SOM was stored associated to the silt-sized fraction, but the storage capacity of SOM was generally more related to the sorption mechanism of clay minerals. An exception was observed in the green manure-treated soil, where the accumulated SOM was 20% more preferentially associated with sand particles, compared to that of mineral NPK treatment. In support of this, extracellular hydrolytic enzymes generally exhibited higher activities in green manure-treated soil, while the lignin-degrading phenol oxidase tended to exhibit slightly higher activity in animal manure-treated soils. These results seem to be reflective of the physical disconnectivity of SOM as well as the enzyme allocation according to their target substrates as stabilization factors. These results were also in agreement with the aromaticity index of SOM as an indicator of humification degree. Mineral NPK- and green manure-treated SOM both exhibited the lowest aromaticity index, while it was two-fold higher for straw-treated SOM and three-fold higher for farmyard manure and cattle slurry-treated SOM. Our results may thus suggest that the shift in the SOM quality may take different directions that are initially controlled by the biochemical degradability of each amendment. The resulting physical allocation of SOM and enzymes seems to determine whether the SOM would be degraded or stabilized for long-term, which is consequently reflected as the aromaticity index of SOM. Our results also indicated that the straw incorporation seems to have the potential to preserve SOM for long-term and therefore can be an interesting alternative to animal manure application.