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Carbon associated with clay and fine silt as an indicator for SOC evolution under different residue management regimes

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Estimates of soil organic carbon (SOC) sequestration or loss can be biased by large uncertainties deriving from temporal and spatial variability of organic carbon concentrations, even at the field level. In order to reduce these uncertainties, we used the organic carbon associated with clay and fine silt particles (stable carbon, slow pool) as an indicator for carbon changes rather than SOC in bulk soil for assessing decadal changes. We used an on-going long-term experiment in the Hesbay region in Belgium, started in 1959, with 3 contrasting management practices (3 x 6 replicates): Residue Export (RE), Farmyard manure application (FYM) and Residue Restitution (RR). After 42 years, there are no significant differences in bulk soil organic carbon concentrations between treatments (RE=9.2 gC.kg-1soil; FYM=10.4 gC.kg-1soil; RR=10.1 gC.kg-1soil). In contrast, there are significant differences ($p<0.05$) in stable carbon between treatments over the same time period. Moreover, we can be 99% confident that stable carbon increased between 1970 and 2012 in FYM (+19%) and RR plots (+14%). There was no significant change of stable carbon in RE plots over the same period. In 1970, no differences in stable carbon concentration were detected between management practices. Labile carbon (carbon non-associated with clay and fine silt particles) did not change significantly from 1970 to 2012 but its variability increased for plots under management. We used the Rothamsted Carbon model (RothC-26.3) to explain how sensitive and slow pools react under different management practices. For bulk soil, observed trends in SOC stocks are in line with the ones predicted. Modelled SOC stocks changes from 1962 to 2012 are -14% (RE) and +10% (FYM). We also used RothC-26.3 to understand the evolution of the sensitive and slow fractions over time. We found that RothC was not capable to simulate the interannual variability of observed SOC stocks. On the other hand, slow RothC pools are useful to understand SOC stocks evolution over decades between two specific periods. In FYM and RR plots, both the RothC pool with slow decomposition (HUM) and the carbon associated with the fine fraction increase. This highlights that residue managements can improve carbon sequestration in agricultural soils, even if no changes are detected in bulk soil.