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Storing additional carbon in soil: different practices, different stabilities of the organic matter?

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A diversity of agricultural practices and systems enable the accrual of soil organic C (SOC) stocks, with variable efficiencies. These C-storing practices increase SOC stocks, either by increasing the inputs of plant biomass or exogenous organic matter, or by decreasing the outputs of SOC reducing SOC mineralisation rates, or both. In the perspective of contributing to climate change mitigation, the temporal stability of the additional SOC stored is critical.

Different approaches can be used to assess the stability of soil organic matter, such as physical fractionation of soil organic matter, chemical extractions, long term incubations and analysis of the thermal behaviour of the organic matter using RockEval© pyrolysis. These address contrasting residence times, such as of months to years (long term incubations), to several decades and centuries (particle size fractionation, RockEval© pyrolysis coupled with PARTYSOC model)

We used the literature and long-term agricultural experiments in which management options (application of exogenous organic matter, conservation agriculture, organic agriculture, agroforestry) result in increased SOC stocks. We investigated the stability of the additional SOC stored, compared to the reference management option.

Methods currently used in the literature to assess the temporal stability of soil organic matter do not address the same SOC kinetic pools. Care must be taken to specify which range of residence times is considered when using any method intending to evaluate the biogeochemical stability of soil organic matter, as well as when using the terms stable or labile.

Management options result in slightly contrasted stability of the additional organic carbon, the application of exogenous organic matter resulting in the most stable additional carbon, compared to management options that increase belowground plant biomass inputs to soil. Carbon storing agricultural management options mobilize different stabilization processes of soil organic matter: chemical recalcitrance, organo-mineral interactions and physical protection.