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Effect of crop residue incorporation on soil organic carbon (SOC) and greenhouse gas (GHG) emissions in European agricultural soils

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Soil organic matter (SOM) improves soil physical (e.g. increased aggregate stability), chemical (e.g. cation exchange capacity) and biological (e.g. biodiversity, earthworms) properties. The sequestration of soil organic carbon (SOC) may mitigate climate change. However, as much as 25-75% of the initial SOC in world agricultural soils may have been lost due to intensive agriculture (Lal, 2013). The European Commission has described the decline of organic matter (OM) as one of the major threats to soils (COM(2006) 231). Incorporation of crop residues may be a sustainable and cost-efficient management practice to maintain the SOC levels and to increase soil fertility in European agricultural soils. Especially Mediterranean soils that have low initial SOC concentrations, and areas where stockless croplands predominate may be suitable for crop residue incorporation.

In this study, we aim to quantify the effects of crop residue incorporation on SOC and GHG emissions (CO_2 and N2O) in different environmental zones (ENZs, Metzger et al., 2005) in Europe. Response ratios for SOC and GHG emissions were calculated from pairwise comparisons between crop residue incorporation and removal. Specifically, we investigated whether ENZs, clay content and experiment duration influence the response ratios. In addition, we studied how response ratios of SOM and crop yields were correlated.

A total of 718 response ratios (RR) were derived from a total of 39 publications, representing 50 experiments (46 field and 4 laboratory) and 15 countries. The SOC concentrations and stocks increased by approximately 10% following crop residue incorporation. In contrast, CO_2 emissions were approximately six times and N2O emissions 12 times higher following crop residue incorporation. The effect of ENZ on the response ratios was not significant. For SOC concentration, the >35% clay content had significantly approximately 8% higher response ratios compared to 18-35% clay content. As the duration of the experiment rose, RR for SOC concentration and stock increased. For N2O emissions, RR was significantly higher in <5 years experiment duration compared to 11-15 years experiment duration. For GHG emissions, the RRs were significantly higher when vegetable crop residues were incorporated instead of cereal crop residues. No significant correlations were found between RR for SOC concentration and yields, but differences between sites could be detected. We conclude that crop residue incorporation is an important management practice for maintaining SOC concentrations and stocks. Its influence in increasing GHG emissions should not be overlooked as the data availability from field experiments on GHG emissions is still scarce.