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Soil organic carbon sequestration potential of conservation vs. conventional tillage

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Soil tillage has been associated with many negative impacts on soil quality, especially a reduction in soil organic carbon (SOC). The benefits of no tillage (NT) on topsoil SOC concentrations have been demonstrated in several reviews, but the effect of reduced tillage (RT) compared to conventional tillage (CT) that usually involves soil inversion through moldboard ploughing is still unclear. Moreover, the effect of tillage on total SOC stocks including deeper layers is still a matter of considerable debate, because the assessment depends on many factors such as depth and method of measurement, cropping systems, soil type, climatic conditions, and length of the experiments used for the analysis.
From a recently published systematic map database consisting of 735 long-term field experiments ($\geq$ 10 years) within the boreal and temperate climate zones (Haddaway et al. 2015; Environmental Evidence 4:23), we selected all tillage studies (about 80) reporting SOC concentrations along with dry soil bulk density and conducted a systematic review. SOC stocks were calculated considering both fixed soil depths and by using the concept of equivalent soil mass. A meta-analysis was used to determine the influence of environmental, management, and soil-related factors regarding their prediction potential on SOC stock changes between the tillage categories NT, RT, and CT. C concentrations and stocks to a certain depth were generally highest under NT, intermediate under RT, and lowest under CT. However, this effect was mainly limited to the first 15 cm and disappeared or was even reversed in deeper layers, especially when adjusting soil depth according to the equivalent soil mineral mass. Our study highlights the impact of tillage-induced changes in soil bulk density between treatments and shows that neglecting the principles of equivalent soil mass leads to overestimation of SOC stocks for by conservation tillage practices.