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Contrasting effects of deep ploughing of croplands and forests on SOC stocks and SOC bioavailability

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Subsoils are essential within the global C cycle since they have a high soil organic carbon (SOC) storage capacity due to a high SOC saturation deficit. However, measures for enhancing SOC stocks commonly focus on topsoils. We assessed the long-term stability of topsoil SOC buried in cropland and forest subsoils by deep ploughing. Deep ploughing was promoted until the 1970s for breaking up hardpan and improving soil structure to optimize crop growth conditions. In forests deep ploughing is performed as a site preparation measure for afforestation of sandy soil aiming at increasing water availability in deeper layers and decreasing weed competition by burial of seeds.

An effect of deep ploughing was the translocation of topsoil SOC into subsoils, with a concomitant mixing of SOC-poor subsoil material into the "new" topsoil horizon. Deep ploughed croplands and forests represent unique long-term "in-situ incubations" of SOC-rich material in subsoils in order to assess the effect of soil depth on SOC turnover. In this study, we sampled soil from five loamy and five sandy cropland sites as well as from five sandy forest sites, which were ploughed to 55-127 cm depth 25 to 53 years ago. Adjacent, equally managed but conventionally ploughed or not ploughed (forests) subplots were sampled as reference.

On average 45 years after the deep ploughing operation, at the cropland sites, the deep ploughed soils contained 42±13 Mg ha^{-1} more SOC than the reference subplots down to 100 cm depth. On the contrary, at the forest sites, the SOC stocks of the deep ploughed soils contained 18±9 Mg ha^{-1} less SOC compared to the reference soils on average 38 years deep ploughing. These contrasting results can be explained, on the one hand, by the slower SOC accumulation in the newly formed topsoils of the deep ploughed forest soil (on average 48% lower SOC stocks in topsoil) compared to the croplands (on average 15% lower SOC stocks in topsoil). On the other hand, the buried topsoils at the forest sites exhibited similar bioavailability of SOC (measured as net C mineralization rates from short-term in-vitro incubations) as compared to the reference topsoils. In contrast, at the sandy cropland sites, net C mineralization rates were significantly lower (67%) in the buried topsoil material compared to the reference topsoil. Buried SOC in the sandy soils is thus highly stable.

Together with these results, we will present data on SOC fractions and discuss their implications for our view on stability of buried SOC in croplands and forests. Our results show that deep ploughing contributes to SOC sequestration by enlarging the storage space for SOC-rich material but only under the preconditions that i) burial is accompanied by decrease in SOC bioavailability and ii) SOC accumulates considerably in the newly formed topsoil.