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Increasing topsoil and subsoil organic carbon storage with improved rotation in cropland-grassland agroecosystems

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Soil organic carbon (SOC) accumulation in agroecosystems is a promising solution to simultaneously improve food security and mitigate climate change. Indeed, because of their large carbon deficit, cropland soils can potentially sequester a substantial amount of atmospheric carbon (C). To estimate the soil C-sequestration potential, it is critical to derive reliable estimations of the current soil C-saturation level. This step is essential to obtain an accurate quantification of C-deficits in cultivated soils. In addition, it is important to identify agricultural practices that favor SOC accumulation in order to reduce the soil C-deficit. Based on a 30-year old soil monitoring network of multiple cropland (CR) and permanent grassland (PG) sites established in western Switzerland, we (i) quantified the C-deficit in croplands, (ii) identified the factors driving the C-deficit and (iii) evaluated the assumption that grasslands can be used as C-saturated reference sites. We demonstrated that SOC in CR were depleted by a third compared to PG. The main factor affecting C-deficit in CR was the proportion of temporary grasslands (TG) within the crop rotation. We also showed that PG have not reached their C-saturation level in the study area and that additional C could be stored in PG soil under optimal management. When accounting for pedo-climatic differences, the C-deficit of CR that do not include TG in the rotation was equivalent to 3 kg C m^{-2} down to 50 cm depth. The relationship between the proportion of TG in the rotation and SOC stocks in the topsoil (0-20 cm) and subsoil (20-50 cm) was linear and similar at both depths, revealing the strong potential of the subsoil to sequester C.