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Conversion of cropland to grassland: increasing or decreasing soil organic carbon?

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Conversion of cropland to permanent grassland is often expected to sequester atmospheric CO_2 by increasing soil organic carbon (SOC) stocks. We investigated this possibility under realistic management conditions on the field scale. We compared the development of the carbon (C) balance and SOC stocks of intensively (high nitrogen input and frequent cutting) and extensively (no nitrogen input, infrequent cutting) managed grassland after conversion from an arable rotation. The study was carried out at a site in the northern lowlands of Switzerland with a temperate climate and a soil classified as Eutri-Stagnic Cambisol. As a first approach, C balance was assessed by measuring C fluxes in and out of the ecosystem including net CO_2 exchange by eddy flux measurements, as well as C import by organic fertilizer and C export by harvest. In a second approach, SOC stocks (0-45 cm depth) were quantified at the beginning (2001) and at the end (2006) of a 5-year observational period. An equivalent soil mass of 500 kg m^{-2} was sampled. Results showed very similar SOC stocks in 2001 of 13-14 kg C m^{-2} for the intensive and extensive field. Over the 5-year period, the observed mean annual increase for the intensive field was small and not significant, whereas for the extensive field a significant decrease of 0.22 kg C m^{-2} yr^{-1} was found. The other approach (flux budget) also indicated a generally positive carbon balance (C accumulation) for the intensive field and a negative balance (C loss) for the extensive field, with substantial inter-annual variations in relation to growing season length and soil moisture. Both, stock and flux measurements, revealed a consistent difference between the C balance of the two management types (about 0.25 kg C m^{-2} yr^{-1}), which also appeared in simulations with the mechanistic grassland model PROGRASS. However, absolute values for the C balance differed between the two experimental approaches. The flux measurements indicated higher gains to the intensive management, whereas the stock approach suggested larger losses due to extensive management. It can be concluded that without continuous nitrogen input, the conversion from arable rotation to permanent grassland may cause a considerable loss of SOC due to increased soil organic matter decomposition.