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Carbon sequestration and turnover in soil under the energy crop *Miscanthus*: Repeated ^{13}C natural abundance approach and literature synthesis

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Abstract

© 2017 John Wiley & Sons Ltd. The stability and turnover of soil organic matter (SOM) are a very important but poorly understood part of carbon (C) cycling. Conversion of C₃ grassland to the C₄ energy crop *Miscanthus* provides an ideal opportunity to quantify medium-term SOM dynamics without disturbance (e.g., plowing), due to the natural shift in the $\delta^{13}\text{C}$ signature of soil C. For the first time, we used a repeated ^{13}C natural abundance approach to measure C turnover in a loamy Gleyic Cambisol after 9 and 21 years of *Miscanthus* cultivation. This is the longest C₃-C₄ vegetation change study on C turnover in soil under energy crops. SOM stocks under *Miscanthus* and reference grassland were similar down to 1 m depth. However, both increased between 9 and 21 years from 105 to 140 mg C ha⁻¹ ($P < 0.05$), indicating nonsteady state of SOM. This calls for caution when estimating SOM turnover based on a single sampling. The mean residence time (MRT) of old C (> 9 years) increased with depth from 19 years (0-10 cm) to 30-152 years (10-50 cm), and remained stable below 50 cm. From 41 literature observations, the average SOM increase after conversion from cropland or grassland to *Miscanthus* was 6.4 and 0.4 mg C ha⁻¹, respectively. The MRT of total C in topsoil under *Miscanthus* remained stable at ~60 years, independent of plantation age, corroborating the idea that C dynamics are dominated by recycling processes rather than by C stabilization. In conclusion, growing *Miscanthus* on C-poor arable soils caused immediate C sequestration because of higher C input and decreased SOM decomposition. However, after replacing grasslands with *Miscanthus*, SOM stocks remained stable and the MRT of old C₃-C₄ increased strongly with depth.

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Keywords

^{13}C natural abundance, C₃-C₄ vegetation change, Carbon sequestration, Energy crop, Mean residence time, Soil organic matter