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Soil organic carbon stock change by short rotation coppice cultivation on croplands

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Bioenergy is a means to climate mitigation if the overall greenhouse gas balance of the respective crop is better than that of the replaced fossil fuel. The change in soil organic carbon (SOC) by land use change to bioenergy has to be integrated into the greenhouse gas balance. One promising way to provide biomass for energy purposes is the cultivation of fast growing trees in short rotation coppices (SRC), because their energy input is low compared to their energy output. Moreover, due to high litter input and no-till management we hypothesize that SOC is accumulating in SRC on the long term.
To study this long term effect 18 old poplar and willow SRC plantations and adjacent croplands with the same land use history were sampled throughout Germany using a standardized sampling protocol with a sampling depth down to 80 cm. The age of SRC ranged from 8 to 35 years and they were harvested every 3 to 15 years. Soil organic carbon content, bulk density, pH value and texture were determined. The SOC stocks were calculated and corrected for equivalent soil masses.
In the top 10 cm, SOC increased under poplar and willow plantations at all sites by 4.8 +/- 3.2 Mg ha-1, which is an accumulation rate of 0.3 Mg ha-1 a-1. Regarding the whole profile to 80 cm depth, the SOC change was not significant with 0.8 +/- 13.5 Mg ha-1. At 8 sites SOC stocks increased compared to the respective cropland, at 10 sites SOC stocks decreased (-18 Mg C ha-1 to +30 Mg C ha-1). The litter accumulation was low compared to afforestations, ranging from 0.4 Mg C ha-1 to 3.2 Mg C ha-1 which is a litter C accumulation rate of 0.2 Mg ha-1 a-1. Including the respective litter carbon, the average SOC accumulation rate was 0.1 $\pm$ 0.8 Mg C ha-1 a-1.
Taking into account the large scatter of SOC stock changes among different sites, the hypothesis of long-term SOC accumulation by SRC cannot generally be confirmed. Nevertheless, SRC may substantially increase SOC if installed on carbon depleted croplands and also low pH values are favoring SOC accumulation.
In conclusion, the results of this comprehensive field study indicate a much lower SOC accumulation rate under SRC than suggested in previous studies.