Towards a full greenhouse gas balance of short rotation coppice – soil organic carbon stock change and N_2O emissions

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Wood from short rotation coppices (SRC) is discussed as bioenergy feedstock with good climate mitigation potential because the energy output to input ratio is high and greenhouse gas (GHG) emissions are low. Into a full greenhouse gas balance of any bioenergy option, cultivation related nitrous oxide (N_2O) emissions have to be integrated due to its large global warming potential. Furthermore, the long term alteration in soil organic carbon (SOC) stocks by land use change to bioenergy crops has to be accounted for.

To test our hypothesis that SRC emit less N_2O than annual bioenergy crops we measured N_2O emissions from SRC, grassland and cropland plots with maize or rapeseed at three different sites on a weekly basis for two years. At the Thuringian site the soil under SRC emitted significantly less N_2O (163 ± 62 N_2O-N ha^{-1} a^{-1}) than under maize (332 ± 51 N_2O-N ha^{-1} a^{-1}). However, N_2O emissions were very low at all sites and reached at most 130 µg N_2O-N m^{-2} h^{-1} at the rape seed field after fertilization.

We further hypothesized that SRC on the long term sequester more SOC than annual bioenergy crops due to frequent litter input and no-till management. To examine this assumption 18 old poplar and willow SRC plantations and adjacent croplands with the same land use history were sampled down to 80 cm throughout Germany. The SOC stocks were calculated and corrected for equivalent soil masses. In the top 10 cm, SOC significantly increased under poplar and willow plantations (17 ± 2 in cropland and 21 ± 2 kg C m^{-3} in SRC). Regarding the whole profile to 80 cm depth, the SOC change was not significant. At 3 sites SOC stocks increased compared to the respective cropland, at 2 sites SOC stocks decreased. Thus, rates of SOC stock change vary widely from –1.3 to 1.4 Mg C ha^{-1} a^{-1} and are much lower than suggested in previous studies.

According to these data the differences between SRC and annual bioenergy crops are low for both N_2O emissions and SOC stocks. However, at wetter sites with higher N_2O emission potential the differences in the GHG balance might be much greater due to the high global warming potential of N_2O.