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Full greenhouse gas balance (CO_2, N2O, CH4) of a bioenergy plantation (POPFULL) converted from agriculture and pasture: carbon debt and climate sensitivity

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Bioenergy from biomass is currently receiving a lot of attention as an energy source alternative to fossil fuels. Bioenergy could have a lower impact on the environment and supposedly lower greenhouse gas emissions. There are, however, still many uncertainties on the claimed "climate neutrality" of bioenergy plantations. A major concern regards the carbon (C) debt from the land use change connected to the establishment of these bioenergy plantations. Land use conversion has been proved to lead to large C emissions, which may require years to decades to be paid off by the C sequestered in the plantations. In this study we report on the greenhouse gas fluxes (CO_2, CH4, and N2O) deriving from the conversion of pasture and agricultural fields into a short-rotation poplar plantation for bioenergy. The establishment of the plantation led to a large overall CO_2 and N2O loss during the first year. Nitrous oxides represented 50% of the overall greenhouse gas balance, which was mostly connected to a week-long peak emission following an extreme rainfall event during the first season. The week-long peak N2O emission event represented most of the total annual N2O emission during the first year. The second year was characterized by a much lower N2O emission and a much larger CO_2 uptake, with the CO_2 uptake being clearly water-limited for most of the summer season. Over the two years CH4 fluxes were constantly very low, consistent with the fact that sandy soils do not support a significant methanogenic community.