Fluxes of the greenhouse gases (CO$_2$, CH4 and N2O) above a short-rotation poplar plantation after conversion from agricultural land

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The increasing demand for renewable energy may lead to the conversion of millions of hectares into bioenergy plantations with a possible substantial transitory carbon (C) loss. In this study we report on the greenhouse gas fluxes (CO$_2$, CH$_4$, and N$_2$O) measured using eddy covariance of a short-rotation bioenergy poplar plantation converted from agricultural fields. During the first six months after the establishment of the plantation (June-Dec 2010) there were substantial CO$_2$, CH$_4$, and N$_2$O emissions (a total of 5.36 ± 0.52 Mg CO$_2$eq ha$^{-1}$ in terms of CO$_2$ equivalents). Nitrous oxide loss mostly occurred during a week-long peak emission after an unusually large rainfall. This week-long N$_2$O emission represented 52% of the entire N$_2$O loss during one and an half years of measurements. As most of the N$_2$O loss occurred in just this week-long period, accurately capturing these emission events are critical to accurate estimates of the GHG balance of bioenergy. While initial establishment (Jun-Dec 2010) of the plantation resulted in a net CO$_2$ loss into the atmosphere (2.76 ± 0.16 Mg CO$_2$eq ha$^{-1}$), in the second year (2011) there was substantial net CO$_2$ uptake (-3.51 ± 0.56 Mg CO$_2$eq ha$^{-1}$). During the entire measurement period, CH$_4$ was a source to the atmosphere (0.63 ± 0.05 Mg CO$_2$eq ha$^{-1}$ in 2010, and 0.49 ± 0.05 Mg CO$_2$eq ha$^{-1}$ in 2011), and was controlled by water table depth. Importantly, over the entire measurement period, the sum of the CH$_4$ and N$_2$O losses was much higher (3.51 ± 0.52 Mg CO$_2$eq ha$^{-1}$) than the net CO$_2$ uptake (-0.76 ± 0.58 Mg CO$_2$eq ha$^{-1}$). As water availability was an important control on the GHG emission of the plantation, expected climate change and altered rainfall pattern could increase the negative environmental impacts of bioenergy.