N_2O emissions from an organic cropping system as affected by legume-based catch crops

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Abstract: Low-input organic cropping systems with legume-based catch crops (LBCC) may contribute to N_2O mitigation by improving N use efficiency. LBCC can both retain soil available N and fix N from the atmosphere in cold seasons, which can be reused by the subsequent main crop in spring following incorporation and decomposition. However, there is a need to better understand how the quality and management of LBCC will influence N_2O emissions compared to non-leguminous catch crops or bare soil, since more mineral N may be released to the soil pool and be available for nitrification and denitrification, potentially leading to higher N_2O emissions. This study investigates N_2O emissions from a spring barley field as affected by LBCC, i.e., red clover (CL), red clover/ryegrass mixture (GC) and winter vetch (WV), as well as two non-legume catch crops (ryegrass (GR) and fodder radish (FR)) and a control (CO) without catch crop. Effects of two management strategies are also tested: removal of the tops of catch crops in late autumn (e.g. for use in biogas production or animal feeding) versus incorporation of the whole plants in spring by tillage. The on-going field experiment (Aug., 2012~Sep., 2013) is on a loamy sand soil in Denmark. The N_2O fluxes measured over a year will be used to test the DNDC model. The field data shows a decline of soil bulk density from 1.38 g cm^{-3} to 1.34 g cm^{-3} before spring tillage and it is reduced further to 1.28 g cm^{-3} one week after the tillage. In a preliminary comparison (only data from CL and CO treatments during 270 days, i.e. Sep., 2012~Jun., 2013), predicted soil NH_4-N fitted well with the measured data during autumn and winter for CL treatment. Soil NO_3-N was overestimated and the WFPS was underestimated. In general, the model did not catch N_2O flux peaks during winter and underestimated the daily fluxes in spring, leading to an underestimation of cumulative emissions of more than 80%. A sensitivity analysis of changing soil bulk density from 1.38 g cm^{-3} to 1.28 g cm^{-3} shows little change of the modelled results. In reality, changing soil bulk density also changes WFPS and therefore gas diffusivity in the soil. Changes in soil physical parameters may be of great importance for N_2O fluxes. It should therefore be possible to make such effect changeable during the simulation period. In addition, in order to better describe the effect of different LBCCs, the crop parameters in the model need to be closely inspected and possibly revised. Results concerning the annual N_2O emissions and from other treatments will be available at a later stage.

Keywords: legume-based catch crops, nitrous oxide, organic cropping, DNDC model, spring barley.