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Carbon and nitrogen budgets of a winter rapeseed field in Estonia: a methodology for the quantification of all relevant pools and fluxes

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Agricultural activities can have several adverse impacts on the environment; such as important greenhouse gas (GHG) emissions. To implement effective mitigation measures and create effective policies, it is necessary to know the full carbon and nitrogen budgets of agro-ecosystems. However, very often, information regarding the pools or fluxes involved in the carbon and nitrogen cycles is limited, and essential complementary data needed for a proper interpretation is lacking.

This study aimed to quantify all the relevant pools and fluxes of a winter rapeseed, a widely spread crop in the Europe and Baltic regions. The N_2O and CH_4 fluxes were measured weekly using the closed static chamber method from August 2016 to August 2017 in a winter rapeseed field in Central Estonia. Additionally, nutrient leaching and soil chemical parameters, as well as environmental parameters like soil moisture, electrical conductivity and temperature were monitored. At the end of the season, the rapeseed and weed biomasses were collected, weighed and analyzed. The remaining relevant fluxes in the N cycle were calculated using various non-empirical methods: NH_3 volatilization was estimated from slurry and environmental parameters, N deposition and NO_x emissions were obtained from national reports, and N_2 emissions were calculated with the mass balance method. Regarding the C cycle, gross primary production (GPP) of the rapeseed field was also calculated by the mass balance method. Simultaneously, for comparison and validation purposes, GPP was estimated from the data provided by MOD17A2H v006 series from NASA, and N_2 was estimated from the measured emissions of N_2O using the N_2:N_2O ratio calculated from the DAYCENT model equations.

N_2 emissions and GPP were the biggest fluxes in the N and C cycles, respectively. N_2 emissions were followed by N extracted with plant biomass in the N cycle, while in the carbon cycle soil and plant respiration and NPP were the highest fluxes after GPP. The carbon balance was positive at the soil level, with a net increase in soil carbon during the period, mainly due to GPP carbon capture. Contrarily, the nitrogen balance resulted in a net loss of N due to the losses related to gaseous emissions (N_2 and N_2O) and leaching.

To conclude, it was possible to close the C and N budgets, despite the inherent difficulties of

estimating the different C and N environmental pools and fluxes, and the uncertainties deriving from some of the fluxes estimations.