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Is shifting from conventional to reduced tillage worth the change in terms of greenhouse gas emissions: feedback from a long-term case study on a cultivated loamy soil in Belgium

François Boland[1], Matthieu Delespesse[1], Henri Chopin[1], Alain Debacq[1], Benjamin Dumont[2], Bernard Longdoz[1], and Bernard Heinesch[1]
[1]Biosystems Dynamics and Exchanges, TERRA Teaching and Research Center, Gembloux Agro-Bio Tech, University of Liège, 5030 Gembloux, Belgium
[2]Plant Sciences, TERRA Teaching and Research Center, Gembloux Agro-Bio Tech, University of Liège, 5030 Gembloux, Belgium

The transition from conventional tillage (CT) to reduced tillage (RT) on cultivated lands to achieve carbon sequestration has shown variable impact on the greenhouse gas (GHG) balance at local sites from short to long-term studies. In this context, replicated automated closed chambers were set up on two plots from a long-term (since 2008) differentiated tillage trial (conventional CT vs. reduced tillage RT) on a loamy soil in Gembloux (Belgium) with the aim to analyse the temporal and spatial variabilities of N_2O fluxes and the impacts of tillage with regards to soil physical and chemical drivers in the soil profile.

Continuous measurements of CO_2 and N_2O emissions were performed with 8 chambers at four hours temporal resolution on each plot of 600 m², within 16 m² sampling square, during the growing season of sugar beet (April to October 2021), following a winter wheat crop with straw incorporation (crop residue). Soil physical (water content and tension, temperature, O_2 concentration, bulk density and gas diffusivity) and chemical (NO_3 and NH_4) drivers in the soil profile (5, 15, 25 cm) were also monitored.

Results show no significant difference between treatments on mean CO_2 and N_2O emissions. Nevertheless, a visible tendency of higher N_2O emissions on RT (>200%) echoes with previous experiment results over this site that indicated significantly higher mean N_2O emissions in the reduced tillage (RT) plot compared to conventional on a maize crop in 2015 and winter wheat in 2016. For each treatment, more than 70% of the N_2O emissions were measured during two peaks episodes that occurred after intense rainfall. A significant correlation was observed between the base-10 logarithm of N_2O and CO_2 fluxes, and it likely shows a link between N_2O production and mineralisation of organic matter, e.g. previous crop residues that were incorporated following previous summer wheat harvest. Soil relative gas diffusivity (D_p/D_o) in the first horizon (0-10 cm) was the best predictor of N_2O fluxes.

The N_2O emissions showed significant spatial variability within both treatments with coefficients of variation up to 400% between chamber measurements on the RT plot, especially during peak

emissions, hampering statistical comparison between treatments. As replicated chambers are covering a limited surface, this suggests N_2O production in small-scale hotspots within the chambers sampling square. These results call for further work on local (sampling square) and plot scale spatial variabilities that need to be investigated to help the optimisation of the sampling strategy for a finer comparison between treatments.