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Dynamics of greenhouse gas emissions associated with soil tillage and cover cropping over a 28 month period and after 18 years of differentiation

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Agricultural practices strongly influence both carbon and nitrogen cycles. In that context, quantification of gaseous losses (nitrous oxide, N2O and carbon dioxide, CO2) is essential both to improve our knowledge of the impact of these practices on carbon and nitrogen balances and to develop mitigation strategies for greenhouse gases (GHG) emissions. This study addresses the impact of two agricultural practices, soil tillage and cover cropping, on GHG emissions. A large uncertainty indeed remains on this subject, partly induced by differences in treatments differentiation duration and methodology for the measurement of emissions. In addition, studies dealing simultaneously with CO2 and N2O emissions are lacking. We analysed the combined effect of soil tillage (no tillage and conventional tillage) and cover cropping (white mustard, presence or absence) on CO2 and N2O emissions on the barley/pea/wheat rotation of an 18 years field experiment in northern France. Automatic chambers were deployed during 28 months and allowed to measure quasi continuously CO2 and N2O emissions.

Results showed that conventional soil tillage induced more CO2 emissions (around +15% either with or without cover crops) and less N2O emissions (around -40% either with or without cover crops) compared to no-till. N2O emissions were however highly variable, especially on the no-tillage treatment where they were very high after fertilization events, with N2O fluxes reaching more than 140 g N ha-1 day-1, but sometimes became negative (fluxes between 0 and -5 g N ha-1 day-1) for more than 100 consecutive days. Moreover, differences between treatments fluctuated during the overall rotation. This fact highlights the need for long measurement periods (a rotation or more) to avoid erroneous conclusions induced by short duration experiments.
There was no differentiation between treatments with and without cover crop at the beginning of the rotation, after fertilization. However, after this initial period, the presence of a cover crop increased the intensity of peak N2O emissions, especially on the no tillage treatment. Cumulative emissions of CO2 were higher for treatments with cover crops, but this effect was exclusively caused by plant respiration during white mustard culture (instead of bare soil for no cover crop treatment), since plants were included in measurement chambers.
Based on the CO2 and N2O measurements, the global warming potential (GWP) of all treatments was calculated. Their comparisons allowed to show that after 18 years of differentiation the contribution of N2O emissions (from 1.5 to 3 kg N2O ha-1 year-1) to GWP and to the difference of GWP between treatments was low ($\sim$10%) compared to that of the CO2 emissions (even after removing plant respiration from cumulative CO2 emissions), and that no-till was the most effective strategy to reduce GWP (-10% compared to conventional tillage). However, the difference in cumulative CO2 emissions between conventional tillage and no-till was of the order of 1000 kg C ha-1 year-1, which seems very high, and not consistent with the low differentiation in C storage variations observed between the treatments.