Impact of future precipitation patterns in agroecosystems on CO$_2$ and N$_2$O emissions – a green manure stable isotope labelling study

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Climate change is likely to affect precipitation patterns in the future, and as such is a determining factor in agricultural systems in terms of soil organic matter mineralization, nutrient release and therefore plant production. This study investigates the impact of precipitation on two different soil types – a sandy calcareous phaeozem (S) and a calcic chernozem (T) – representative of the Pannonian area of the Marchfeld region in Austria. A regionalized scenario RCP 6.0 derived from the 5th IPCC was used on a long-term lysimeter study in the Marchfeld, where future rainfall patterns were compared with current precipitation since 2011. In this study, green manure (Sinapis alba) labelled with $^{13}$C and $^{15}$N stable isotopes was applied to the lysimeter soil in April 2018.

Mineralization of green manure and release of inorganic bioavailable $^{15}$N NO$_3$ was confirmed after soil sampling at different time points throughout the growing season and elemental analyser – isotope ratio mass spectrometer (EA-IRMS) measurements. In addition to soil, plant and groundwater sampling, $^{15}$N N$_2$O and $^{13}$C CO$_2$ measurements were conducted by using a cavity ring down spectrometer (CRDS) installed in the field and gas chromatography – isotope ratio mass spectrometry (GC-IRMS) respectively. Results showed initially low emissions of N$_2$O (0.01 – 0.02 µg N$_2$O m$^{-2}$ h$^{-1}$) after addition of green manure. In the second week N$_2$O emission were higher under the current precipitation scenario. Incorporation of $^{15}$N label from the green manure into N$_2$O was not observed. A simulated heavy rainfall event (60 mm) increased N$_2$O emissions within a few hours with up to ten fold higher emissions in the future scenario, still no incorporation of label was observed. Highest N$_2$O emissions especially in the current scenario was observed after commercial fertilizer (50 kg/ha) was added.

Source signatures of CO$_2$ according to the Keeling plots showed an immediate uptake (~hours) of the labelled manure. Differences in the green manure mineralization rate was identified for the soil types (S faster than T) but not for the future precipitation regime. However, total CO$_2$ emission (40 – 250 mgC m$^{-2}$ h$^{-1}$) from the calcic chernozem (T) were less for the future scenario. This study suggests that soil CO$_2$ emissions will become lower in these future precipitation scenarios. It also demonstrated the relevance of green manure as a fertilization strategy to avoid N$_2$O emissions.