Determination of greenhouse gas sources and sinks in Swiss arable soils under organic and non-organic management

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Agricultural practices contribute considerably to emissions of greenhouse gases (GHG). Knowledge on the impact of organic (ORG) compared to non-organic (NON-ORG) farming on soil-derived nitrous oxide (N2O) and methane (CH4) emissions is still limited. We conducted a literature search on measured soil GHG fluxes under ORG and NON-ORG from farming system comparisons and performed a meta-analysis. Based on 12 studies covering annual measurements, it appeared that area-scaled N2O emissions are with 14% significantly lower under ORG. However, yield-scaled N2O emissions are only 9% higher for ORG. Emissions from NON-ORG soils seemed to be influenced mainly by total N inputs, whereas for ORG other soil characteristics seemed to be more important because N2O from organic N fertilisers emits decoupled from the inputs. Furthermore, we observed a 12% higher CH4 uptake for arable soils under ORG.

The findings of the Meta-Analysis serving as hypotheses we investigated N2O and CH4 soil gas fluxes with manual chambers from 24 Aug 2012 to 18 Mar 2014 in a grass-clover– silage maize – green manure cropping sequence in the DOK. We compared the systems BIODYN and BIOORG with CONMIN and CONFYM together with NOFERT. We observed a 40.2% reduction of area scaled N2O emissions for ORG compared to NON-ORG (conventional). Despite the pronounced difference in maize yields, yield-scaled N2O emissions did not differ between ORG and NON-ORG. The 56% lower emissions for BIODYN compared to CONFYM can be related to the 52% lower input, but the resulting yield gap of only 27% for BIODYN indicates that this system's N efficiency is superior and thus contributes to GHG mitigation. We recorded on area scale under silage maize a modest CH4 uptake for BIODYN and CONMIN and high CH4 emissions for CONFYM likely due to the stacked manure applied. We found that, in addition to N input, soil quality properties significantly affected N2O emissions.

In order to discern pre-crop and farming system specific differences we monitored N2O and CH4 soil gas fluxes from October 2014 until July 2015 covering the cropping of winter wheat, either with rapeseed or soy as pre-crop, in BIOORG, CONMIN and CONFYM. We found no clear farming system differences but distinct pre-crop effects. The microbial mediated decomposition and mineralization of crop-residues influences considerably the N2O and CH4 fluxes with changing effects over time. The C/N ratio dependent decomposition trends towards a (steady state) low soil C/N ratio and pH neutrality and is heavily impacted by N-fertilisation. BIODYN was not included in this study.

BIODYN indicates a pathway towards ecological intensification of agriculture. Lower N-inputs applied as composted farmyard manure seem to cause the systems efficiency. This confirms the closing conclusion of the initial Meta-Analysis that closes as follows: "Improving resource efficiency through increased productivity is of key importance in this respect for the further development of organic farming systems."