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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."