FARMING PRACTICE
ORGANIC FARMING SYSTEMS

IMPACT: GHG EMISSIONS

Reference 18

Skinner, C; Gattinger, A; Muller, A; Mader, P; Fliessbach, A; Stolze, M; Ruser, R; Niggli, U. 2014 Greenhouse gas fluxes from agricultural soils under organic and non-organic management - A global meta-analysis Science of the Total Environment 468–469, 553–563 10.1016/j.scitotenv.2013.08.098

Background and objective

Organic agriculture may or may not lead to lower soil-derived GHG emissions, as not only management characteristics but site properties (soil characteristics, climate etc.) control soil GHG fluxes as well. The generally lower N input level in organic agriculture compared to non-organic however supports the expectation of lower nitrous oxide emissions and enhanced methane uptake in organically managed soils. There are some indications that organic agriculture leads to less soil-born greenhouse gas emissions than conventional agriculture (Niggli et al., 2009). This phenomenon has, however, never been investigated systematically. A comprehensive literature review followed by a meta-analysis was conducted to compare non-CO_2 GHG emissions fromsoils under organic and non-organic management.

Search strategy and selection criteria

Most of the collected research papers were published in scientific journals. We also included studies from conference proceedings, book chapters and dissertations to enlarge the data set, since those contributions also undergo a peer-review process. Eligible data originates from paired comparisons on organic and non-organic farming systems from peer-reviewed research papers that report field measurements of nitrous oxide and methane fluxes from agricultural soils. All studies are based on farming system comparisons where the organic practice was explicitly defined as such by the respective authors.

Data and analysis

Meta-analysis, meta-regression. We used random effects meta-analysis to investigate our data. We employed the inverse-variance method conventionally used in meta analysis (Borenstein et al., 2009) as well as in meta-analysis on GHG flux data (e.g. Lubbers et al. 2013) as a weighing function of the various studies. This allows assessing the significance levels of any differences in the effect sizes, i.e. the GHG fluxes between farming systems identified by the meta-analysis. The analysis was undertaken with the "Comprehensive Meta-Analysis 2.0" software (Biostat, Englewood, NJ/USA). In addition we subjected the nitrous oxide dataset under arable land use to a mixed-effects meta-regression, as only this subset of our database provides rather comprehensive information on factors assumed to control GHG fluxes.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
13	Field studies assessing the performance of organic systems in comparison to conventional systems. In study organic systems organic practices were applied for at least three consecutive years prior to sampling.	Organic systems (Arable crops, Grassland, Paddy rice fields)	Conventional systems	Metric: N_2O emission per unit of area and product; CH_4 emission per unit of area and product; Effect size: Difference of of the considered metrics between intervention and control	50

Results

- Across all annual GHG measurements on arable and grassland use, soils under organic farming emit less nitrous oxide: 1.05 kg less N2O–N ha−1 a−1 (492 kg CO_2-eq. ha−1 a−1) than the non-organic counterparts (70 comparisons; p 0.001).
- Higher yield-scaled nitrous oxide emissions were obtained for organically managed soils, with a mean difference of 42.4 kg CO_2-eq. t−1 DM (dry matter of crop yield) (25 comparisons; p = 0.01).
- All arable soils showed an average methane uptake, which was slightly higher (both area-scaled and yield-scaled) under organic than under non-organic management with a mean difference of − 3.2 kg CO_2 eq. ha− 1 a− 1 (8 comparisons; p = 0.01).
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Factors influencing effect sizes

- Per unit of field area: Positive; Per unit of product: Negative. : Crop rotation, total N inputs (for emissions from conventionally managed soils), concentration of soil N and soil organic carbon, soil texture (clay contents)

Conclusion

There is scientific evidence for lower nitrous oxide emissions from organically managed soils when scaled to the area of cultivated land but higher emissions when crop yield-scaled. This discrepancy is due to the observed 26% lower crop yield under organic management. All arable soils showed an average methane uptake, which was slightly higher (both area-scaled and yield-scaled) under organic than under non-organic management.