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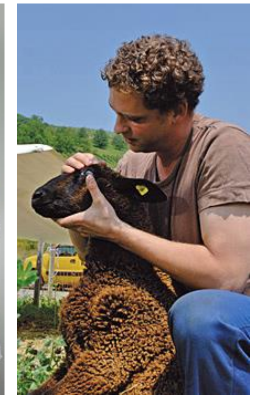

Enhanced top soil carbon stocks under organic farming

A. Gattinger, A. Muller, M. Haeni, C. Skinner, A. Fließbach, N. Buchmann, P. Mäder, M. Stolze, P. Smith, N. El-Hage Scialabba, and U. Niggli

andreas.gattinger@fibl.org

Stiftung
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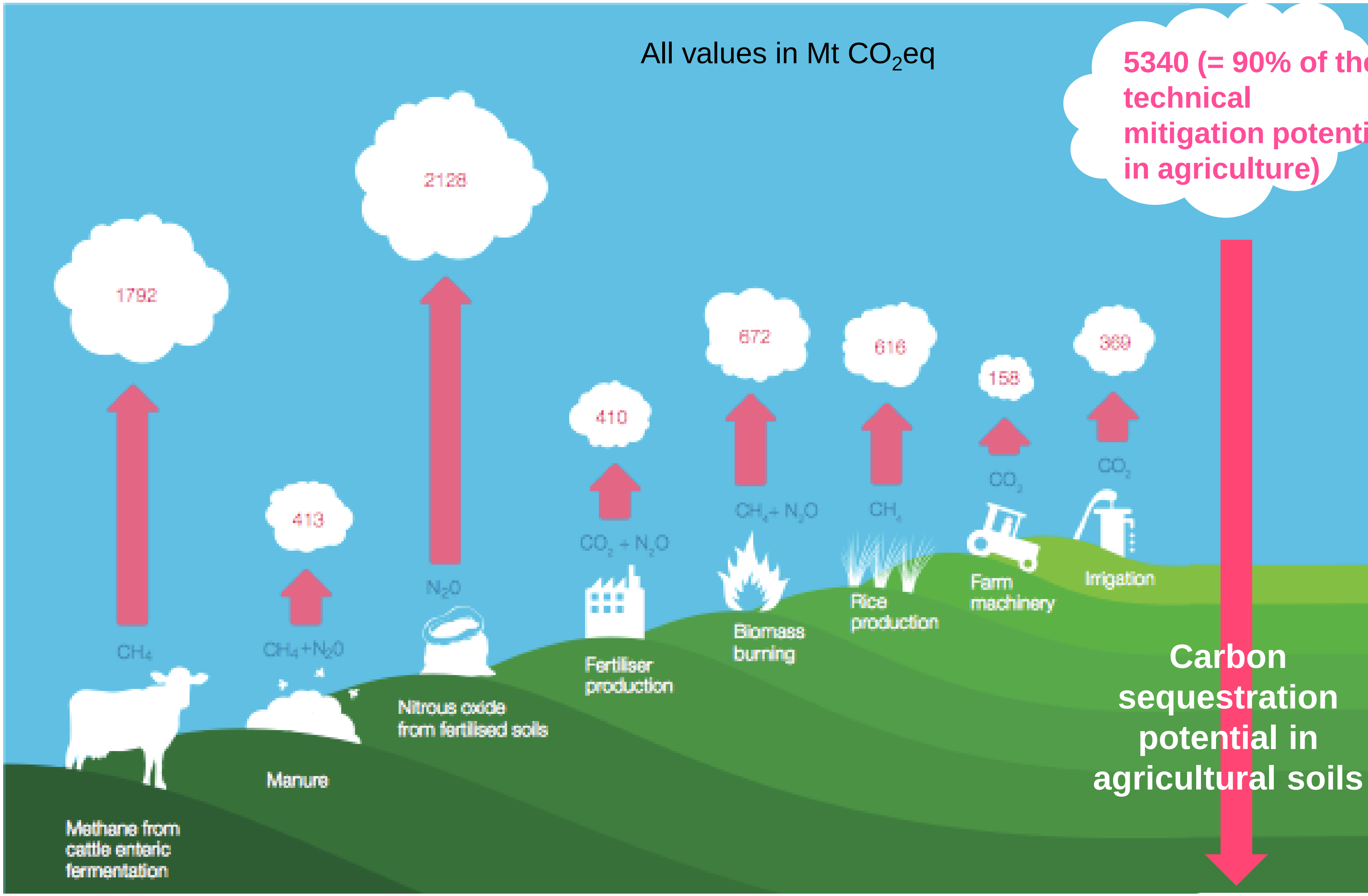
FiBL – since 1974 active in research and advise on organic farming

135 Mitarbeitende Schweiz
20 in Deutschland
20 in Österreich
70 Studenten und Praktikanten

Contents

- Introduction and objectives
- Material and Methods
- Results
- Summary and conclusions

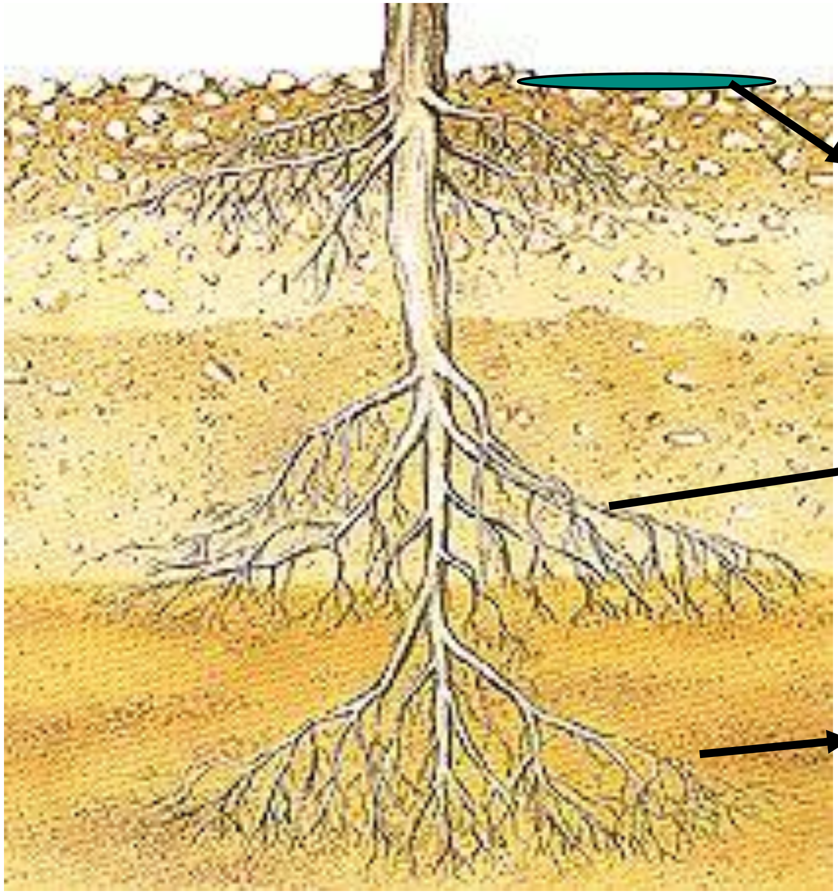
Background: GHG Emissions in Agriculture



Adapted from “Cool Farming”, Bellarby et al. 2008

The concept of C sequestration in soil

CO_2 –fixation via photosynthesis



Transformation into soil organic matter (Humus formation)

Soil organic matter and organic farming

- Increasing and maintaining soil organic matter (SOM) is a core principle in organic farming
- It is essential for plant nutrition and soil fertility built-up in organic (= low external input) farming systems
- Diverse and legume containing crop rations and organic manuring are integral measures in OF
- Hence SOM (= soil carbon sequestration) levels are higher under OF practices?

Aims of the meta study

- Quantifying differences in soil organic carbon under organic and non-organic management

- Analysing factors influencing observed soil carbon differences between organic and non-organic management:
  - Land use (arable, grassland, etc.)
  - pedoclimatic properties (temperature, precipitation, clay content)
  - mangement factors: organic fertilisation, crop rotation

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Approach

1. Literature search
2. Literature review/evaluation
3. If positive: integration into data matrix and parametrisation
4. Meta analysis with *R metafor* package. Effect sizes (= target variables):
   SOC concentration on a weight by weight basis
   SOC stocks on a weight by area basis
   C sequestration rates on weight by area and time since conversion from non-organic to organic management

Qualifying criteria for eligible publications

- Only studies based on pairwise comparisons (under similar site conditions) for organic and non-organic (i.e. conventional, integrated) farming practices are considered that report measured values of soil organic carbon

- Only reviewed papers: a) peer-reviewed scientific journals b) conference proceedings/book chapters/dissertations

- Only experiments were included where the relevant organic farming principles were applied for at least three consecutive years.

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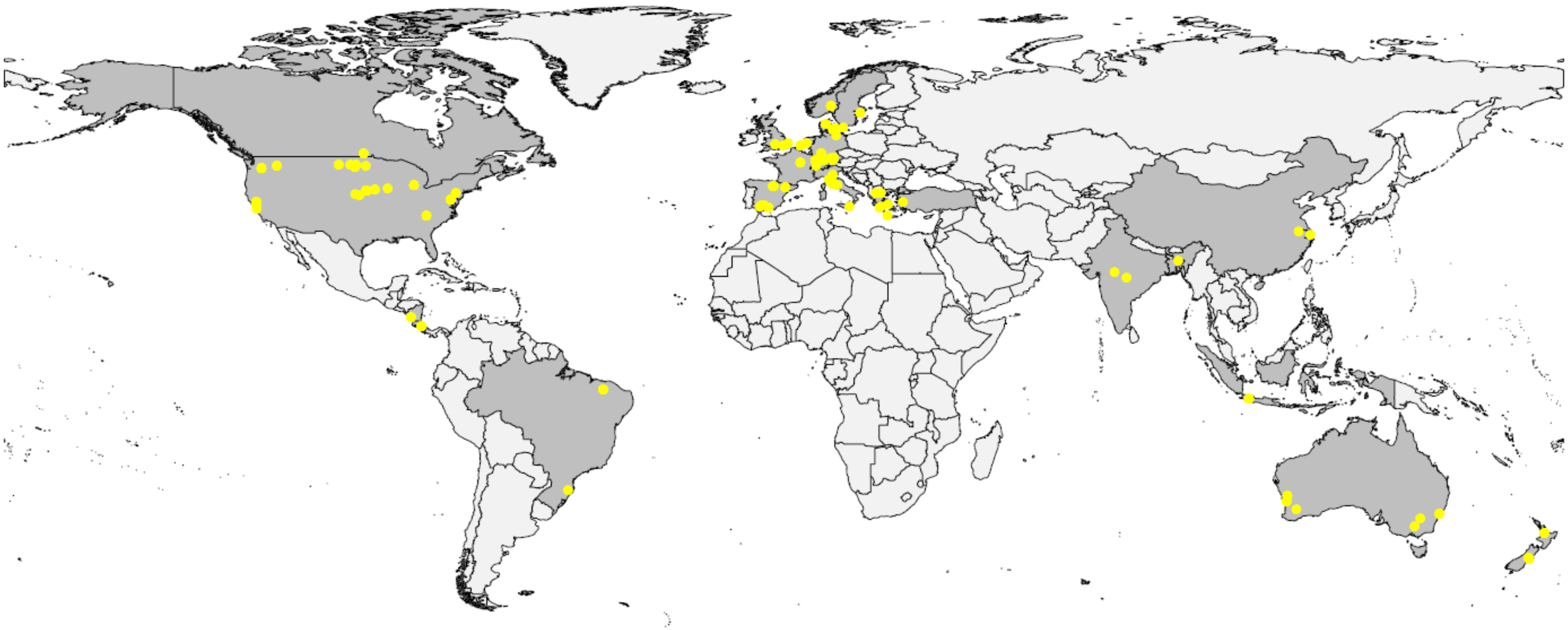
Geographic distribution of the system comparisons for meta-analysis



74 system comparison studies, 211 comparative pairs

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Gattinger et al., PNAS, 2012

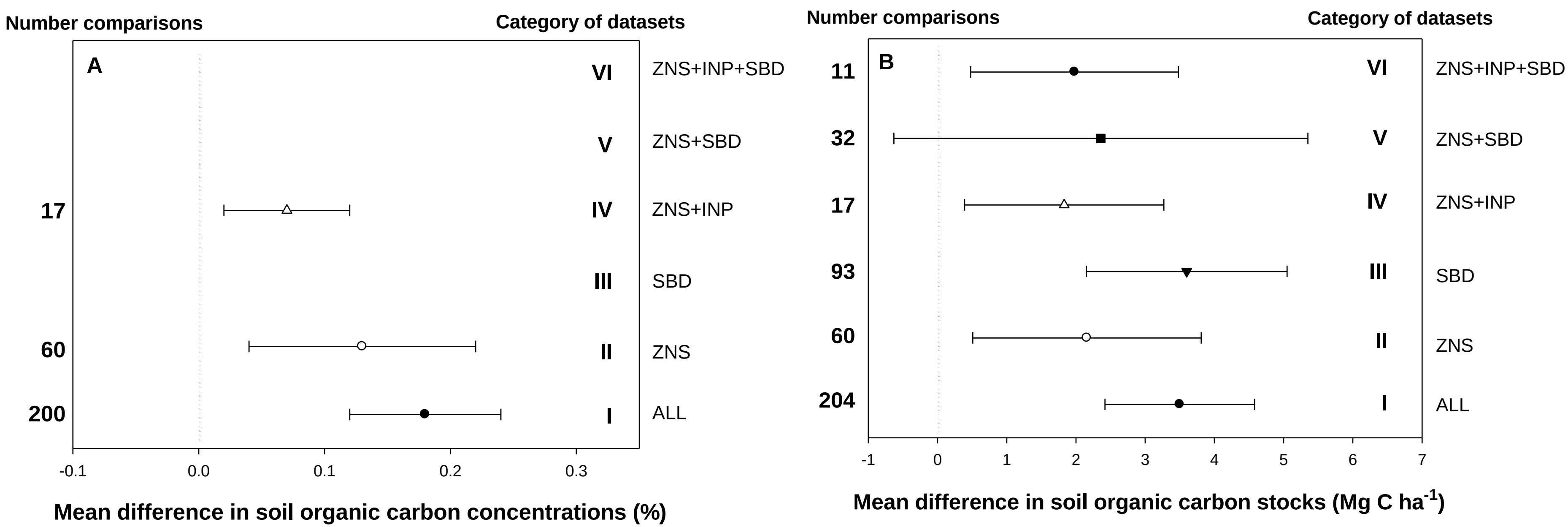
Overview of the obtained „soil carbon“ publications for meta-analysis

Table 1. Overview of the obtained publications matching the search and eligibility criteria

Criterion	SOC concentration	SOC stocks	C sequestration
Type of publications			
Scientific journals	70 publications	26 publications	18* publications
Dissertations/books chapters/proceedings	4 publications	3 publications	2* publications
Type of comparisons			
Plot scale	26 publications	23 publications	19 publications
Farm scale	48 publications	16 publications	1 publications
Coverage of land use types	Full coverage	Full coverage	Only arable and vegetables
Coverage of climatic zones	6 of 8 (except boreal and arid)	5 of 8	6 of 8
Coverage of continents†	5 of 6 (except Africa)	5 of 6 (except Africa)	5 of 6 (except Africa)
Sampling depth (top–bottom) (cm)	Mean: 2.4–18.4/median: 0–15.0	Mean: 1.8–19.4/median: 0–15.0	Mean: 0.8–22.5/median: 0–20.0
For all SOC datasets		Mean: 1.8–19.0/median: 0–15	
Experimental duration (y)	Mean: 13.2/median: 8.0	Mean: 16.1/median: 10.0	Mean: 12.5/median: 11.0
For all SOC datasets		Mean: 14.4/median: 10.0	

SOC concentrations, stocks, and C sequestration rates are the three effect-sizes in this metaanalysis.
*Of 20 publications on SOC sequestration, 11 report measured bulk densities, for the other 9 bulk densities were estimated.
†Continents except Antarctica.

More carbon in organically managed soils?



Higher soil organic carbon concentrations (%) and stocks (t ha^{-1}) under organic farming management.

What influences differences in soil carbon?

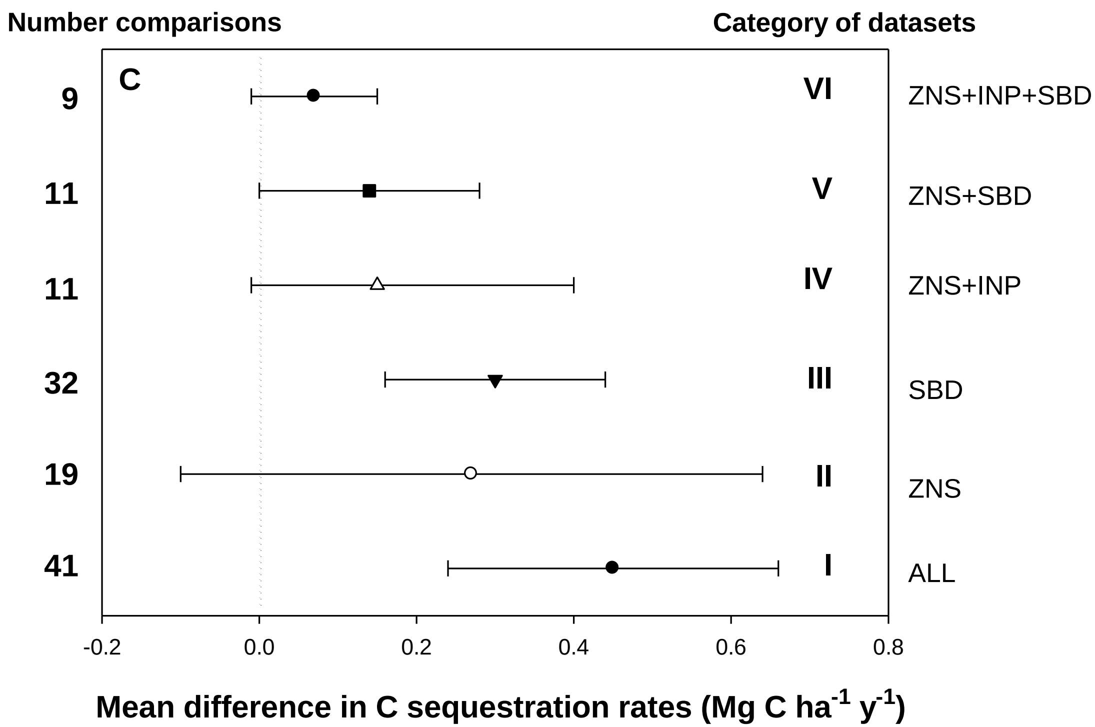
Based on meta-regression, no significant drivers could be identified, only tendencies:

- Management effects are stronger than site factors (temperature, precipitation, clay content in soil).
- Higher inputs of external C inputs (= organic fertiliser) in organic systems (1.20 vs. 0.29 Mg C ha^{-1} y^{-1})
- Higher frequency of cropping of deep rooting forage legume in organic systems.

↓

These are elements typical for mixed farming (integration of crop and livestock production) and in organic farming mixed farming systems are more frequent.

Is carbon sequestration possible within organic farming systems?



Yes, it is possible. Net sequestration of 450 kg C ha^{-1} y^{-1} for all organic systems; the potential is lower for for zero net input systems (< 1.O ELU ha^{-1}): 70 – 270 kg C ha^{-1} y^{-1}.

What does it mean in the wider context?

Switching to organic agriculture with a net C sequestration rate of 0.27 Mg C ha^{-1} y^{-}1 for net zero input systems…

- Would result in 0.37 Gt C sequestered per year globally (0.03 Gt C in Europe, 0.04 Gt C in the United States), thus offsetting 3% of current total GHG emissions (2.3% for Europe, 2.3% for the United States)
- Would offset 25% of total current agricultural emissions (23% for Europe, 36% for the United States), and equaling approximately 25% of the annual technical agricultural mitigation potential.
- The cumulative mitigation till 2030 would contribute 13% to the cumulative reductions that would be necessary until 2030 to stay on the path to reach the two degree goal by 2100 [56 Gt C globally from 2010 till 2030 according to the RCP2.6 scenario]

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Summary and conclusions

- Meta-analysis from the farming systems database compiled for this study confirms higher SOC concentrations and stocks in top soils under organic farming.
- Second, SOC differences seemed to be mainly influenced by elements of mixed farming (livestock plus crop production), such as organic matter recycling and forage legumes in the crop rotation. It is therefore likely that SOC concentrations and stocks under modern agriculture could be improved if these measures were adopted. These measures are intrinsic to organic agriculture but can in principle be applied in any agricultural production system.
- Further research is required to underpin the observed findings for the entire soil profile and for developing regions (e.g., SSA) where no data from farming systems comparisons are available at the moment.

Long-term farming systems comparisons in the tropics (organic vs. conventional)

Maize and vegetables in Kenya

Cotton in India

Cacao in Bolivia

http://www.systems-comparison.fibl.org/en/scp-home.html

Stiftung Mercator Schweiz

Round Table on Organic Agriculture and Climate Change

FAO FIAT PANIS

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We are grateful to the authors of the 74 studies whose extensive field work provided the data for this meta-analysis.

www.pnas.org/cgi/doi/10.1073/pnas.1209429109

Further information

http://www.fibl.org/de/themen/klima.html
http://www.fibl.org/de/themen/nachhaltigkeit.html
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