Reply to Leifeld et al.: Enhanced top soil carbon stocks under organic farming is not equated with climate change mitigation

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In their letter, Leifeld et al. (1) argue that our metaanalysis to identify differences in soil organic carbon (SOC) between organic (OF) and nonorganic farming [conventional farming (CF)] (2) selected CF systems that were nonrepresentative. This was not the case. We included data from all available pairwise field comparisons between OF and CF identified in the literature. The observed difference in external carbon (C) inputs between OF and CF did not result from a bias in the selection of studies/treatments but was attributable to the fact that the field comparisons we analyzed (2) were not from fertilization experiments but from pairwise farming system comparisons where the design and the underlying treatments reflected the current farming practices in the region in which the studies were conducted at the time the experiments were initiated.

In addition, it is important to not only address external but total C inputs, i.e., organic fertilizers and plant residues. We found indications that differences in external C inputs and crop rotations were important, and we noted this. For six studies, which reported total C input data, the mean total annual C input was 4.23 and 4.86 Mg C ha^{-1} for CF and OF systems, respectively (2). The more pronounced separation of livestock and arable production in CF was also seen in the difference in crop rotation between OF and CF (2), with more forage legumes in OF, a typical feature for crop rotations of mid-European agricultural systems until the 1970s.

Furthermore, we do not believe that, universally, farmyard manure is used efficiently in CF. Because of a tendency to separate arable and livestock systems in CF in developed countries, huge amounts of manure in livestock-dense areas leads to the well-known problems of over-fertilization (3) and suboptimal C sequestration. Although the maximum C sequestration rates may be reached earlier in the fields with high external C input, fields without external C input via farmyard manure are depleted in SOC. The fact that one-third of arable soils were eroded within 40 y worldwide under intensive CF (4) underlines the need for careful SOC management via manure and crop residues.

Regarding the second part of the comment from Leifeld et al. (1), we were careful to emphasize that we do not equate SOC accumulation with mitigation. We stated, "Further, the estimation of carbon sequestration alone does not equate to climate change mitigation. . .", giving a range of reasons.

Finally, yields in OF tend to be lower, but this is not the case for all crops and all climate zones (5). To fully account for the impact of any differences in yield between OF and CF on greenhouse gas emissions, lifecycle emissions from all activities, including indirect land use change, would be required. That was not our aim, as is clear even from the title of the paper. Our findings are simple and clear: SOC stocks are enhanced under OF. Other impacts require further analysis.

1 Leifeld J, et al. (2013) Organic farming gives no climate change benefit through soil carbon sequestration. *Proc Natl Acad Sci USA* 110:E984.

2 Gattinger A, et al. (2012) Enhanced top soil carbon stocks under organic farming. *Proc Natl Acad Sci USA* 109(44): 18226–18231.

3 Sutton MA, et al. (2011) Too much of a good thing. *Nature* 472 (7342):159–161.

4 Pimentel D, et al. (1995) Environmental and economic costs of soil erosion and conservation benefits. *Science* 267(5201): 1117–1123.

5 Seufert V, Ramankutty N, Foley JA (2012) Comparing the yields of organic and conventional agriculture. *Nature* 485(7397): 229–232.

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The authors declare no conflict of interest.

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