No effect of cropping system on the greenhouse gas N_2O

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Organic farming is comparable to conventional in terms of field emissions of the strong greenhouse gas nitrous oxide (N_2O). Our study points to the need for increased yields in organic farming as measure to reduced emissions per unit of produce.

In general organic farming is regarded as a production system with low environmental impact, but it may not be the case when it comes to emissions of nitrous oxide (N_2O) from organically managed soils. Nitrous oxide is a strong greenhouse gas, which is produced by bacteria in the soil during periods of high nitrogen (N) availability, for instance following fertilization. Currently, N_2O emissions from agricultural soils account for about 8 % of the Danish release of greenhouse gases to the atmosphere. Crop production in organic farming to a large extent relies on N supply via the long-term decomposition of plant residue, manure and soil organic matter, which needs to be balanced by the crop N demand in order to avoid N_2O losses. This is in contrast to the targeted short-term fertility management used in conventional farming, where N is introduced with mineral fertilizer when needed for plant growth. The consequences for the N_2O fluxes of these two very different fertility management strategies have been more or less unclear.

The objective of this study was to evaluate whether N_2O emissions from cropping systems are affected by 1) organic versus conventional farming practises, 2) use of grass-clover ley in the rotation as whole-year green manure and 3) use of catch crops. Nitrous oxide fluxes were measured in winter wheat field plots that belonged to four different long-term crop rotation systems at Research Centre Foulum and Flakkebjerg in Denmark, and monitoring took place every second week from September 2007 to September 2008 using static chambers (Fig. 1).

No long-term effect of grass-clover or catch crops

Grass-clover ley is used as a whole-year green manure in the crop rotation, and thereby provides an alternative source of N through biological nitrogen fixation. However, mineralization of the N-rich residues after ploughing down of the grass-clover ley could lead to increased N_2O emissions from the following crops. In our study the grass-clover ley was followed by a potato crop in 2006 before the winter wheat crop was sown in 2007. In the winter wheat crop we could not detect any differences in N_2O emissions between cropping systems with and without grass-clover in the rotation. Thus, any potential residual effect of grass-clover on the N_2O fluxes may have disappeared within the first year after ploughing down of the ley. Neither did the presence of catch crops in the cropping system seem to affect the N_2O losses from the system.

Comparable N_2O emissions from organic and conventional systems
High N_2O emissions occurred in the autumn of 2007 following harvest of the preceding potato crop (Fig. 2). The main source was mineralization of N from potato crop residues and soil organic matter, a process that was probably stimulated by the intensive soil disturbance during harvest.

As seen in many other studies, a peak in the N_2O emission occurred after the fertilization in spring (Fig. 2). The conventionally managed systems received mineral fertilizer at a rate of 170 kg N ha^{-1}, whereas the organic systems were fertilized with pig slurry at about 100 kg N ha^{-1}; thus the N supply was 40 % lower in the organic system. At Foulum, the N_2O losses from the organic and conventional systems were similar, but at Flakkebjerg during spring the emissions tended to be higher from the conventional system. Thus, measured on an area basis the organically and conventionally managed systems gave rise to comparable amounts of N_2O despite the lower N-input to the organic system. However, at both sites the yield of winter wheat in the organic system was about half of the yield in the conventional system, and therefore the picture changed somewhat when we calculate the N_2O emission related to crop yield. In this case the N_2O loss associated with the production of 1 tons of organic winter wheat was similar or higher than for the conventional wheat.

Conclusions
The crop rotations investigated did not show clear effects of several management options on N_2O emissions, and we therefore recognise that it may be difficult to improve this aspect of sustainability in organic farming systems. However, to reduce the N_2O losses related to crop yield we advice organic farming to aim at increasing crop yields without an increase in the N-input.

Text for figures

Fig. 1. Chamber used to measure N_2O fluxes in the winter wheat crop

Fig. 2. Fluxes of N_2O in organically and conventionally managed winter wheat at Foulum and Flakkebjerg