Is organic farming a mitigation option? – A study on N_2O emission from winter wheat

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On a global scale, nitrous oxide (N_2O) is a major contributor to the emission of greenhouse gases (Mosier et al., 1998), and in Denmark agriculture is by far the largest emitter of N_2O (Olesen et al., 2004). In general, organic farming is regarded as a production system with low environmental impact, but it may not always be the case when is comes to N_2O emissions from organically managed soils. Crop production in organic farming systems relies to a large extent on soil fertility for nutrient supply. The soil fertility must be maintained via choice of crop rotation and (green) manuring practices. The timing of plant residue, manure and soil organic matter decomposition is crucial for the fate of mineralised nitrogen (N), which may be lost to the atmosphere as N_2O if not synchronized with the crop N demand. This is in contrast to conventional farming where mineral fertilizer is supplied when needed for plant growth. Statistical analyses have indicated that the N_2O emission factor is higher for manure (and presumably crop residues) than for mineral fertilizers (Lægreid and Aastveit, 2002).
In the present study N_2O fluxes were measured in winter wheat crops every second week from sowing in October 2007 to harvest in August 2008. The objective of the study is to evaluate the effect of organic versus conventional farming, the use of green manure and the use of catch crops on N_2O emissions from the cropping systems. The study was conducted in a long-term organic crop rotation on a sandy loam soil situated at Research Centre Flakkebjerg, Denmark. Nitrous oxide fluxes were measured using a static chamber method based on 60×60 cm^2 chambers placed on a permanent base. Monitoring took place in winter wheat of four rotations: an organic rotation including grass-clover for green manure and including catch crop (O+GM+CC), an organic rotation without green manure but with catch crop (O-GM+CC), an organic rotation without green manure and without catch crop (O-GM-CC) and finally a conventional rotation without green manure and without catch crop (C-GM-CC). Organic winter wheat was fertilized with pig slurry whereas the conventional wheat received mineral fertilizer.
The accumulated N_2O emissions from October 2007 to August 2008 in winter wheat of the four rotations are illustrated in Figure 1. The preliminary data shows no significant differences in the accumulated N_2O emission between the four rotations, but a strong tendency towards a higher N_2O emission from the conventional winter wheat than from the organic winter wheat ($P = 0.06$). Statistical analyses on the full dataset are needed to reveal other effects on the N_2O emission. However, the accumulated N_2O emissions indicate that including grass-clover as green manure in the crop rotation may lead to increased N_2O emissions from the following cash crops due to higher soil fertility. In contrast growing a catch crop following winter wheat may reduce the N_2O emission from coming crops.
Analyses of cropping systems often focus on the environmental impact per unit of land area. However, the land area to produce a given amount will vary with productivity,

which makes it relevant to evaluate cropping systems in terms of their impact per unit of product produced. The yield in the organic winter wheat was 3.7 ± 0.1 tons ha^{-1}, which was half of the yield in the conventional wheat of 7.6 ± 0.2 tons ha^{-1}. The N_2O emissions related to the production of 1 kg of winter wheat in the four rotations appear in Figure 2. The organic crop rotation without green manure but with catch crop (O-GM+CC) had the lowest N_2O loss per produced kg of wheat, whereas the two other organic rotations emitted in amounts comparable to the conventional system in terms of N_2O emission per kg wheat.

In conclusion, the organic winter wheat tended to give rise to a lower N_2O emission per unit of land area than the conventional wheat, but when calculated per kg yield then only one of the organic crop rotations seemed to perform better than the conventional rotation. The preliminary data indicate that including green manure in the organic crop rotation may lead to increased N_2O emissions, whereas catch crops may reduce the N_2O emission. This study shows that organic farming has the potential to reduce N_2O emissions from agricultural soils.

References

Lægreid, M. and Aastveit, A.H., In: Petersen, S.O. and Olesen, J.E. (eds.), Greenhouse gas inventories for agriculture in the Nordic countries. DIAS report, Plant Production no. 81, 2002, pp. 122-134.

Mosier, A. et al., Nutrient Cycling in Agroecosystems, 1998, 52, 225-248.

Olesen, J.E. et al., Jordbrug og klimaændringer - samspil til vandmiljøplaner. DJF rapport Markbrug nr. 109, 2004 (in Danish).