A better nitrogen use to improve organic wheat production

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Different crop management strategies are investigated in representative soils and climatic conditions of Denmark to enhance the yield and quality of organic wheat. The agronomic practices include the use of manure, catch crops and the composition of the crop rotation. Among these, manure application was the main factor affecting yields. Model predictions indicate that wheat yield could be improved by increasing manure nitrogen.

The sustainability of organic farming largely relies on the quality of production and the price to consumers. In the case of cereals, the improvement of grain yield and quality is essential in a competitive production system.

The "AGronomical and TEChnological methods to improve ORGanic wheat quality" (AGTEC-Org) project has been developed under the CORE Organic ERA-net to identify agronomical and food processing technologies that enhance the baking quality and nutritional value of organic wheat. This article focuses on the effects of soil type, manure application and use of catch crops on the grain yield and quality of organic wheat.

Field trials in Denmark

The results presented correspond to experiments conducted in Denmark during the years 2007 and 2008 on three sites differing in soil type: loamy sand (Foulum), sandy loam (Flakkebjerg) and a coarse sandy (Jyndevad). Average annual rainfall at the three sites is 700, 625 and 960 mm, respectively.

The crop rotation was composed by spring barley followed by faba bean, potatoes and winter wheat. Manured winter wheat received an average of 110 kg N per ha from untreated pig slurry in spring.

Catch crops were undersown with spring barley, faba bean and winter wheat in spring at Foulum and Jyndevad, and after the harvest of these crops at Flakkebjerg. All catch crop residues were added to the soil. No catch crops were used in one treatment. Crop management data is summarized in Table 1.

Soil and crop management effects

A soil effect as well as a manure effect in grain dry matter and quality was found in terms of grain

Treatment	+M +C	- M +C	+M -C
FOULUM			
Soil organic carbon (%)	2,0	2,2	2,2
Sowing	25. Sep	25. Sep	25. Sep
Manure (N-P-K) (kg per ha)	110-21-120	0-0-70	110-21-120
Harvest date	12. Aug	12. Aug	12. Aug
FLAKKEBJERG			
Soil organic carbon (%)	0,9	0,9	0,9
Sowing	5. Oct	5. Oct	5. Oct
Manure (N-P-K) (kg per ha)	110-17-90	0-0-60	110-17-90
Harvest date	21. Aug	21. Aug	21. Aug
JYNDEVAD			
Soil organic carbon (%)	1,1	1,1	1,2
Sowing	26. Sep	26. Sep	26. Sep
Manure (N-P-K) (kg per ha)	110-18-105	0-0-70	110-18-105
Harvest date	9. Aug	9. Aug	9. Aug

Table 1. Crop management: +M/-M (with/without manure); +C/-C (with/without catch crops). Average dates are presented. Soil organic matter was measured in autumn 2008.

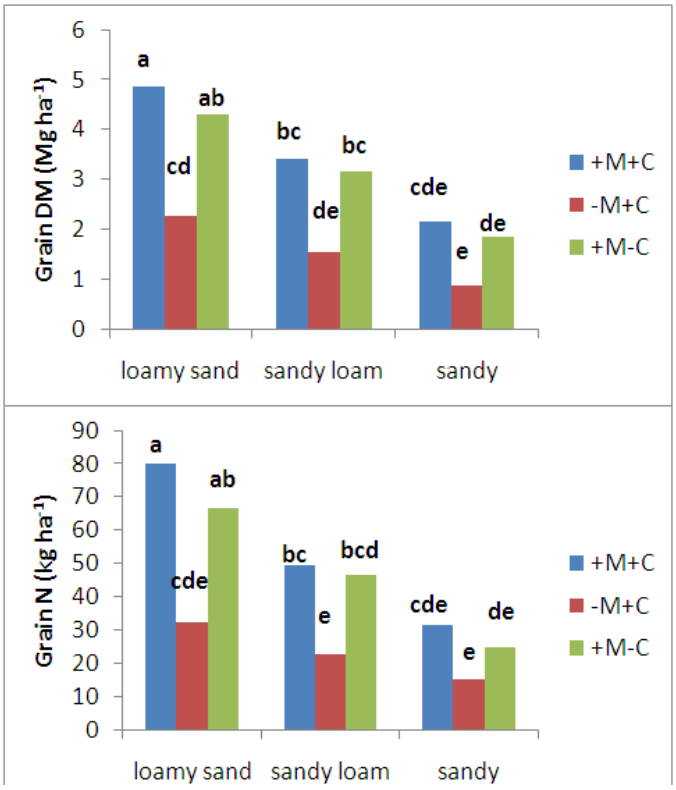

Fig. 1. Winter wheat grain dry matter (DM) and N yield in three different soils and cropping systems. Values are averages of years 2007 and 2008. Different letters indicate significant effect at P < 0.05.

nitrogen content (Fig.1). Grain yields were higher in the loamy sand soil and lower in the coarse sandy soil. Within each site application of manure resulted in a significant benefit. The effect was more pronounced in the loamy sand soil where yield was about twice (increase of 2.6 Mg per ha and 48 kg N per ha) in comparison with the treatment without manure. A minor impact of manure on yield and grain N was found in the more sandy soil (maximum increase of 1.3 Mg per ha and 16 kg N per ha). Introducing catch crops in the rotation in the treatments with manure had no significant effect on yields. This may relate to the cropping system characteristics, since no catch crops were used with the crop previous to winter wheat. Thus, the N mineralized from catch crops residues had probably been taken up by the crop prior to the winter wheat. There was, however, a significant reduction of the N leached after harvest of winter wheat at the sandy and sandy loam soils when using catch crops (Doltra et al., 2011).

Towards a better N use

The FASSET model was calibrated and validated for winter wheat under Nordic conditions (Olesen et al., 2002; Doltra et al., 2011) and used to analyse scenarios of increasing manure to cereals in the rotation with catch crops (Fig. 2). Simulation outcomes indicate the possibility of achieving yields close to that obtained in a similar non-organic rotation by applying, depending on the site, 200-300 kg N per ha in manure. This could be done without significant increase of the N lost by leaching (Fig. 3) while the losses due to ammonia volatilization would strongly depend on the application system. The response to increasing N rates might, however, be overestimated since no effects of weeds or pest are considered in FASSET.

Current regulations limit the N that can be imported from conventional to organic farming in Denmark. This has raised the question of whether these policies should be revised to improve N use in organic cereal systems. Research must be addressed for that purpose, particularly dealing with the effects of manure timing and application system, storage facilities and odor emissions, as well as the impacts of weeds and pests, on the yield and quality of organic wheat.

References

Doltra, J., Lægdsmand, M., Olesen, J.E. 2011. Cereal yield and quality as affected by nitrogen availability in organic and conventional arable crop rotations: a combined modeling and experimental approach. *Eur. J. Agron.* DOI: 10.1016/j.eja.2010.11.002.

Olesen, J.E., Petersen, B.M., Berntsen, J., Hansen, S., Jamieson, P.D., Thomsen, A.G., 2002. Crop nitrogen demand and canopy area expansion in winter wheat during vegetative growth. *Eur. J. Agron.* 16, 279-294.

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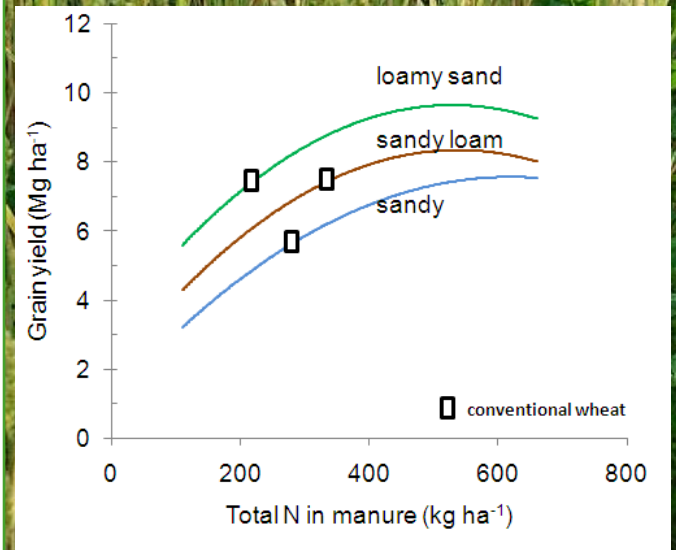

Fig. 2. Simulated grain dry matter yields with increasing levels of N applied in manure to winter wheat in a system with catch crops.

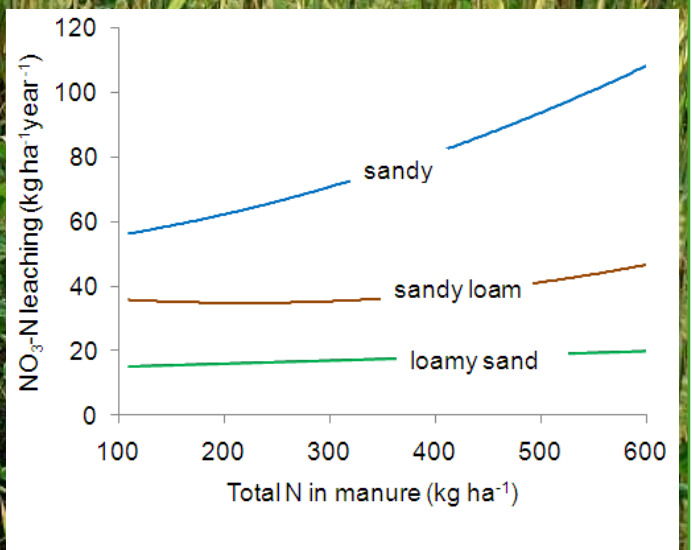

Fig 3. Simulated average annual leaching during a four-year rotation with increasing levels of N applied in manure to winter wheat in a system with catch crops.