

Modelling of processes at the farm level, with special emphasis on nitrogen and carbon flow and turnover

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Background

The challenge in organic farming is to optimise short-term productivity while maintaining long-term soil fertility. The organic farming system is very complex, with multiple interactions and feedbacks. One way of analysing the behaviour of whole systems is to integrate the process-based knowledge in dynamic models. Such models may also be powerful tools in generalising results both from short and long-term experiments. A prerequisite is that the models are general, reliable and thoroughly validated.

In low input cropping systems, as organic farming, the utilisation of N mineralisation from soil organic matter (SOM) is of major importance. Therefore modelling of organic crop rotations will rely heavily on the performance of the SOM turnover model. Despite this, it can be demonstrated that commonly used SOM models have very varying properties, and in many cases fail to yield acceptable simulations when comparing with measurements. Therefore further model development in this area is needed.

Objective

The objective of the Ph.D.-project is to improve the modelling of the turnover of organic matter in soil. The project will give special focus to:

- Good representations of the effects of climate, management and texture
- Contributions to the modelling of the turnover of nitrogen in grazed pastures
- Contributions to establishing a modelling framework (FASSET), in order to make improved assessments of the nitrate leaching from conventional and organic farms.

Progress - 2004

The software C-TOOL was developed in 2003 to handle the combined C and N turnover, and has further been incorporated in the whole-farm model FASSET. Also in 2003 a large database regarding the short- and long-term turnover of organic matter was completed.

Utilising C-TOOL and the database, the model CN-SIM (Petersen et al., 2004a, 2004b) has been developed, and is presently used within FASSET to simulate the N-turnover of as well organic and conventional farms. Three articles (Berntsen & Petersen, 2004; Berntsen et al., 2004a, 2004b) and a number of reports and presentations using this model within FASSET have been submitted/presented/published, and presently further 4 FASSET-related articles are under preparation in DIAS and DARCOF. No funding specifically for the Ph.D. has been received in

2004. The modelling work is now completed, so that all results for the thesis are obtained, and all the three focal points (see Objective) have been addressed.

Courses

The following Ph.D. courses have been attended: "Dynamics of Organic Matter in Soil" (KU, 26.05. - 1.06. 2002), "Research methodologies in relation to Principles and Practice of Organic Agriculture" (SOAR, 7.10. - 11.10. 2002) and "Values, ideologies, science and organic farming" (SOAR, 12.09. – 17.09. 2003). The course "Advanced Mathematics for Biology - Module A" (KVL) is ongoing.

Plans - 2004

The work with the thesis is expected to continue until fall 2005. To accomplish 30 ECTS point, 5 points still lack, so a presently undecided Ph.D. course (or courses) will have to be completed. Because there is no more funding available, the completion of the thesis is predominantly a spare-time project

Proposed content of Ph.D. thesis

Chapter 2-6 are constituted of articles, which are or will be sent to international, reviewed journals.

1. *Synopsis.*
2. *A flexible tool for simulation of soil carbon turnover.* Published in Ecological modelling.
3. *A system analysis of two soil organic matter models.* Draft at present, will be sent to Geoderma 2005.
4. *CN-SIM - a model for the turnover of soil organic matter. I: Long term carbon development.* In press, Soil Biology & Biochemistry.
5. *CN-SIM - a model for the turnover of soil organic matter. II: Short term carbon and nitrogen development.* In press, Soil Biology & Biochemistry.
6. *The influence of model structure on simulations of C and N turnover in soil.* Draft at present, will be submitted 2005 to a still undecided journal.

Publications

(Only the ones directly associated with the Ph.D. project are listed. *Organic eprint* (<http://orgprints.org>) numbers are given in parenthesis)

- Berntsen, J & Petersen, B.M. 2004. Simulating trends in crop yield and soil carbon in a long-term experiment – effects of rising CO₂, N deposition and improved cultivation. Nutrient Cycling in Agroecosystems, submitted. (OE nr. 4000)
- Petersen, B.M., Berntsen, J., Hansen, S. & Jensen, L.S. 2004a. CN-SIM - a model for the turnover of soil organic matter. I: Long term carbon development. Soil Biol. Biochem. In press. (OE nr. 87)
- Petersen, B.M., Jensen, L.S., Berntsen, B., Hansen, S., Pedersen, A., Henriksen, T.M., Sørensen, P. & Trinsoutrot-Gattin, I. 2004b. CN-SIM - a model for the turnover of soil organic matter. II: Short term carbon and nitrogen development. Soil Biol. Biochem. In press. (OE nr. 88)
- Berntsen, J., Petersen, B.M., Olesen, J.E., Eriksen, J. & Sørensen, K. 2004a. Simulation of residual effects and nitrate leaching after incorporation of different ley types. Eur. J. Agron., accepted. (OE nr. 4001)
- Berntsen, J., Hauggard-Nielsen, H., Olesen, J.E., Petersen, B.M., Jensen, E.S. & Thomsen. 2004b. Modelling dry matter production and resource use in intercrops of pea and barley. Field Crops Research, 88, 69-83. (OE nr. 1698)
- Berntsen, J., Olesen, J.E., Petersen, B.M., Eriksen, J. & Askegaard, M., 2003. Simulation of nitrate leaching from an organic dairy crop rotation with different manure types and loads. Abstracts for the 12th N workshop. 21-24 September, 2003 Exeter, Devon, UK. (OE nr. 1700)
- Petersen, B.M., Olesen, J.E. & Heidmann, T. 2002. A flexible tool for simulation of soil carbon turnover. Ecological Modelling, 151, 1-14. (OE nr. 85)
- Petersen, B.M. & Berntsen, J., 2002. Omsætning i jordpuljen på forskellige bedriftstyper. Temadag arrangeret af Afd. for Jordbrugssystemer 24. april 2002. Forskningscenter Foulum. Intern rapport nr. 157: 13-24. (OE nr. 86)
- Petersen, B.M. 2001. Using C-Tool to simulate soil carbon and radiocarbon development. In: COST 627. Carbon storage in European Grasslands. Danish Institute of Agricultural Sciences, Research Centre Foulum, Denmark. pp 22. (OE nr. 89)