



Progress Report 2004 and Application for Continuation in 2005

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The Directorate for Food, Fisheries and Agro Business
under the Danish Ministry of Food, Agriculture and Fisheries

1. Research program

Research in organic farming 2000-2005 (DARCOF II)

2. Project title and number

I.16 Regional Groundwater Protection by Optimised Organic Farming Systems (ØKOVAND)

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6. Project period (month, year)

Start of project: April 2002

End of project: July 2005

7. Midterm description of the project, its results and progress, and application for continuation in 2004

A. Project summary

In Denmark the public gives high priority to being able to use untreated ground water for drinking. There is a growing understanding that clean ground water can only be maintained through active means. A way of regulating land use in vulnerable areas could be to use organic farming. Pesticide use will then stop. However, this does not necessarily mean a stop to nitrate leaching. Probably the loss of nitrate will differ with the type of organic cropping system used and that is the focus of this study.

Our hypothesis is that some of the management steps that characterise organic farming systems can change both the quantity and the quality of the ground water compared with conventional farming. The idea is to focus on the aspects of organic farming systems that presumably will affect the ground water. The total effect of the different management steps on ground water can only be evaluated by the use of a model that integrates the effects from the farming system. This requires that the effects of the organic farm system on the model parameters that are of importance for nitrate leaching are determined.

We especially need knowledge about how the hydraulic parameters are affected by the farming system, and if there are aspects of organic farming systems that generally result in an increased leaching of dissolved organic carbon (DOC) from the plough layer, which can promote a DOC-driven denitrification in the subsoil of leached nitrate. We have identified four management tools that we think would be of particular importance to investigate. These are: (1) the level of application of farmyard manure, (2) the effect of crop rotation and catch crops on the hydraulic properties and denitrification, (3) the effect of N-fixing plants on denitrification, and the effect of tillage systems such as on-land ploughing (4) on hydraulic properties.

On the basis of these investigations we will be able to recommend systems of organic farming that are better able to reduce nitrate leaching and which will be tested in model scenarios to calculate the leaching from the vadose zone. Further, some of the scenarios will be modelled for a catchment area to see whether the effects will persist in ground water at the regional level.

Table A.1: Work package list (from application)**Table 1: Workpackage list**

WP No	WP title	Participants*	Budget (in kkr)	Start	End	Deliverable, No
1	Project co-ordination	<u>OHJ</u>	135	2002/04	2005/07	D1(1-4)
2	Identification of relevant organic farm systems	<u>JPM</u> All	60	2002/04	2005/07	D2.(1-2)
3	Effect of organic farm systems on soil structure and hydraulic parameters	<u>PS</u> OHJ	698	2002/09	2004/12	D3.(1-5)
4	Effect of organic farming systems on DOC mobilisation and DOC-assisted denitrification	<u>FPV</u> HCBH, PS, HHJ	1255	2002/04	2004/12	D4.1-4 13 i alt
5	Root and vadose zone modelling	<u>SH</u> LSJ	612	2002/06	2005/07	D5.1-2 3 i alt
6	Regional modelling of nitrate to ground water	<u>MS</u>	240	2004/01	2005/07	D6.1
Total			3000			

* Responsible participants are underlined

B. Objectives and expected achievements

to determine the effect of different organic farming systems on ground water by model calculations and from this to recommend some organic farming systems that are optimal in relation to the amount of good quality ground water.

to create the model input and adjustment with regard to the effect of different organic farming systems on the soil hydraulic properties and leaching of soluble organic matter and its role for supporting denitrification.

C. Midterm results and progress

C.1 Description (summary) of main results and conclusions

WP 3: Effect of organic farm systems on soil structure and hydraulic parameters

Subsoiling of a dense plough pan

Our results showed that the saturated hydraulic conductivity of soil at the 20-40 cm depth decreased as a result of mechanical subsoiling. From a first sight this may seem paradoxical. However, the observation is in agreement with results obtained in the DACROF project ROMAPAC, where root growth was restricted in the subsoiled plot because there are less continuous larger pores. See Status Report 2003 for some details.

Long-term effects of animal manure

The results from the long-term field trials with different fertilization at Askov Experimental Sta-

tion interestingly indicate that the level of nutrients applied significantly influence the volume of macropores for the 20-40 cm soil layer, Table 1. In contrast, no difference could be detected between the animal manure versus synthetic fertilizer system. Apparently, the roots of well-fertilized crops better create persistent macropores than when poorly fertilized.

Table 1. Soil pore volume in different size fractions $>30 \mu\text{m}$ as influenced by different fertilization treatments. Soil cores sampled in the 20-40 cm layer of field B5, 2002.

Pore size fraction μm	Fertilization system			Nutrient level		
	AM	NPK	P	'1'	'1½'	P
	m^3m^{-3}			m^3m^{-3}		
>300	0.071	0.069	>30	0.061	0.079	0.054
300-100	0.037	0.033	>30	0.025	0.046	0.072
100-60	0.019	0.019	>30	0.013	0.024	0.054
60-30	0.025	0.026	>30	0.023	0.028	0.161
>30 (sum)	0.152	0.147	>30	0.122	0.177	0.042

The results in Table 1 were reflected in higher hydraulic conductivities of the soil with higher volumes of macropores (data not shown here).

Effects of crop rotations

The results from the samplings in the crop rotation trial at Research Centre Foulum interestingly showed that a poor crop rotation displayed higher volumes of macropores and a higher permeability than a diversified crop rotation. This effect was observed both years of sampling. However, as the samples were retrieved in November, when an active system of roots from the catch crop in the diversified crop rotation, we interpret the observation as being an artefact due to these roots blocking the macropores. We have planned an extra sampling in November 2004 in order to test this hypothesis.

WP 4.1 Quantification of amount and export of DOC and DON from different soil layers

As described in the last year status report, leaching of DOC and DON was quantified in the Grass-Clover Experiment (GCE) during the winter 2002-2003. It was here i.a., found that 5-25 kg $\text{NO}_3\text{-N}/\text{ha}$ was leached from the 9th year grass-clover and the ploughed 1st year grass-clover, respectively, but that $\text{NO}_3\text{-N}$ only represented from 50 to 80% of the total N leaching. However, these measurements were carried out on loamy sand during a winter with very low precipitation and runoff.

Through co-operation with GREENGRASS and with financial support from DARCOF, we had the possibility to measure leaching of DOC and DON during the period May 2003 to April 2004 from ploughed grass-clover on a coarse sandy soil. The measurement took place under spring barley established after ploughing of grass-clover in the spring 2003. Spring barley was grown either without catch crops (bare soil) or with catch crops undersown in the spring. In the catch-crop treatment the spring barley was either harvested as a green crop for silage (green crop) or at maturity (catch crop).

A summary of results from the two field experiments is shown in Fig. 4.1.1, where it can be seen that the leaching was considerably lower in the loamy sand than in the coarse sand. However, it should be noticed that measurements were carried out during two different seasons with a runoff at 200 and 600 mm, respectively. Further, notice the significant reduction in the NO_3 -leaching caused by using catch crops, and the additional reduction caused by harvesting the barley crop

early (green crop) allowing the catch crop to be fully developed before the start of the leaching season. The results further showed that $\text{NO}_3\text{-N}$ amounted from less than 50% to about 90% of the total N-leaching, and that up 35 kg DON/ha was leached. Analysis of DOC are not yet fully completed, but assuming a C:N-ratio in the coarse sandy soil as found in the loamy sand, the leaching of DOC was between 100 and 250 kg C/ha.

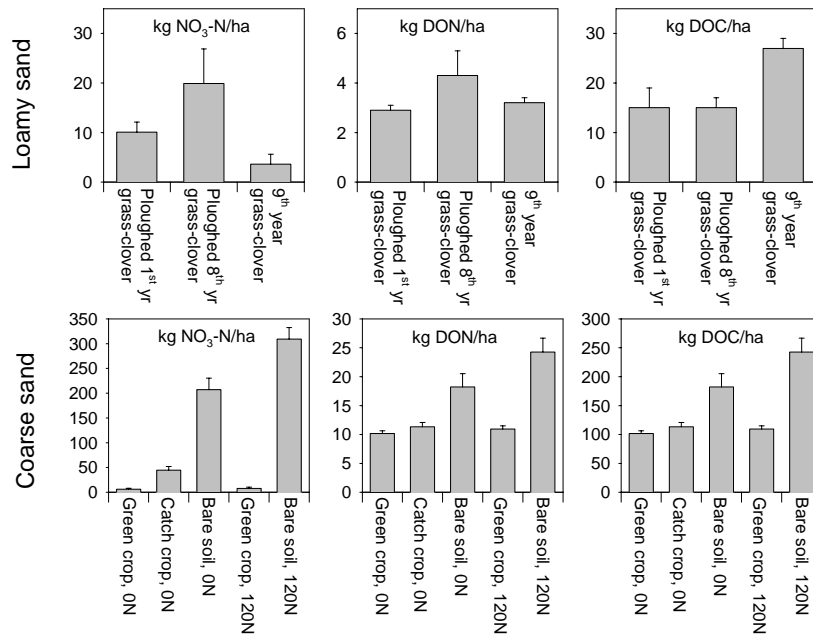


Fig. 4.1.1. Leaching of $\text{NO}_3\text{-N}$, dissolved organic N (DON) and dissolved organic carbon (DOC) in the loamy sand and the coarse sandy soil. See text for further details.

WP4.2:

In order to study the origin of DOM and the contribution from the single species columns were installed to depths of 20, 40 and 60 cm in a second year grass-clover ley. Underneath the mezotrons suction cups were installed in order to collect pore-water from the root zone. Grass or clover in the mezotrons was labelled using leaf labelling with ^{15}N - and ^{14}C urea. During the labelling period of 5 days and at regular intervals thereafter pore-water from the root zone was collected. The canopy was harvested three times during the experimental period with an interval between harvesting of three weeks. At the end of the experimental period the mezotrons were excavated and divided into soil and plant compartments.

In order to model the water transport in the mezotrons bromide was added before the leaf labelling, and in order to have a surplus of pore-water the mezotrons was irrigated at regular intervals. Pore-water samples were immediately analysed for total content of ^{14}C -labelled compounds. Still analysis of ^{15}N content of the pore-water has to be undertaken together with measurements of inorganic parameters like pH and content of bromide. Also the analysis of ^{14}C and ^{15}N in soil and plant material has only been performed on very few samples at this point.

The preliminary results show that ^{14}C from both grass and clover can be found in the percolating pore-water and the trends are that the amount of ^{14}C is higher from grass than clover. The con-

tent of ^{14}C in the dissolved CO_2 is yet to be determined. The leaching of ^{14}C was highest during the labelling period and after the first harvest of the canopy where a pulse of ^{14}C was observed. The first results from the analysis of plant material show that both ^{14}C and ^{15}N are transferred between the species, but whether this is due to transfer via the root system or via the canopy has not been elucidated so far.

WP 4.3 Sorption of DOM from different sources

Dissolved organic matter (DOM) has been extracted from the Burkhøj (Foulum) Ap horizon using Na-saturated Chelex 100 resins. Sorption is very sensitive to pH. It was seen, that sorption strongly increases with time in particular at pH 5 and at higher DOM concentrations, the affinity for sorption of DOM is 3 - 5 times higher for the E and B horizons than the A horizon at pH 5, no sorption maximum is observed within the tested DOC concentrations, DOM is released from the soil at low added DOM concentrations; this is most pronounced for the A-horizon and finally, sorption is much lower at higher pH than at lower pH. The A-horizon does not sorb DOM at pH 7, but rather desorbs DOM. Also the E and B horizons desorb DOM at pH 7 up to solution DOC concentrations of 1 - 2 mM.

The results indicate that DOM can be mobilised from A horizons and that the soil pH exerts a strong control on the mobility of the DOM. Furthermore, the observation that about 50 % of the total soil content of C can be extracted by use of Chelex resins is quite unexpected. This indicates that a large fraction of the soil humic substances in this particular soil can be mobilised and is more bioavailable than previously thought.

WP 4.4 Effects of DOC on denitrification

In the natural environment all factors, such as pore size and distribution, oxygen status and water potential, act simultaneously, and to estimate denitrification under 'real life' conditions it is therefore important to measure on intact soil samples, where also a number of soil physical characters will be measured (WP 3). The measurements on intact 100-cm³ soil samples from three depths (10, 30 and 50 cm) at the long-term fertiliser experiment (LTF), the crop rotation experiment (CRE) and the grass-clover experiment (GCE) are now completed. Measurements on these samples were carried out at three different water potentials (-10, -30 and -100 cm) from near saturated to field capacity, and after addition of a carbon source representing DOC at different concentrations (0, 50 and 200 mg C l⁻¹).

The denitrification was characterised by a large variability resulting in statistically non-significant differences between carbon additions. However, in samples from 30 and 50 cm the denitrification tended to increase with increasing concentrations of carbon. The dominating factor was water content, and the results showed (Fig. 4.4.1 a) that the denitrification increases dramatically at water filled pore space (WFPS) above 60%. This finding lead to a modification of the water function in the Daisy denitrification module (WP5). Apart from the soil water content, the denitrification also seemed to be negatively correlated to air permeability (Fig. 4.4.1 b).

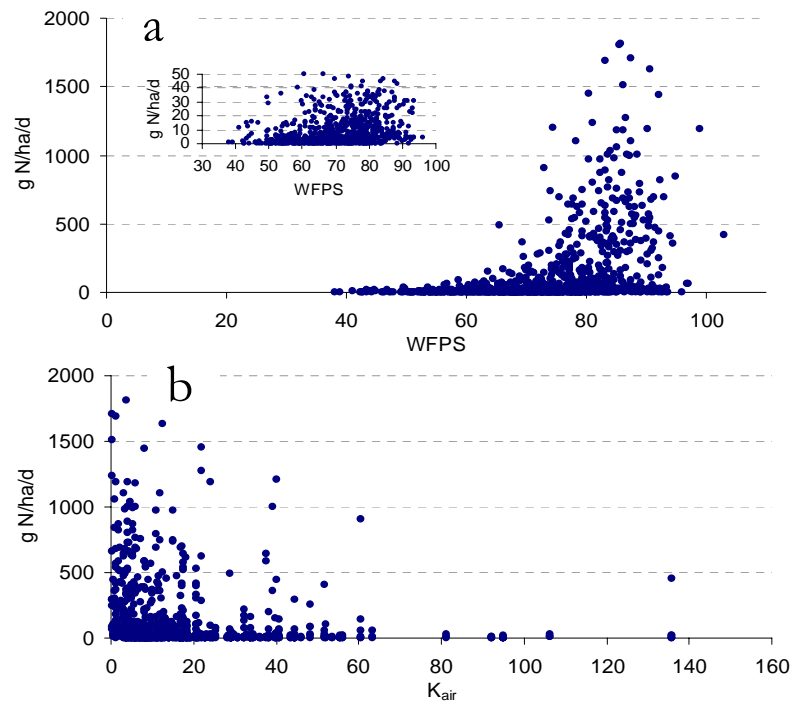


Fig. 4.4.1. Relationships between denitrification (g N/ha/d), water filled pore space (WFPS) and air permeability (K_{air}). The graphs include all ca. 1100 measuring points.

WP5:

DOM/DOC module

The new developed dissolved organic matter (DOM) module has been tested with the sparse numbers available from literature, and the dynamics seemed plausible. The structure of the DOM module has been parameterised from sorption data (WP4.3) and field experiments (WP4.1) and literature (e.g. decay rates and diffusion coefficients of DOM). However, one of the main issues during parameterisation of the DOM module has been to identify and particularly to quantify the sources of DOM in soil. According to numerous investigations DOM is produced principally by microbial activity, root exudation, and leaching from litter and humus in the soil. However, the quantitative contribution made by each of these sources is controversial:

- Qualls et al. (1991) found that large concentration of hydrophilic neutral compounds after litter fall have been interpreted as an indicator for temporarily contributions of recent litter to DOM in forest floor.
- Yano et al. (2000) hypothesized that roots and root exudes were a significant source of biodegradable dissolved organic carbon (DOC) as no correlation was found between DOC and freshly fallen litter, but a correlation between DOC and fine root biomass was obtained. However, Yano et al. (2000) also observed a significant production of non-biodegradable DOC in forest floor, suggesting that an abiotic process, such as chemical equilibration between forest floor and forest floor solution results in relatively high concentrations of non-biodegradable DOC.
- Guggenberger et al. (1994) suggested from structural analysis of DOM from a coniferous forest that DOM released into forest floor is related to microbial activity by oxidative

- degradation of plant derived organic matter and by production of microbial metabolites.
- McDowell and Wood (1984) and David and Vance (1991) found similarities between the NMR spectra of DOC humic fractions and solid soil organic matter and close relationship between dissolved and solid organic matter which indicated that there is a reactive or soluble fraction of the total soil organic matter (SOM) pool that may be solubilized and lost to either microbial decomposition or leaching.

Data of change in ^{14}C indicate that most DOC in the soil is fairly old, at least 30 years at 5 cm dept (Tegen and Dorr, 1996) and at 10-25 cm (Trumbore et al., 1992) supporting that leaching of SOM rather than of recent litter is the major source of DOM. This is supported by findings of Hagedorn et al. (2004) who investigated the origin of DOC in a 4-year experiment exposing spruce and beech, growing on a sandy loam and on calcareous sand, to CO_2 depleted in ^{13}C . In the soil solution of the topsoil, DOC contained only 5-10 % new C from the trees. Apparently, throughfall, fresh litter and roots made only minor contributions to DOC. However, water-extractable organic C contained significantly larger fractions of new C (25-30 %) implying that the sampling method strongly influences the characteristics and sources of DOM. Hagedorn et al. (2004) suggested that DOM is produced during incomplete decomposition of recalcitrant native C in the soils, whereas easily degradable new components are rapidly consumed by microbes and thus make only a minor contribution to DOM.

The structure of the DOM module in Daisy is very flexible regarding contribution from different sources (recently added organic matter, microorganism or soil organic matter). However, the parameterization has focused on the results of ^{14}C , which suggest that DOM is rather old and mainly is produced from SOM by some physical/chemical/biological processes resulting in that some part of SOM in soil is dissolved. The biological processes contribute by microbial degradation of organic matter, releasing a fraction of metabolites as DOM. Additionally a fraction of the relatively physically stabilized organic matter pool (the SOM2 pool) in Daisy may be physical/biological destabilized during decomposition, resulting in that some part of SOM in soil is dissolved.

Recently, increasing evidence from studies in soil systems indicates that sorptive protection of organic matter may be of particular importance (e.g., Kaiser et al., 1996; Qualls and Haines, 1992). According to several authors (e.g. Moore, 1989; McDowell and Wood, 1984) the change in quantity of DOM during passage through the mineral soil is caused by sorption of DOM on to the soil mineral phase. However, the quantitative importance of sorption in SOM stabilization and accumulation is not well understood (Sollins et al., 1996). How much of the organic matter in soil might be sorbed? Extraction of DOM from agricultural topsoil by a chelating resin (results from WP4.3) extracted approximately 50 % of the total organic C. This indicates that a large fraction of the soil humic substances in this soil can be mobilized by removing metals from the soil organic fraction. Hence, removing polyvalent cations from the soil probably results in release of organic matter associated/sorbed to clay minerals.

Additionally, it is often found that soil is able to release DOM when exposed to aqueous solution containing no or very low concentrations of DOM (Kaiser, 2001; results from WP4.3). Thus, the soil solid phase may not only sorb DOM but may also release it depending on solution DOM concentrations. A model called the Initial Mass approach describes desorption and sorption at equilibrium. The Initial Mass approach is developed and described by Nodvin et al. (1986) for a number of anions and DOC. The Initial Mass approach has in several studies been able to describe the amount of DOC, removed or released to the solution by the soil, as a linear function of the initial amount added to the soil-water system (Moore et al., 1992; Vance and David, 1992; Guggenberger and Zech, 1992).

Sorption/desorption of DOM in the structure of the DOM module in Daisy, a simplified approach is followed in modeling DOM sorption/desorption to soils, taking advantages of estimated relationships linking soil properties to sorption properties across a range of soil types. The Initial Mass approach is used to estimate a DOC concentration specific for the soil, where no net sorption/desorption of DOM occurs. An empiric, kinetic term couples the 'equilibrium' concentration to the actual DOM concentration in the soil, incorporating considerations as diffusion and sorption time in the sorption/desorption process. The kinetics is induced by concentration gradient between the estimated concentrations where no net change in DOM concentration occurs and the actual DOM concentration.

The calibration of the DOM module to field data (WP4.1) is almost finishing. However, sensitivity analysis is not conducted yet.

Denitrification module

The denitrification module has been recalibrated to be in line with observations made by Finn P. Vinter. The organic matter turnover module has been recalibrated as part a Daisy Standardization project, financed by Danish Environmental Protection Agency, the counties (amterne), and the Danish Agricultural Advisory Service. Further calibration and some structural changes to that module are being made as part of the BIOMOD project.

WP6:

The work package starts this year and runs into 2005. The groundwater model has been definitively selected. It is "Søndersø" on Funen. Part of this area is classified as "infiltration zone" to existing water works. Nitrate is found in the pumped water, and the county of Funen are preparing control measures. The area is dominated by moraine clay (JB6), but about 1/3 is more sandy (JB4) and about 200 ha are organic soils. The present land use of the area is shown in table 6.1.

Table 6.1

Farm type	Ha
Pig farms	3147
Cattle farms	1300
Crop prod. only	642
Mixed farming	383
Unknown, receives pig manure	2867
Fallow	287
Continuous grass	335
Other (forest, lakes, town, etc.	2566
	11526

Suggestions for different crop rotations have been made and scenario land use for this area have been decided. Regarding the description of redox conditions, the WP will cooperate with a PhD-student from KVL/GEUS, who works with the same area and hydraulic model.

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C.2 Fulfilment of deliverables and milestones

(To be completed for each work package)

WP1: Project co-ordination	Time schedule according to application	Deviations, if any*
Deliverables		
D 1.1 First annual report 2002	2002/10	OK
D1.2. Second annual report 2003	2003/10	OK
D1.3. Third annual report 2004	2004/10	OK
D1.4. Report with optimal organic farming systems (See M2.3 and 5.5)	2005/07	
D1.5. Final report 2005	2005/07	
Milestones		
M1.1 First annual report completed	2002/10	OK
M1.2 Second annual report completed	2003/10	OK
M1.3 Third annual report completed	2004/10	OK
M1.4 Final report completed	2005/07	

WP2: Identification of relevant organic farm systems	Time schedule according to application	Deviations, if any*
Deliverables		
D2.1 Suggestions of organic farming systems and crop rotation to test in the project	2002/06	OK
D2.2 Description of agricultural practices in the farming systems for use in simulations	2003/12	OK
D2.3 List with optimal organic farming systems	2005/07	

Milestones		
M2.1 Agreement on farming systems to test	2002/06	OK
M2.2 Agreement on agricultural description for model simulations	2003/12	OK
M2.3 Report with optimal organic farming systems (See M1.4 and M5.5)	2005/07	

WP3: Effect of organic farm systems on soil structure and hydraulic parameters	Time schedule according to application	Deviations, if any*
Deliverables		
D3.1 Effect of management tools on porosity, retention curves, saturated and unsaturated hydraulic conductivities	2003/12	OK
D3.2 Effect of management tools on tortuosity and pore connectivity	2003/12	OK
D3.3 Semi-quantitative description of depth and distribution of roots and macropores in the field trials	2003/05	Partly
D3.4 Soil physical characterised soil samples for the denitrification incubation experiments	2003/08	OK
D3.5 Suggestions on how to extrapolate parameter effects to other soil types	2004/04	OK
Milestones		
M3.1 Sampling in the field trials finished	2003/10	OK
M3.2 Data of hydraulic properties and pore characterisation parameters delivered to modellers	2003/12	OK
M3.3 Soil samples for the denitrification incubation delivered	2003/08	OK
M3.4 Agreement on how to extrapolate parameter effects to other soil types	2004/03	OK

WP4: Effect of organic farming systems on DOC mobilisation and DOC-assisted denitrification	Time schedule according to application	Deviations, if any*
Deliverables		
D4.1-1 Field record of the time dependent profile DOC (including DON) concentrations under conditions of high carbon and nitrogen turnover	2003/12	OK
D4.1-2 DOM isolates for further characterisation in WP 4.2 and for use in sorption work in WP 4.3	2003/05	OK
D4.1-3 Dataset for calibration of DOC modelling by DAISY	2003/12	OK
D4.1-4 Measurements of DON-leaching in a coarse sandy soil	Not included in application	see point D
D4.2-1 Determination of origin of DOM in grass-clover mixtures	2003/07	Partly
D4.2-2 Determination of the composition of DOM originating from specific species	2003/12	see below
D4.2-3 Determination of the contribution of single species to the mobile part of the DOM	2003/07	Partly
D4.2-4 DOM pulse as related to precipitation intensity	2003/07	see below
D4.3-1 Quantitative measures of DOC bonding according to soil composition, DOC composition and DOC concentration	2003/12	OK
D4.3-2 Selective sorption of specific DOC fractions during sorption	2003/07	2003/11
D4.3-3 Input parameters to DAISY modelling of DOC dynamics	2003/12	OK
D4.4-1 Determination of soil physical characteristics on intact soil cores for denitrification measurements	2003/06	OK
D4.4-2 Dataset from measurements on intact soil cores for calibration of Daisy denitrification sub-module	2003/12	OK
D4.4-3 Influence of DOC on potential denitrification as a function of crop type, organic fertiliser input	2003/12	OK
Milestones		
M4.1-1 Teflon suction cups installed	2002/09	OK
M4.1-2 Sampling from suction cups and analysis of DOC finalised	2004/04	OK
M4.2-1 Soil column studies about origin of DOM in grass-clover mixtures completed	2003/05	see below

M4.2-2 Dataset for calibration of DOC modelling by DAISY delivered	2003/09	see below
M4.3-1 Studies on DOM sorption and composition completed	2003/08	OK
M4.3-2 Sorption parameters for calibration of DOC modelling by DAISY delivered	2003/09	OK
M4.4-1 Studies on relationships between DOC, soil physical characters and denitrification completed	2004/03	OK
M4.4-2 Dataset for calibration of denitrification sub-module in DAISY delivered	2004/03	OK
M4.4-3 Studies on the influence of DOC on potential denitrification as a function of crop type, organic fertiliser input and soil depth completed	2004/03	OK

WP5: Root and vadose zone modelling	Time schedule according to application	Deviations, if any*
Deliverables		
D5.1-1 Operational DOC module in DAISY	2004/01	Ready
D5.2-1 Scenario simulations of the suggested organic farming systems and standard conventional systems	2004/09	2004/10
D5.2-2. Input data for regional groundwater simulations	2004/09	2004/10
Milestones		
M5.1-1 DOC module ready	2003/12	Ready
M5.2-1 Agreement on agricultural description	2003/12	OK
M5.2-2 Scenario simulation finished	2004/10	2004/11
M5.2-3 Input data delivered to WP6	2004/10	2004/11
M5.2-4 Report with optimal organic farming systems (See M1.3 and M2.3)	2005/07	

WP6: Regional modelling of nitrate to ground water	Time schedule according to application	Deviations, if any*
Deliverables		
D6.1. Report describing the results of the upscaling exercise	2005/07	
Milestones		
M6.1. Agreement on choice of groundwater model (2002/10)	2002/10	Final decision now taken
M6.2. Agreement on agricultural description	2003/12	OK
M6.3. Report describing the results of the upscaling exercise	2005/07	

* *Deviations are to be further discussed in D*

D. Description of deviations and subsequent adjustments of plans

WP 3: Effect of organic farm systems on soil structure and hydraulic parameters

All samplings and measurements have been completed as planned. We intend to sample an extra collection of samples from the crop rotation trial at Foulum in order to test the hypothesis derived from the results of the first two years (see section C1).

WP 4.1 Quantification of amount and export of DOC and DON from different soil layers

Via supplementary financial support from DARCOF for chemical analysis and cooperation between ØKOVAND and GREENGRASS it became possible to include measurements of DON- and DOC-leaching in a coarse sandy soil. This, however, has implied a delay in the publication of the WP4-activities.

WP4.2

There was a change in plans so that the work in this work package became included in Ph.D. study in SOAR. This delayed the work. Further the first Ph.D. student resigned in 2003 and a

new Ph.D. student started the work in April 2004. The work in 2004 has focused on WP 4.2-1 and 4.2-3, with the work of 4.2-2 yet to be undertaken. The investigations in WP 4.2-4 will probably not be done, instead the influence of harvesting of the canopy has been studied in relation to a DOM pulse. Since the result from the WP has not been completed at present time, the modellers in WP 5 have to make use of the data from the other work packages.

WP4.3

It was originally planned to isolate DOM from soil water from suction cells. However, due to the rather low volumes of soil water gained from the suction cells and the low DOC concentrations in the soil water, it was decided to isolate DOM in a different way. We have used the Chelex resin method for isolation of DOM as this method does not imply the use of strong acids or bases, and because the use of this method is well documented. The Chelex resins extract metal cations like Ca^{2+} , Fe^{3+} and Al^{3+} from the soil thus causing liberation of DOM to the solution. Thus the method is a rather gentle method only causing a minimum of disturbance of the soil.

WP5

This WP has been 1 month delayed due to a delay in the data transfer from WP3 and 4.

WP6

Earlier it was decided to use a groundwater model of Odense Å as the basis for scenario modelling. However, to improve the detail of modelling and to make the exercise more realistic it was decided to choose an area where zonation for groundwater protection actually takes place. "Søndersø" is such an area, and at the same time, most of the model area is inside the earlier selected catchment. Nitrate problems are observed in the area. The basic hydrological model is more detailed than the Odense Å model considered earlier, and the project will further benefit from cooperation with a PhD-student looking into redox-conditions and descriptions in the same area.

While the time schedule for the final report will not change, the time schedule is pushed a bit forward, as the groundwater model simulations awaits the simulations of WP5. Therefore DHI want to transfer 40.100 dkr from this years budget to 2005.

E. Project publications and other products

1. Products from Organic Eprints archive

Submitted for peer-review but not yet accepted

**Munkholm, L.J. and Schjøning, P. and Jørgensen, M.H. and Thorup-Kristensen, K. (2004) Mitigation of subsoil recompaction by light traffic and on-land ploughing. II: Root and yield response. [preprint]

**Munkholm, L.J. and Schjøning, P. and Rüegg, K. (2004) Mitigation of subsoil compaction by light traffic and on-land ploughing. I. Soil response. [preprint]

Not peer-reviewed**English**

**Munkholm, L.J. and Schjøning, P. (2003) Mechanical subsoiling: Mitigation of recompaction by light traffic and on-land ploughing. Paper presented at 16th International Conference of the International Soil Tillage Research Organization, Brisbane, Australia, July 2003; Published in *Proceedings, 16th International Conference of the International Soil Tillage Research Organization (CD-ROM)*.

Danish

**Schjøning, P. and Munkholm, L.J. and Elmholt, S. (2003) Jordkvalitet og dyrkningsmetoder [Soil quality and management], in Holmstrup, M., Eds. *Økologisk landbrug og naturen - gør økologisk landbrug en forskel for natur og miljø?*, chapter 1, page 9-19. Miljøbiblioteket 1. Gads Forlag.

Vinther, F.P. (2003) Kvælstof forsvinder [Nitrogen disappears]. In *Økologisk Jordbrug*, No 297, page 8.

Vinther, Finn P. and Hansen, Søren (2004) SimDen - en simpel model til kvantificering af N₂O-emission og denitrifikation. [SimDen - a simple model for quantification of N₂O-emission and denitrification.]. DJF rapport no. 104, Department for Agroecology, Danish Institute of Agricultural Sciences.

Vinther, F.P. (October 2003) Hvor bliver kvælstoffet af? [Where does the nitrogen go?]. Online at <http://www.foejo.dk/enyt2/enyt/okt03/index.html>. October 2003, "DARCOF e-news"

2. Other products (oral presentations, public meetings, field days, etc.)

Vinther, F. P., Eriksen, J. & Hansen, E. M. (2004) Leaching of dissolved organic carbon (DOC) and nitrogen (DON) from grass-clover pastures after ploughing. DOM 2004 - International workshop: Dissolved Organic Matter and the Cycling of Carbon, Nutrients and Metals, October 3-6, Bayreuth, Germany.

Rasmussen, J. and Høgh-Jensen, H., 2004. Origin and composition of dissolved organic C and N from grass-clover mixtures. Poster and short paper at the joint meeting of working groups 1, 2, 3 and 4 of the Cost Action 627 – Carbon sequestration In European grasslands – June 3-6, Ghent, Belgium

* 25-75% financed by DARCOF

** 5-25% financed by DARCOF

F. Scientific education

WP3 RVAU student Lene Mathiasen has writing her masters thesis at Foulum in connection with the work on WP3 concentrating on the tillage trials at Rugballegaard.

WP4.2. This project is now part of a Ph.D. project for Jim Rasmussen within SOAR

WP4.3 and 5. This project is part of a current Ph.D. project for Birgitte Gjetterman on dissolved

organic matter mobilisation and transport.

G. National and international co-operation

We are using the experimental area described in DARCOF project VII.11. The two projects work in close collaboration experimentally and in the interpretation of data. The experiment is labelled the “Grass-clover experiment” (GCE). (Contact: Jørgen Eriksen, DIAS)

Through co-operation with GREENGRASS and with financial support from DARCOF, we had the possibility to measure leaching of DOC and DON during the period May 2003 to April 2004 from ploughed grass-clover on a coarse sandy soil.

In November 2002 we will sample in the long-term crop rotation experiment that is financed by DARCOF project II-23 “Experimental units for research in organic farming systems” (EXUNIT) (Contact: Jørgen E. Olesen, DIAS), in long-term fertiliser experiments in Askov (Contact: Bent T. Christensen, DIAS) and in “The Row Cropping Experiment” in Bygholm (Contact: Per Schjønning, DIAS)

Several of the participants in this project are involved the DARCOF project “Interaction between nitrogen dynamics, crop production and biodiversity in organic rotations analysed by dynamic simulation models” - BIOMOD (LSJ, SH, JEO, FPV) and we make use of the improvements of Daisy and data input to simulate organic farming systems.

Further international co-operation is planned according to the proposal

H. Critical reflection on the project

We still believe that the idea to use models to integrate the different effects of organic farming on nitrate leaching and therefore concentrate on measuring the effects on the model parameters is the only way we can integrate the interaction between farming system, climate and soil types within a reasonable economic frame.

We did only find small differences in the hydraulic properties due to management typical for organic farming. We think we have used rather good study objects where also the long-term effects would appear. So apparently the effects are small.

We are very happy that it was possible to expand the investigations in leaching of dissolved organic matter to a sandy soil. This makes it possible to calibrate the Daisy DOM module for a two soil types which really improve the reliability of the simulations.

However, the very significant amounts of dissolved organic nitrogen (DON) leaching out of the root zone emphasises a need for investigating the fate of this at depth. As the present measurement programme stops at about 1 m’s depth, there is, in reality, no validation of simulation of transport and transformations in deeper layers.

8. Budget

A. Account for any change in budgets

B. Budget for the whole project (1.000 DKK)

Total consumption of funds from DARCOF and expected consumption this year and coming years

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Man-months						
Scientific personnel	5	17	7,5	5.5		
Technical personnel	3.2	15.2	5.2	0.3		

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Salaries						
Scientific personnel	211	674	337.1	308,2		
Technical personnel	78	384	134	7		
Other operational costs	71	175	83,5	37,2		
Equipment						
Others (please specify)						
Direct costs						
Indirect costs (20% of direct costs)	72	247	110,3	70,7		
Total	432	1480	664.9	423,1		3000

Comments:

The groundwater model simulations are slightly delayed because they await the simulations of WP5. Therefore DHI want to transfer 40.100 dkr from 2004 to 2005.

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project			
Ole Hørbye Jacobsen	DIAS	Sep. 31 2004	

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

Name of Institute: Danish Institute of Agricultural Sciences, Department of Crop Physiology and Soil Science

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Man-months						
Scientific personnel	3	12	2.5	3		
Technical personnel	1.3	11.7	3.2	0.3		

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Salaries						
Scientific personnel	131	474	121	156		
Technical personnel	30	300	86	7		
Other operational costs	39	81	24	9		
Equipment						
Others (please specify)						
Direct costs						
Indirect costs (20% of direct costs)	40	171	46	35		
Total	240	1026	277	207		1750

Comments:

Name of Institute and department: The Royal Veterinary and Agricultural University,
Department of Agricultural Sciences

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Man-months						
Scientific personnel	2	5	4	1		10
Technical personnel		1.5	1			2.5

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Salaries						
Scientific personnel	80	200	160	40		480
Technical personnel		36	24			60
Other operational costs	3	51	32	7		93
Equipment						
Others (please specify)						
Direct costs						
Indirect costs (20% of direct costs)	17	58	43	9		
Total	100	345	259	56		760

Comments:

Name of Institute and department: The Royal Veterinary and Agricultural University,
Chemistry Department

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Man-months						
Scientific personnel						
Technical personnel	2	2	1			

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Salaries						
Scientific personnel						
Technical personnel	48	72				
Other operational costs	29	49	11			
Equipment						
Others (please specify)						
Direct costs						
Indirect costs (20% of direct costs)	15	24	2			
Total	92	145	13			250

Comments:

Name of Institute: DHI Water & Environment

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Man-months						
Scientific personnel			1	2		
Technical personnel						

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Salaries						
Scientific personnel			56,1	112,2		
Technical personnel						
Other operational costs			10,5	21,2		
Equipment						
Others (please specify)						
Direct costs						
Indirect costs (20% of direct costs)			13,3	26,7		
Total			79,9	160,1		240

Comments:

The groundwater model simulations are slightly delayed because they await the simulations of WP5. Therefore DHI want to transfer 40.100 dkr from 2004 to 2005.

C. Budget for co-financing from each participating institute (1.000 DKK)

Name of Institute: The Royal Veterinary and Agricultural University

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	2006	Total
Man-months						
Scientific personnel	3.5	3.5	2.5	1.5		
Technical personnel	2	6	2			

Comments: