



Progress Report 2007 and Application for Continuation in 2008

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Research in Organic Food and Farming
International Research Co-operation and Organic Integrity
(DARCOF III 2005-2010)

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1. Project title and acronym

The effect of cropping systems on production and the environment (CROPSYS)

2. Project journal number

3304-FOJO-05-04-01

3. Project period (month, year)

Start of project: January 2006

End of project: June 2007

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7. Midterm description of the project, its results and progress, and application for continuation in 2008

A. Project summary

Modern agricultural systems greatly influence the environment, and there is a particular emphasis in Denmark on nitrate leaching and greenhouse gas emissions from agriculture. Sustainable agricultural systems also need to fulfil the requirements for quantity and quality of the agricultural produce. 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. A proper management of this to improve crop yields and reduce emissions to the environment requires an in-depth understanding of soil processes and nutrient dynamics, and their effects on crops and weeds.

A long-term organic crop rotation (CRO) experiment was initiated in 1997 at three different locations in Denmark; in 2005 it is modified to include also a conventional system. The three locations represent typical soils (sand, loamy sand and sandy loam) and climates for Danish agriculture. The design of the currently 8-year old rotations allows for effects of manure application and catch crops to be distinguished, and for effects of soil type and climate to be quantified. Thus, a differentiated analysis of management strategies can be conducted. The project will exploit this unique long-term experiment for an integrated study of the productivity and nitrogen (N) flows in organic cropping systems.

The project will quantify productivity and environmental impacts of different organic and conventional cropping systems across a range of soil and climatic conditions, and identify management measures, which contribute significantly to a sustainable development of the individual cropping systems. This will be achieved through an integrated experimental and modelling programme, where measurements of key indicators of productivity and environmental impact and of the underlying processes and dynamic soil properties are carried out in the CRO experiment. A simulation model (FASSET) and a life cycle analysis (LCA) model will be used to analyse different management scenarios. The output of the work is guidelines for improving the sustainable development of organic crop production systems in Denmark.

WP1 will coordinate the project and ensure the communication between partners and with stakeholders. A common measurement and management protocol for the CRO experiment will be maintained. All data from the CRO experiment will be stored in a database for access by all partners.

WP2 will manage the CRO experiment. The experiment includes three 4-year crop rotations representing an organic green manure/cash crop rotation, an organic cash crop rotation and a conven-

tional cash crop rotation. A factorial design is used, which includes two manure treatments and two catch crops treatments. With two replicate plots for each system combination, a total of 64 field plots are managed at each site. Crop yield and biomass of crops and weeds will be measured. The crop N uptake will be measured and the N₂-fixation will be measured in legume crops and catch crops.

WP3 will measure nitrate leaching of all cropping systems of the CRO experiment. This enables an interpretation of short- and long-term effects of management and location on the nitrate leaching. The leaching of dissolved organic nitrogen (DON) will be measured in a campaign coordinated with measurements of topsoil DON in WP5. The potential uptake of N by roots in soil layers below the installed suction cups will be analysed from measurements of root development using minirhizotrons and modelling (WP6).

WP4 will measure nitrous oxide emissions from four selected treatments in the CRO experiment during a 12 month period at two of the locations. Samples of the topsoil will be taken at the sandy loam site to investigate cropping systems effects on denitrification and the ratio of N₂O:N₂ production. Soil samples will be collected in autumn 2008 at two depths for measurements of total carbon (C) and N to analyse trends in soil C and N storage.

WP5 will quantify the effects of contrasting cropping systems on a range of soil attributes (including pore size distribution, air permeability, soil workability, soil mineral N, DON, microbial biomass N). Measurements will be taken during two years in the CRO experiment. Some of the measurements will be taken in all systems. However, the majority of the effort will focus on the four contrasting systems and the two sites also used in WP4. In addition, soil samples will be analysed for net N mineralisation and for microbial biomass pools.

WP6 will use statistical methods, simulation modelling (FASSET) and life cycle analyses (LCA) to generalise the results of the CRO experiment (WP2 to WP5) to other climatic and soil conditions and to other management strategies. This will include an assessment of the environmental impact of the whole product chain for both organic and conventional farming systems. These results will be used for quantifying management measures that may contribute significantly to a sustainable development of organic farming systems.

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

WP No.	WP title	Responsible scientist	Budget DKK	Start	End	Deliverables
1	Project management and communication	JEO	632,200	2006-01	2010-06	D1.1-D1.5
2	Productivity of cropping systems	MAS	7,923,571	2006-01	2009-12	D2.1-D2.4
3	N leaching losses	MAS	2,737,905	2006-01	2009-12	D3.1-D3.3
4	Greenhouse gases and denitrification	SOP	2,142,529	2007-01	2009-12	D4.1-D4.3
5	Soil quality	PSC	2,702,913	2007-01	2009-12	D5.1-D5.3
6	Scenario analyses and synthesis	JEO	1,723,090	2008-10	2010-06	D6.1-D6.5
Total			17,862,209			

B. Objectives and expected achievements

The overall goal is to quantify productivity and environmental impacts of different organic and conventional cropping systems across a range of soil and climatic conditions, and to identify management measures which contribute significantly to a sustainable development of the individual cropping systems. The basic hypothesis is that organic cropping systems can be maintained with high productivity at low environmental impact through better crop rotation design and management, as modified by soil type and climate. This will be achieved through a better description of the role of soil N dynamics, soil properties and crop and weed dynamics in the different systems, and using modelling and scenario analyses to integrate and evaluate production-related and environmental indicators of sustainability.

C. Midterm results and progress

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

WP1. Project management and communication

Within the project group the management has focused on ensuring that all measurements and samplings within the crop rotation experiment could be done without interfering with each other. There are many associated projects using the crop rotation experiment, and all these have some sort of special requirements either in terms of space for sampling/measurements or requirements for crop products. The requirements have been specified in protocols that are incorporated into the CROPSYS project manual, which is revised every year. The coordination of various measurement activities are also treated in detail during the annual winter and summer meetings, where all project partners of both CROPSYS and the associated projects are invited to participate.

The crop rotation experiment was changed in 2005 to also include conventional crop management treatments in addition to the organic treatments. This has posed many challenges to the technical staff in terms of proper management of the conventional treatments, which require other types of attention than the organic treatments. Especially the crop protection issues have been a challenge and we therefore invited a specialist from the Danish Agricultural Advisory Service to participate in the winter meeting in 2007 to discuss in detail the guidelines for proper conventional crop protection for the crops grown in the conventional treatments.

Another challenge has shown to be the need care in ensuring that no pesticides are deposited within the organic plots. At all sites care is taken during the spraying to avoid wind drift of the pesticides. However, unfortunately a careless tractor driver at Flakkebjerg in 2007 did not bother to sufficiently lift the spray boom while travelling past organic plots. This resulted in a small deposition of chemicals on tall weeds (thistles). We believe that no crop deposition took place in this case. However, on another occasion we cannot rule out that the same driver did deposit a small amount of pesticides in parts of a few organic plots. None of the affected crops will be used in further analyses. We do not think that there are any longer-term effects of this, and action has been taken to ensure that such situations will not be repeated.

In June 2006 the project organised a seminar at Research Centre Foulum on "Production and environmental impacts in organic farming". The seminar included presentations and discussions in the auditorium at Research Centre Foulum followed by a visit to the field trial at Foulumgård. There was a good and lively discussion at the seminar and summaries of the presentations and discussions are available from the okoforsk website.

WP2. Production of cropping systems

Measurements of yield (task 2.2), weed (task 2.3), nitrogen uptake and N_2 fixation (task 2.4) were carried out at all locations. Table 1 shows the dry matter (DM) yields of spring barley, winter wheat, faba bean and potato tubers in the three crop rotations with the different combinations of fertilizer application and catch crop use. As an average of the fertilized treatments and crops (grass-clover not included) the conventional treatment gave about 50% higher yields at Jyndevad and Flakkebjerg but only 16% higher yields at Foulum. In the cereal crops there was largest yield effect of catch crops in O4 (with no grass-clover green manure crop) than in O2 (with grass-clover green manure crop). The organic crops responded positive to manure application, most at Jyndevad where yields increased by two to four fold. The large effect of manure application in faba bean at Jyndevad indicates that nutrients other than N and K (applied in vinasse) had been yield limiting. We expect that measurements of nutrient contents carried out in the collaborating project OrgTrace will provide us with more knowledge about the cause of this yield limitation.

The grass-clover in O2 was cut three times and in the two treatments with manure application the cuts were removed. In total about 350 and 190 kg N ha⁻¹ was harvested at Jyndevad and Foulum, respectively, as an average of catch crop treatments. In our models this N is anaerobically digested and recirculated to the fields. Thus, for distribution in 2007 the N harvest would in the theory provide the crop rotation with 70 kg N ha⁻¹ more at Jyndevad and 90 kg N ha⁻¹ less at Foulum compared with the planned

280 kg N ha⁻¹. Unfortunately the grass-clover yields from the first cut at Flakkebjerg are missing due to mechanical damage on the harvester.

Using the difference method for estimation of the N₂ fixation we measured about 290, 270 and 100 kg fixed N₂ ha⁻¹ in above-ground plant material at Jyndevad, Foulum and Flakkebjerg, respectively. The corresponding clover contents were 90%, 60% and 40% of total DM as an average of treatments and cuts. In faba bean the estimated N₂ fixation was about 170, 220 and 50 kg N ha⁻¹ at Jyndevad, Foulum and Flakkebjerg, respectively, as an average of treatments.

Table 1. Grain, seed and tuber yields in 2006 (t DM ha⁻¹).

Crop rotation	Fertilizer	Catch crop	Crop		Spring barley			Winter wheat			Faba bean			Potato			
			JY	FO	FL	JY	FO	FL	JY	FO	FL	JY	FO	FL	JY	FO	FL
t DM ha ⁻¹															Kg DM ha ⁻¹		
O2	-	+	2.03	3.98	3.04	0.68	3.60	3.60						3.51	5.49	3.47	
	+	-	2.63	4.69	3.52	2.75	6.36	5.09						6.16	5.96	5.1	
	+	+	4.23	4.77	3.50	3.15	6.16	5.19						6.5	5.31	4.35	
O4	-	+	2.07	3.67	2.77	0.79	2.53	2.46	0.36	3.13	1.36	3.05	4.43	3.28			
	+	-	3.23	4.38	3.23	2.82	5.19	3.17	2.24	3.26	1.93	5.87	5.58	4.72			
	+	+	4.08	5.14	4.28	2.52	6.08	4.20	1.42	3.59	1.45	6.75	5.45	4.66			
C4	+	-	4.84	5.74	5.19	5.67	7.05	7.24	3.08	3.84	2.27	8.19	6.93	6.96			
	+	+	4.23	5.84	5.52	5.94	6.83	7.68	2.54	3.58	2.52	7.54	6.05	6.66			

WP3. N leaching losses

Soil water has been sampled during 2006/07 from the installed suction cups (task 3.1). Figure 1 shows an example of soil water nitrate-N concentrations in faba bean in a selected treatment at the three locations. There was significant effect of catch crops on the nitrate concentrations. The effect was pronounced already in spring 2006, where a catch crop from the prior spring barley was ploughed in.

Contrary to Foulum and Flakkebjerg, all harrowings after harvest of faba bean was carried out in the spring 2007. This probably explains the lack of difference between the catch crop treatments in the autumn/winter period at Jyndevad.

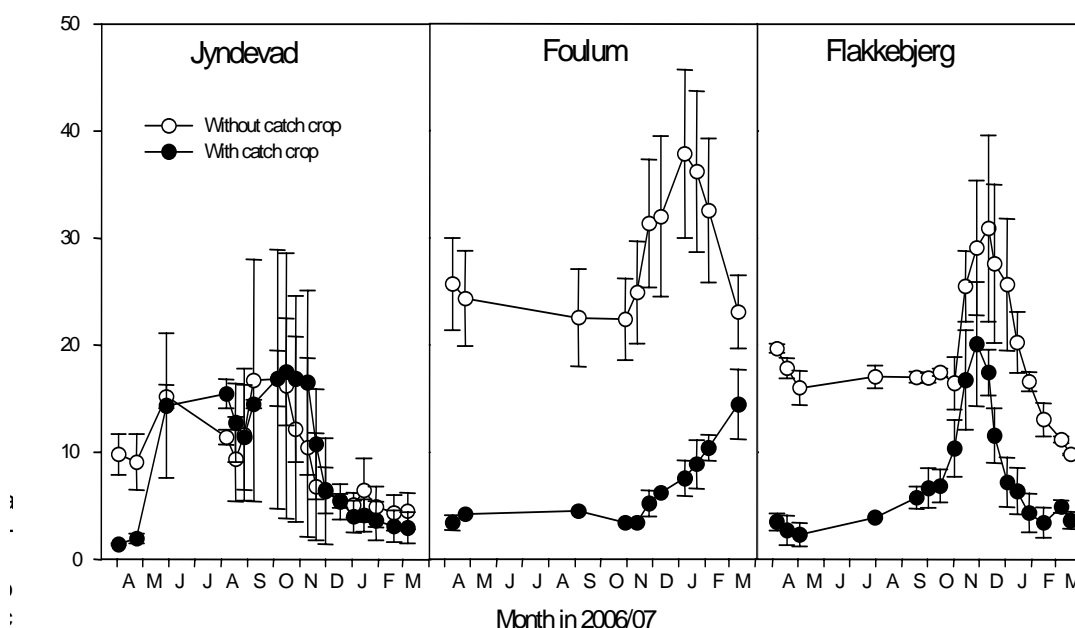


Figure 1. Nitrate-N concentrations in faba bean in crop rotation 4, with fertilizer, and with and without catch crop at the three locations, 2006/07 (n=2).

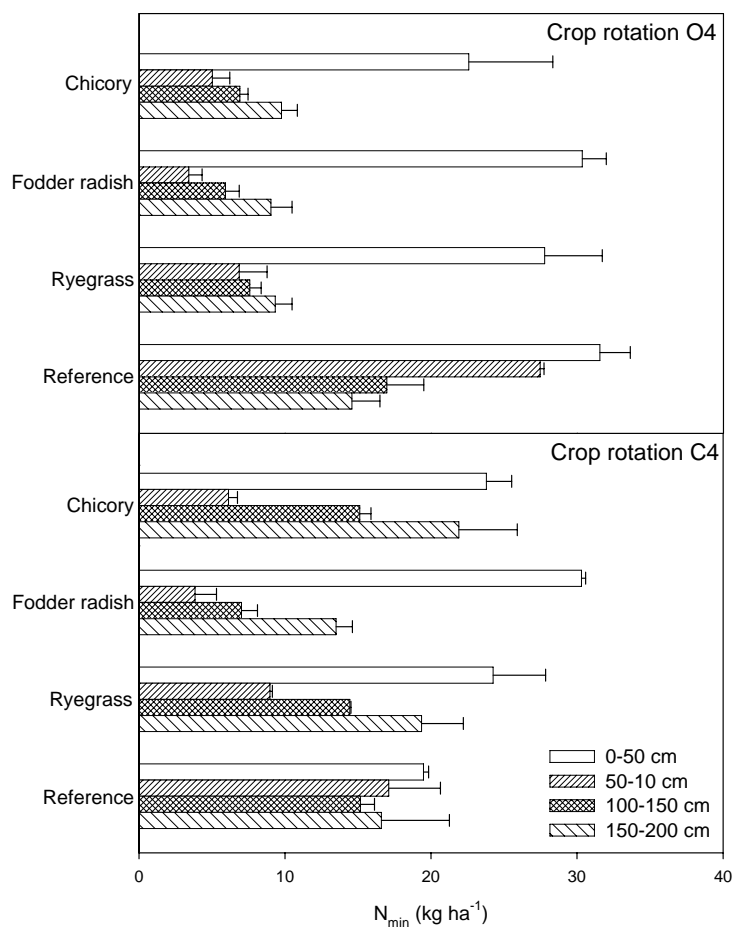


Figure 2. Mineral nitrogen (N_{min}) at different depths measured under different catch crops and a reference without catch crop at Foulum, 2006 ($n=2$).

Figure 2 shows soil mineral nitrogen concentrations measured in early November at Foulum in the investigation of root depths (task 3.3). The data from both Foulum and Flakkebjerg (not shown) shows significant effects on the N_{min} contents at different depths. Furthermore, it appears that the effect of catch crop type on the N_{min} content to a high degree depends on the crop rotation due to different degree of competition from the spring barley nurse crop. The root development was video filmed in installed minirhizotrons, and these data are under analysis.

WP4. Greenhouse gases and denitrification

WP 4.1 includes a nitrous oxide (N_2O) monitoring programme at the field sites in Foulum and Flakkebjerg. Miniplots (2 per block) have been selected in the winter wheat crop of four rotations, i.e., O2(+CC), O4(-CC), O4(+CC) and C4(-CC). Flux measurements will be carried out with static chambers, and gas samples will be taken over an approx. 2-h period and analyzed by gas chromatography.

In 2007 equipment for the monitoring programs has been purchased or constructed. The preceding crop, potatoes, was harvested in September. The monitoring program will run between late September 2007 and August 2008.

In WP 4.2, the potential for N emissions as influenced by crop rotation was considered. Microbial activity was stimulated by exposure of intact soil cores to a freezing-thawing event, and by addition of soil nitrate. Also, samples were incubated at three different water potentials. The experiment was thus set up to study interactions between crop rotation and soil aeration with respect to N losses to the atmosphere.

For the main experiment of this activity, intact soil cores (100 cm³) were collected in late March at Flakkebjerg from each of three miniplots in the winter wheat field of crop rotations O2(+CC), O4(-CC), O4(+CC) and C4(-CC). In the lab, the soil water potential was adjusted to three matric potentials, so that a nitrate solution (labelled with ¹⁵N) could be added to give resulting potentials of -100, -30 and -10 hPa. The samples were exposed to freezing (-10°C for 48 h) and then incubated at 20 °C for 72 h. Gas samples were taken for nitrous oxide analysis, and for total N and ¹⁵N analysis by mass spectrometry in the lab. Soil samples were extracted for analysis of mineral N.

Data analysis has not been completed yet. From a preliminary inspection of the data it is clear that increasing water content stimulated the potential for N losses. At this point it is not possible to say if there was a main effect of crop rotation, or a significant interaction between rotation and soil water.

WP5. Soil quality

Task 5.1 Measurements of selected soil attributes

Soil tilth properties

Field measurements and sampling for laboratory studies took place in early-mid April 2007. All eight crop rotations at the Foulum and Flakkebjerg sites were addressed. At Foulum, the measurement programme includes measurement of air permeability at a water potential of -100 hPa, while at Flakkebjerg it comprises all parameters described in the Technical Annex to the Project Description. The very dry and warm weather in April had dried the soil to a water content considerably below field capacity, which made it difficult to perform the soil drop test at the Flakkebjerg location. Due to this, the test did not reveal significant differences between treatments. The measurement programme in the laboratory is still in progress. Preliminary results from the clay dispersibility test seem also to be influenced by the low water content as no significant trends could be detected. Calibration with the specific contents of clay has not yet been possible but this may modify the trends and statistics.

Dynamics of nitrogen

The dynamics of nitrogen in soil under the four crop rotations O2(+CC), O4(-CC), O4(+CC) and C4(-CC) was investigated during the 2007 cropping season at Jyndevad, Foulum and Flakkebjerg. Since the focus of the project is on the long-term consequences of crop rotation for soil fertility, N inputs from spring manure application was eliminated. The experimental procedure was as follows: Nine metal rings (250 cm³) were inserted between plant rows in 3 miniplots per block in the winter wheat crop in November 2006. Weed was removed by hand in connection with samplings; in the case serious infestations a spare ring was sacrificed. The rings were covered with split plastic tubing during manure application. On the dates 10 April, 14 May, 2 July and 14 August two randomly selected rings per miniplot were taken, mixed and subsampled for analysis of mineral N, biomass N and potentially mineralizable N (anaerobic incubation). In addition, subsamples were shipped to University of Copenhagen for additional characterization of the microbial biomass.

Analyses in the lab are still on-going, but preliminary data inspection indicates that the sampling procedure covered the field plot variability adequately and enables effects of crop rotation to be identified. Two of the assays show, across all three soil types, that crop rotations with catch crops contain higher pools of labile organic N (Figure 3). When all data are available, it will be decided if the procedure for 2008 will be adjusted in order to address other aspects of soil N, for example the importance of plant uptake for pools of labile organic N.

Task 5.2 Soil microbial biomass pool

In WP5.2 microbial biomass and activity is determined together with an estimate of the distribution on fungi and bacteria. All respiration incubations have been performed and data analysed for the first sampling of the year. This sampling revealed a markedly lower microbial biomass in the conventional crop rotation without catch crops (C4-CC). The first analyses of the distribution of activity on fungi and bacteria, analysed by selective inhibition has shown that this distribution is best analysed at nutrient rich conditions. Apparently fungi and bacteria contribute differently to the activity in the four field treatments investigated. During the coming months data work will be accomplished for the incubation treatments and it will be decided if further assays of fungal and bacterial biomass could be performed on the soil samples from 2007 that are preserved in the lab.

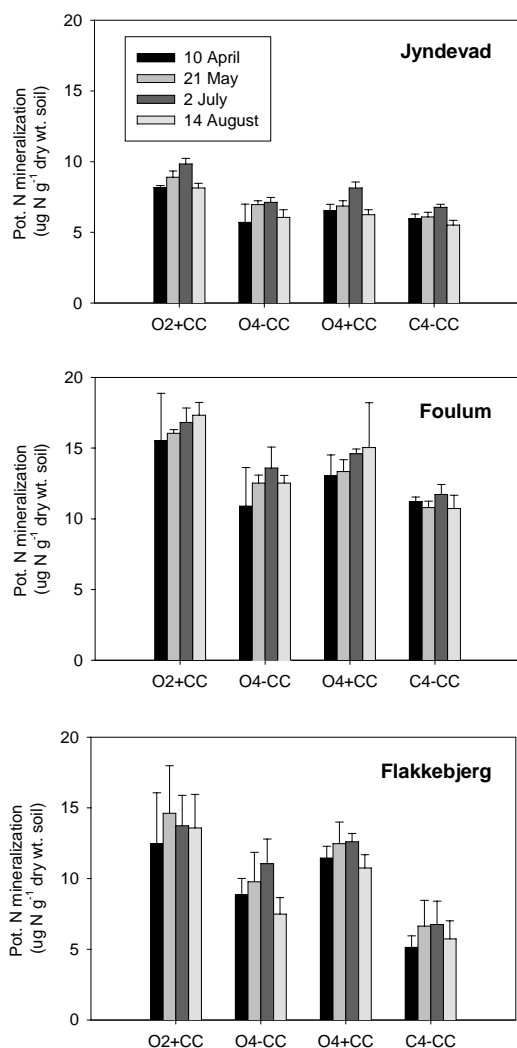


Figure 3. Potential N mineralization in soil from the sampling days indicated was determined by a 7-d anaerobic incubation of soil-water slurries at 40°C.

WP6. Scenario analyses and synthesis

WP6 has not started yet. However, the modelling in WP6 will be supplemented with similar activities in the EU-project NitroEurope, where the data from CROPSYS will be used for validating a range of ecosystem models. Work has been ongoing to deliver data in the right format to the NitroEurope project.

C.2 Fulfilment of deliverables and milestones

Deliverables list (from application)

Deliverable No	Deliverable title	Lead scientist	Delivery date	Allocated scientific person months	Type of deliverable	Fulfilled (ok) or deviations (d)*
D1.1	Annual reports	JEO	200x-09	0.5	R	ok
D1.2	Common protocols for conducting the CRO experiment	JEO	2006-02	1.5	R	ok
D1.3	Field days for farmers and advisors at the field experimental sites	JEO	200x-06	0.5	O	ok
D1.4	Project web-site	JEO	2006-03	0.5	O	ok
D1.5	Papers on general results of the project in agricultural and other Danish journals	JEO	2006:2010	1.0	P	ok
D2.1	Refereed paper on crop yields as affected by crop rotation, nutrient application, catch crops and site	JEO	2009-12	6.0	S	
D2.2	Refereed paper on weed propagation in different organic cropping systems	IAR	2009-12	6.0	S	
D2.3	Refereed paper on the yield – weed – nitrogen dynamics in different organic cropping systems	MAS	2009-12	6.0	S	
D2.4	Papers for farmer journals on crop production in organic farming systems	IAR	2009-06	1.0	P	
D3.1	Refereed paper on nitrate leaching as affected by crop rotation, nutrient application, catch crops and site	MAS	2009-10	5.0	S	
D3.2	Refereed paper on N flows and losses in legume based cropping systems	MAS	2009-12	5.0	S	
D3.3	Papers for farmer journals on N leaching from organic and conventional cropping systems	MAS	2009-12	1.0	S	
D4.1	Refereed paper on N ₂ O monitoring program	PAM	2009-12	5.0	S	
D4.2	Refereed paper on laboratory study of N ₂ O and denitrification	SOP	2008-12	5.0	S	
D4.3	Paper for farmers and advisors on soil C/N pools as influenced by crop rotation and management	SOP	2009-12	1.0	P	
D5.1	Refereed paper on the effect of cropping systems on soil quality attributes	PSC	2009-08	10.0	S	
D5.2	Refereed paper on the structure and function of organism groups responsible for N-mineralization	SCH	2009-10	8.1	S	
D5.3	Paper for farmers on effect of cropping systems on soil quality	PSC	2009-11	1.0	P	
D6.1	Refereed paper on validation and scenario analysis with the FASSET model	JBE	2009-12	5.0	S	
D6.2	Refereed paper on the LCA of organic and conventional crop farms	NHA	2009-12	5.0	S	
D6.3	Refereed paper on the link between soil functioning and indicators	JEO	2010-03	5.0	S	
D6.4	Refereed paper on management effects on sustainability indicators	JEO	2010-07	6.0	S	
D6.5	Papers for Danish journals on improved guidelines for organic crop production systems in Denmark	JEO	2010-05	1.0	P	

* *Deviations are to be further discussed in D*

Milestones list (from application)

Milestone No	Milestone title	Delivery date	Fulfilled (ok) or deviations (d)*
M1.1	Revised database for CRO experiment	Apr 2006	ok
M1.2	Database updated with results of previous years experimental data	Jan 200x	ok
M1.3	Meeting with all involved scientists and technicians and invited stakeholders	Jan 200x	ok
M1.4	Meeting at the CRO experiments with involved scientists and technicians	Jun 200x	ok
M2.1	All crop production results in the database	Jan 2009	
M2.2	The natural abundance ¹⁵ N analyses finished	Jan 2009	
M2.3	Soil analyses stored in the database	Jun 2009	
M3.1	The deep root investigation finished	Dec 2008	
M3.2	All nitrate concentrations in the database	Jun 2008	
M3.3	DON concentrations in the database	Jul 2009	
M4.1	Preparation of new chamber units completed	Jun 2007	ok
M4.2	Nitrous oxide monitoring program completed	Aug 2008	
M4.3	Laboratory study completed	Dec 2007	
M4.4	Analyses of soil C and N completed	Mar 2009	
M5.1	Data on soil quality attributes stored in database	Feb 2009	
M5.2	Data on microbial biomass pools stored in database	Feb 2009	
M6.1	Link between CRO experiment database and FASSET model updated	Jan 2009	
M6.2	Typical organic and conventional crop rotations defined	Jun 2009	
M6.3	Statistical analyses completed	Oct 2009	
M6.4	Project workshop to discuss management effects on sustainable development	Nov 2009	

* *Deviations are to be further discussed in D*

(The nature of the deliverables must be indicated by S = publication in scientific journal with peer review; P = publication in journals without peer review; R = reports; C = presentation at meetings and congresses or O = other types of deliverables, e.g., prototypes, models, websites, etc.).

D. Description of deviations and subsequent adjustments of plans

WP2. Production of cropping systems

It was originally planned to measure N₂ fixation at Foulum and Flakkebjerg by means of the ¹⁵N natural abundance method, and at Jyndevad by means of an empirical model (in the DARCOFII project 'Genesis' we found that the ¹⁵N natural abundance of the soil at Jyndevad was too weak for determination of the N₂-fixation). Due to uncertainty about the suitability of the ¹⁵N natural abundance method at Flakkebjerg, it was decided instead to use the empirical model at all locations, and in addition to this also measure the N₂ fixation at all locations by means of the difference method of *Munroe and Davies* (1974) where N₂ fixation = N in legume – N in a reference non-legume. This implied the establishment of reference mini-plots with non-N₂ fixing crops in all plots with N₂ fixation. The advantage of the revised plan is that the same methods are used at all locations.

Munroe, J.M.M., Davies, D.A. (1974): Potential pasture production in the uplands of Wales. 5. The nitrogen contribution of white clover. *J. British Grassland Soc.* 29, 213-223.

WP4. Greenhouse gases and denitrification

Due to technical problems it was not possible to determine soil diffusivity on the samples used in WP4.2. Separate analyses of bulk soil samples showed that soil nitrate pools were very low at the time of sampling, and it was therefore decided to add this substrate of denitrification, the main source of N₂O and N₂. This enabled us to introduce ¹⁵N-labelled nitrate and thus quantify total denitrification without the use of acetylene, the efficiency of which may vary with the soil water content delaying gas transport to the sites of denitrification.

WP5. Soil quality

Within Task 5.1 (Measurement of selected soil attributes), we have changed the measurement programmes slightly compared to the plans listed in the technical Annex to the Project Description. Regarding the soil till characteristics, we decided to give high priority to the Flakkebjerg site due to the interesting results found in a previous study (*Schjønning et al., 2007*). The measurements at Flakkebjerg therefore have included all eight crop rotations rather than just the four highlighted in the Project Description. We stick to the original plans in terms of including the Foulum site with a screening of soil pore characteristics (the air permeability measurement). However, in order to allow the extended measurements at the Flakkebjerg site, we have excluded the planned measurements of the soil water characteristics (the water retention curve) at Foulum.

We have also modified the measurements to characterize the nitrogen dynamics. We decided to estimate the potentially mineralizable pool of N by an anaerobic incubation rather than the actual mineralization in the collected soil cores.

When all data from the 2007 samplings are available, it will be decided if the procedure for 2008 will be adjusted in order to address other aspects of soil N, for example the importance of plant uptake for pools of labile organic N.

E. Project publications and other products

1. Products from Organic Eprints archive

Holst, N., Rasmussen, I.A. & Bastiaans, L. (2007): Field weed population dynamics: a review of model approaches and applications. *Weed Research* 47 (1), 1-14. (**)

Olesen, J.E. & Dalgaard, T. (2006). Kan økologisk jordbrug være med til at løse verdens klimaproblemer? *Global Økologi* 13(3), 14-15.

- Olesen, J.E. (2006). Pres på bæredygtigheden. Økologisk Jordbrug 16 (362), 6.
- Rasmussen, I.A. (2006). Rodukrudt i sædskifteforsøg. Økologisk Jordbrug 364, 6.
- Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (2006). Sædskifteforsøg skal give nye svar. Økologisk Jordbrug 359, 9.
- Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (2006). Sædskifteforsøg skifter retning. Økologisk Jordbrug 359, 8-9.
- Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (2007): Perennial weed control and nitrogen leaching in long-term organic crop rotation experiments for cereal production. In: Melander, B., Cloutier, D. & Gerowitt, B. (eds.): Proceedings 7th EWRS workshop on Physical and Cultural Weed Control, 11-14 March 2007, Salem, Germany, p. 133.
- Rasmussen, I.A., Bastiaans, L., Holst, N., Grundy, A. & Melander, B. (2007): Report from an EWRS workshop on modelling weed population dynamics. In: Melander, B., Cloutier, D. & Gerowitt, B. (eds.): Proceedings 7th EWRS workshop on Physical and Cultural Weed Control, 11-14 March 2007, Salem, Germany, p. 174. (*)
- Rasmussen, I.A., Bastiaans, L., Holst, N., Grundy, A. & Melander, B. (2007): 'All models are wrong – but some are useful' - a report from an EWRS workshop on modelling weed population dynamics. In: Barberi, P. et al. (eds.): 14th EWRS Symposium, 17-21 June 2007, Hamar, Norway, p. 116. (**)
- Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (2007): Perennial weeds in organic arable farming – challenges & dilemmas. In: Lund, M. et al. (eds.): NJF 23rd Congress 2007: Trends and Perspectives in Agriculture, 26-29 June 2007, Copenhagen, Denmark. NJF Report 3(2), 316-317.

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

The presentations and summaries of the discussion from the seminar on "Produktion og miljøbelastning i økologisk jordbrug" are available at www.okoforsk.dk.

Records of field activities from the three field sites are available at www.okolog.dk. This provides a very good channel for communicating practical information on crop management in organic farming. However, since resources for this have been very limited, almost all entries here are from the Jyndevad site.

Several demonstrations have been given to farmers/advisors and other visiting groups at all three field trial locations.

* 25-75% financed by DARCOF

** 5-25% financed by DARCOF

F. Scientific education

A PhD study has been initiated within CROPSYS, and the PhD student Ngonidzashe Chirinda started in June 2007. The PhD study is jointly funded by CROPSYS, SOAR and KU-LIFE. The primary supervisor is John Porter from KU-LIFE and the project supervisor is Jørgen E. Olesen. The topic of the PhD study is "Influence of cropping systems on greenhouse gas emissions". This study is linked to WP4, WP5 and WP6, and will as thus include both experimental and modelling aspects.

In connection with WP4.1, SOP has provided written procedures and practical instructions of Ph.D. student Ngonidzashe Chirinda with respect to mineral N, potential denitrifying enzyme assay, potential ammonium oxidation assay, biomass N analysis, respiration measurements and nitrous oxide analyses. Field variability has been examined for assessment of soil sampling procedure.

G. National and international cooperation

The CRO experiment is part of the ISOFAR Long Term Experiment network.

P1 is member of the management committee in COST action 729 on "Assessing and managing nitrogen fluxes in the atmosphere-biosphere system in Europe". The methodology and methods of measuring nitrogen fluxes in the CRO experiment will be discussed at COST729 meetings.

P4 is member of the management committee of COST action 856 on "Denitrification in agriculture, air and water pollution".

P1 and P4 participate in an integrated project called "The nitrogen cycle and its influence on the European greenhouse gas balance (NitroEurope)" under the EU FP6. The CRO experiment is part of a network of long-term experiments in this proposal, and it is used for measuring management and environmental effects on nitrogen fluxes. This will in particular supplement the measurements of nitrous oxide emissions performed in the CROPSYS project. Data from the CRO experiment will also be used for testing and improving ecosystem models within the NitroEurope project.

Data from the CROPSYS project will be used by the DARCOF-III BioConcens project for testing models for analysing production and environmental effects of bioenergy production.

The CROPSYS project will deliver crop products to the DARCOF-III ORGTRACE project for use in a study on the effect of production systems on quality and health aspects. For some of the crops this will mean that virtually all crop produce will be delivered to ORGTRACE.

Samples of wheat grain will be used for analysis of baking quality in the CORE-ORGANIC project AGTEC_Org (Agronomical and technological methods to improve organic wheat quality).

An experiment on effects of manure placement for organic potatoes has been conducted over the period 2006 to 2008 in the CRO experiment at Jyndevad and Foulum with support from "Fonden for Økologisk Jordbrug".

In the DFFE project CoolCrop additional measurements will be taken in the grass-clover fields to quantify the effects of use of the grass-clover for bioenergy purposes for production and N-cycling.

A study on the yield reducing effect of perennial weeds as affected by crop rotation has been conducted in the CRO experiment with support from "Fonden for Økologisk Jordbrug".

We have delivered soil samples and associated data to a project on soil carbon balance carried out at the Justus-Liebig University in Giessen, Germany.

We have initiated a cooperation with a newly established international research project 'Soil-it-is' (www.agrsci.dk/soil-it-is/) by delivering samples from the CROPSYS Flakkebjerg location to studies on basic aspects of colloid mobilization.

H. Critical reflection on the project

One of the primary discussion issues in the project group has been dilemma between ensuring proper soil and crop management, and the need to ensure conditions for the measurements in both CROPSYS and the associated projects that allow effects of the farming systems to be measured and compared in equal terms and with statistical confidence. Examples are restrictions in possibilities of changing varieties or re-sowing failed crops, because of need to deliver crop products to other projects, and a decision not to lime the experiments, because this would influence the measurements of soil carbon. These discussions have in most cases ended up in favouring the needs of the measurements and delivery of products for other studies. However, we have tried to do this with as little consequence for proper crop management as possible. This has led to a more complex management of the crop rotation experiments than we anticipated and therefore a higher workload, especially for the technicians involved with the experiments at the three locations.

The higher workload on the technicians because of more complex management has unfortunately meant that the time available for communication of the crop management through the okolog web-site has had considerably less priority. However, we will seek additional funding for this activity in the near future. We believe that this priority is the right one, since a high quality of the experiment and the associated project is necessary for ensuring useful scientific results.

None of the changes in work plan give rise to any concerns with the respect to the quality and rele-

vance of the results obtained.

8. Budget

A. Account for any change in budgets

B. Budget for the whole project (1.000 DKK)

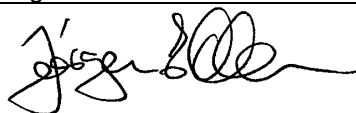
Total consumption of funds from DARCOF and expected consumption this year and coming years

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	96.6	9.7	23	23.5	37	8.1	101.3
Technical personnel	83.6	13.5	29.9	27.8	5.3	0.5	77.1

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	4769	442	915	1156	1977	452	4942
Technical personnel	2587	386	948	948	174	15	2471
Other operational costs	2390	756	787	792	55	0	2390
Equipment	115	14	106	0	0	0	120
Others (travel+cons.)	1799	314	612	566	190	56	1738
Direct costs	11660	1911	3368	3462	2396	523	11660
Indirect costs (20% of direct costs)	2333	382	674	693	479	106	2334
Total	13993	2294	4043	4154	2876	628	13993

Comments:

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project Jørgen E. Olesen	University of Aarhus Faculty of Agric. Sci. Institute of	27/9 2007	

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

University of Aarhus, Faculty of Agricultural Sciences, Inst. of Agroecology and Environment

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	46.0	8.2	14.5	15.5	28.5	5.0	71.7
Technical personnel	70.0	5.2	18.9	16.3	4.5	0.5	45.5

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	3508	371	559	807	1533	291	3560
Technical personnel	1422	143	605	517	146	15	1426
Other operational costs	2390	756	787	792	55	0	2390
Equipment	115	14	106	0	0	0	120
Others (travel+cons.)	1237	178	441	378	139	40	1176
Direct costs	8672	1461	2498	2493	1873	346	8672
Indirect costs (20% of direct costs)	1735	292	500	499	375	69	1735
Total	10407	1754	2998	2992	2248	416	10407

Comments:

A. Budget for each participating institute (1.000 DKr)

University of Aarhus, Faculty of Agricultural Sciences, Inst. of Integrated Pest Management

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	8.0	1.5	1.0	1.5	3.0	1.0	8.0
Technical personnel	26.6	8.3	8.5	9.0	0.8	0.0	26.6

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	407	71	49	76	159	52	407
Technical personnel	817	243	259	286	28	0	816
Other operational costs	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	444	136	138	135	25	10	444
Direct costs	1667	450	446	498	212	62	1668
Indirect costs (20% of direct costs)	334	90	89	100	42	12	333
Total	2001	540	536	597	254	74	2001

Comments:

A. Budget for each participating institute (1.000 DKr)

University of Aarhus, Faculty of Agricultural Sciences, Inst. of Genetics

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	5.0	0	0	0	4.0	1.0	5.0
Technical personnel	0.0	0	0	0	0.0	0.0	0.0

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	274	0	0	0	217	57	274
Technical personnel	0	0	0	0	0	0	0
Other operational costs	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	3	0	0	0	2	1	3
Direct costs	277	0	0	0	219	58	277
Indirect costs (20% of direct costs)	55	0	0	0	44	12	55
Total	332	0	0	0	263	69	332

Comments:

A. Budget for each participating institute (1.000 DKr)

Risø National Laboratory, Technical University of Denmark. Biosystems Department

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	10	0	4.5	4.5	0.5	0.5	10
Technical personnel	3	0	1.5	1.5	0	0	3

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	437	0	187	193	28	28	437
Technical personnel	109	0	54	55	0	0	109
Other operational costs	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	38	0	13	18	7	0	38
Direct costs	583	0	254	266	35	28	583
Indirect costs (20% of direct costs)	117	0	51	53	7	6	117
Total	700	0	305	319	42	34	700

Comments:

A. Budget for each participating institute (1.000 Dkr)

University of Copenhagen, Biological Institute

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	3.6	0	3.0	2.0	1.0	0.6	6.6
Technical personnel	8.0	0	1.0	1.0	0.0	0.0	2.0

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	144	0	120	80	40	24	264
Technical personnel	240	0	30	90	0	0	120
Other operational costs	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	77	0	20	35	17	5	77
Direct costs	461	0	170	205	57	29	461
Indirect costs (20% of direct costs)	92	0	34	41	11	7	93
Total	554	0	204	246	69	35	554

Comments:

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

University of Aarhus, Faculty of Agricultural Sciences, Inst. of Agroecology and Environment

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	12.0	0	4.0	4.0	4.0	0	12.0
Technical personnel	1.2	0	0.0	0.0	0.0	0	1.2

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	406	0	130	135	141	0	406
Technical personnel	32	0	10	10	11	0	32
Other operational costs	2221	1176	736	754	24	0	2689
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	25	0	8	8	9	0	25
Direct costs	2684	1176	884	908	184	0	3152
Indirect costs (20% of direct costs)	537	447	177	182	37	0	3994
Total	3220	1623	1061	1090	221	0	3994

Comments:

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

University of Aarhus, Faculty of Agricultural Sciences, Inst. of Integrated Pest Management

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	0	0	0	0	0	0	0
Technical personnel	13.7	5.2	4.5	4.0	0	0	13.7

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	417	152	137	127	0	0	417
Technical personnel	0	0	0	0	0	0	0
Other operational costs	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	0	0	0	0	0	0	0
Direct costs	417	152	137	127	0	0	417
Indirect costs (20% of direct costs)	84	31	28	26	0	0	84
Total	500	183	165	153	0	0	500

Comments:

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

University of Aarhus, Faculty of Agricultural Sciences, Inst. of Genetics

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	0	0	0	0	0	0	0
Technical personnel	0	0	0	0	0	0	0

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	0	0	0	0	0	0	0
Technical personnel	0	0	0	0	0	0	0
Other operational costs	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	0	0	0	0	0	0	0
Direct costs	0	0	0	0	0	0	0
Indirect costs (20% of direct costs)	82	0	0	0	65	17	82
Total	82	0	0	0	65	17	82

Comments:

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

Risø National Laboratory, Technical University of Denmark. Biosystems Department

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	0	0	0	0	0	0	0
Technical personnel	0	0	0	0	0	0	0

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	0	0	0	0	0	0	0
Technical personnel	0	0	0	0	0	0	0
Other operational costs	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	0	0	0	0	0	0	0
Direct costs	0	0	0	0	0	0	0
Indirect costs (20% of direct costs)	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Comments:

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

University of Copenhagen, Biological Institute

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Man-months							
Scientific personnel	1.0	0.2	0.2	0.2	0.2	0.2	1.0
Technical personnel	0	0	0	0	0	0	0

Year:	Original budget	Consumption 2005/2006	Expected consumption 2007	2008	2009	2010	Total
Salaries							
Scientific personnel	55	11	11	11	11	11	55
Technical personnel	0	0	0	0	0	0	0
Other operational costs	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (travel+cons.)	0	0	0	0	0	0	0
Direct costs	55	11	11	11	11	11	55
Indirect costs (20% of direct costs)	11	2	2	2	2	2	11
Total	66	13	13	13	13	13	66

Comments: