Danish Research Centre
for Organic Farming

Midterm Status Report 2002 and Application for Continuation in 2003

For research projects financed by grants from
The Directorate for Food, Fisheries and Agro Business
under the Danish Ministry of Food, Agriculture and Fisheries

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1. Research program

Research in organic farming 2000-2005 (DARCOF II)

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2. Project title and number

Interactions between nitrogen dynamics, crop production and biodiversity in organic crop rotations analysed by dynamic simulation models – Project Number I,3.
Acronym: BIOMOD

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6. Project period (month, year)

Start of project:	August 2000
End of project:	December 2003

7. Midterm description of the project, its results and progress, and application for continuation in 2003

A. Project summary

The challenge in organic farming is to optimise short-term productivity while maintaining long-term soil fertility, increasing recycling of nutrients and resources, reducing nutrient losses to the surrounding environment and increasing natural control of pests and diseases. The organic farming system is very complex, with multiple interactions and hence holistic research is essential, but often very difficult. One way to analyse the behaviour of whole systems is to integrate the process-based knowledge and analytical studies of system components in mechanistic and dynamic simulation models. Such models may also be powerful tools in generalising results of both short and long-term experiments. This may enable predictions about other treatments, but only if the models are general, reliable and validated against experimental data for whole organic crop rotations. Furthermore, valid and extensive models may be used not only to analyse consequences for the organic farm production, but also for environmental impact and biodiversity.

Three simulation models have been used in different DARCOF-I projects, namely DAISY, FASSET and the Food Web Model. Although different in approach and degree of detail, they supplement each other on several important aspects (scope, processes, balances, environmental impact and nature content). The models have shown a general capability for simulating important aspects of organic farming systems, but areas where they are not capable of simulating organic crop rotations adequately have also been identified: i) competition between undersown crops and main crops, ii) root development of main and catch crops and iii) nitrogen turn-over in grazed grass/clover pastures both before and after incorporation.

Therefore, this project has been designed with three major aims:
i) Expand and calibrate the models on areas where they do not have sufficient skills.
ii) Validation of the improved and calibrated models on independent experimental data.
iii) Scenario analyses for different crop rotations (dairy, arable and vegetable).

The idea behind the project is to use simulation models to make predictions on different organic farming systems that can help the development of recommendations for organic farmers. This will assist in design of crop rotations, i.e. choice of main crop, catch crops or green manure, animal manure application, management of grass/clover pastures and grazing intensity, and help the evaluation of environmental effects as nitrate leaching, biodiversity and trends in organic matter content. It is thus expected that the models in the future will help both to improve organic farming, protect the environment and to support the national administration and political system. The models will also be of great value in future organic farming research as they can be used for initial testing of new hypotheses, or to generate new hypotheses, thereby contributing to the goal orientation and proper focussing of experimental and empirical research.

All three models mentioned above have been included in the project, due to their differences in focus and strengths and to enable a model comparison, where the required degree of model detail can be evaluated. This will optimise the quality and range of the simulation output. The project will draw extensively on data sets from both completed and ongoing DARCOF projects, but within the project an additional comprehensive data set from two dairy farms on different soil types with special focus on grazed clover/grass pastures will be generated for independent validation.

DAISY

DAISY (Hansen *et al.*, 1991) is a deterministic and mechanistic model that simulates the water and energy flows, the plant growth, and the C and N fluxes in the soil-plant-atmosphere system. It consists of sub-models for soil water (based on Richards equation), solute movement (based on advection-dispersion), soil temperature, soil organic matter (incl. microbial biomass, SMB), soil mineral N, crop growth and system management. The nitrogen transformations simulated by DAISY are mineralisation–immobilisation turnover, nitrification and denitrification.

The model was originally developed to predict N-leaching and crop production in temperate, intensive cropping systems. Consequently, DAISY was originally calibrated on systems with high input of mineral fertiliser, liquid manure or farmyard manure. The DAISY model has been extensively validated for various conditions of conventional agriculture (Hansen *et al.*, 1991, Jensen *et al.*, 1994a; Petersen *et al.*, 1995; Svendsen *et al.*, 1995). Recently, the DAISY model has been tested and validated on detailed and comprehensive field data sets on soil C and N turnover at both the short (Mueller *et al.*, 1997, 1998) and long term (Jensen *et al.*, 1997). Also recently, the uncertainty in simulated N leaching due to spatial variability and uncertainty in input data has been thoroughly evaluated (Djurhuus *et al.*, 1999; Hansen *et al.*, 1999), and the present, reprogrammed version builds on the open-source software architecture (Abrahamsen & Hansen, in press).

DAISY has been used as a management tool at field scale (Jensen *et al.*, 1994b), in studies at catchment (Styczen & Storm, 1993; Thirup, 1999) or regional scale (Refsgaard *et al.*, 1998; 1999), the latter with integration to hydrological models at the catchment and river scale, enabling the evaluation of contamination effects on both groundwater and aquatic environments.

The model has only recently been applied to low-input, organic farming conditions. In the first DARCOF programme the model was used to simulate crop production and N dynamics in both an intensive vegetable crop rotation with a high proportion of catch crops and green manures and a organic cropping sequence quantifying the residual N effect of a grass-clover ley (variably grazed) on subsequent crop production and N leaching (Jensen *et al.*, 1999). This has revealed that DAISY may adequately describe N dynamics in the vegetable/catch-crop/green-manure system with some recalibration and adjustment. However, the N dynamics and N leaching after incorporation of grazed grass-clover leys could not be appropriately simulated when realistic values for nitrogen content in the pasture was used. Hence there is a need for further development in both of these areas.

FASSET

FASSET (Jacobsen *et al.*, 1998a,b) is a whole farm model, capable of simulating major processes at the farm level, including processes and interactions of soil, crop, livestock and machinery and their effects on productivity, nutrient cycling, nitrogen losses and farm profitability. FASSET differs from other farm simulation models by dynamically simulating all these processes.

FASSET is a deterministic, dynamic simulation model with a daily time step (Olesen *et al.*, 1996), sharing general principles regarding soil/crop interactions with models as DAISY

(Hansen *et al.*, 1991) and SOIL/SOIL-N (Johnsson *et al.*, 1987). Compared to DAISY, crop growth and soil water movements are simulated using simpler routines. The emphasis is on flows of nitrogen and carbon throughout the farm system, including turnover of soil organic matter, plant uptake, denitrification, nitrate leaching, animal intake and total ammonia loss. The soil organic matter (SOM) turnover is presently simulated with a model structure identical to DAISY. Pig and dairy production are simulated according to feeding plans. Intake of grazing cattle is determined by the daily production on the field, and the model allows effects of grazing cattle on pastures to be simulated. Any number of fields can be simulated, and crops facilitated include winter wheat, spring wheat, winter barley, spring barley, fodder beets, winter rape, peas, grass and clover. The models also facilitates simulation of competition and coexistence between plant species, which makes it possible to simulate crops like grass/clover leys, barley/pea mixture, and undersown crops.

Work in the DARCOF project I.7 in 1998-99 has focused on adapting the FASSET model to simulate crop growth under organic farming conditions. This has involved adapting and testing the nitrogen response in the model also to crop production under low input conditions (Olesen *et al.*,2002a, b), and the FASSET wheat module has been compared with SIRIUS and AFRCWHEAT (Jamieson *et al.*, 2000). A general model for competition between plant species has been implemented based on the approach by Olesen *et al.* (1997), including a simple approach for competition for soil water and nitrogen, and this has been tested for a pea/barley mixture in an organic farming systems experiment (Berntsen & Olesen, in prep), but has presently not undergone a broader validation. The model has also been extended with the capabilities to simulate urine and dung patches on grazed grass/clover fields based on the principles outlined by Hutchings & Kristensen (1995). The soil/crop model is currently being validated against observed crop production and nitrogen losses from an experimental organic dairy farm crop rotation (Berntsen *et al.*, in press).

The food web model

The food web model was developed within the two DARCOF projects I.7 “Interactions between soil fauna, nitrogen dynamics and plant growth – research and simulation models” and IV.3 “Qualitative and quantitative relationships between soil preparation procedures, microflora, fauna and the timing of nitrogen release in organic farming”. The former project ended in 1999, and the latter runs throughout 2000. In the latter project the model development was coupled with a very intensive sampling programme that included soil physics, microflora, microfauna, mesofauna, epigeic insect predators, nitrogen dynamics, plant growth and yield.

The food web model has been constructed to simulate the interactions between soil tillage, soil structure, micro-flora, soil fauna, nitrogen mineralisation and crop yield, and it consists of three modules: a food web, a crop module and a soil module. The food web model is a multitrophic, stage structured, physiological driven population dynamic model that is driven by the different organisms’ temperature dependent food demand (Gutierrez *et al.*, 1984; Gutierrez, 1992; Gutierrez *et al.*, 1994; Holst *et al.*, 1997). The trophic interactions determine how much supply the organism can acquire, and the population growth is controlled by the supply/demand ratio. The model works at the finest possible taxonomic level, i.e. species level for epigeic predators, earthworms and Collembola. For other organisms the level will be genus, family or functional groups. The food web module treats all interactions as predator – prey interactions, i.e. bacteria, fungi and earthworms are “predators” eating organic matter, Collembola are “predators” eating bacteria etc. This approach also means that organic matter is regarded a “population” that is stage structured. the organic matter can be diminished due to predatory activities, i.e. the “predation” by bacteria and fungi, which makes the degradation of organic matter, and in turn the release of nitrogen, dependent on microbial activity. The differences between stages of organic matter will mainly be their suitability as food for the "predators". Thus, the degradation of organic matter is made dependent on the biological activity.

All three models are implemented using the object oriented programming language C++ that facilitates exchange of programme modules.

In 2001 the project was given extra volume by including the project NITMOD as three new work packages (WP 6 – WP8) and integrating a part of NITMOD with BIOMOD WP3. Therefore, the objectives of NITMOD are mentioned here. The aim of NITMOD is to develop a strongly improved model to describe the degradation of organic matter in the soil, and to develop a simple and robust model for the transportation of water and matter. The objectives can be summarised in four points:

1. to speed up the development of an improved model of the turnover of C and N in the soil, and provide a broader data foundation for the development and calibration of this model.
2. to parameterise the modules describing the decay of dead roots through the available and relevant data from the continuous release of C and N from the roots of different crops.
3. to develop, calibrate and validate a simple, empirical model for the transport of solutes, mainly through literature data on the leaching of conservative tracers.
4. to improve the data foundation for the calibration and validation of the model for turnover of C and N in BIOMOD by supplementary measurements in organic crop rotations.

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

Table 1: Work package list

Work-package No.	Work package title	Responsible participant	Budget	Start	End	Deliverable No
1	Adaptation of a model for competition between undersown crops and main crops	JB	940,256	2000/04	2003/06	D1-D4
2	Improvement of root growth model	KTK	898,182	2000/10	2003/06	D5-D7
3	Parameterisation of the soil organic matter turnover sub-modules of DAISY and FASSET	BMP	677,320	2000/10	2002/12	D8-D11
4	Crop production, nitrogen balance, nitrate leaching and biodiversity in crop rotations on private farms	JEO	2,372,420	2000/04	2003/10	D12-D13
5	Whole model calibration, validation inter-comparison and scenario analyses	JAA	3,019,830	2000/10	2003/12	D14-D17
6	Parameterisation of the release from the roots	JB	220,951	2001/03	2002/06	D18-19
7	Validation and further development of a solute transport model	JB	227,361	2001/06	2002/12	D20-22
8	Measurements in field experiments	JEO	357,660	2001/03	2002/03	D23-24

B. Objectives and expected achievements

The idea behind the project is to apply dynamic simulation models to organic crop rotations. Before models can be applied to such complex systems as organic crop rotations, they have to be thoroughly validated against experimental data. Such a validation has to ensure that the models are reliable and trustworthy.

The project has three aims:

1. Expand and calibrate models on areas they do not currently have sufficient skill (WP1 to WP3)
2. Validation of the improved and calibrated models on independent experimental data (WP4 and WP5)
3. Scenario analyses of range of management options on different farm types (WP5.2).

The models will be extended in three areas that present models do not handle properly. These three areas, of great importance in organic crop rotations, are undersown crops, root growth and turnover of organic matter. Present experimental data on the two first areas are not of a sufficiently high quality to be used for a calibration, and the current project will thus initiate experiments to collect this kind of data. The obtained data sets will be used not only for model calibration but also as a supplement to other experimental research in organic farming. Existing high quality data on turnover of organic matter will be used to improve the organic matter module in the models.

Validation of the improved models will be performed on independent data to ensure that the models are general and able to make prediction outside their calibration range. Existing data sets from previous and ongoing DARCOF projects will be used for this. These data do, however, not sufficiently cover the dynamics of grazed grass/clover pastures, which are essential for many organic farming systems. An independent data set will be obtained from two dairy farms on different soil types and focus on grazed clover/grass pasture in WP4.

Scenarios of selected features on three important organic farming systems (vegetables, arable, and dairy farms) will then be performed using the revised models. These scenarios will highlight effects of soil type and crop management, including catch crops, proportion of grass/clover pastures in the rotation, and manure application on selected parameters, i.e. nitrate leaching, crop yields, biodiversity and soil organic matter content. Both short-term and long-term trends will be evaluated.

The main achievement will be model predictions on different organic farming systems, predictions that can help the development of recommendations for organic farmers. This will assist in design of crop rotations, i.e. choice of main crop, catch crops or green manure, animal manure application, management of grass/clover pastures and grazing intensity. Another potential use will be evaluation of environmental effects as nitrate leaching, biodiversity and trends in organic matter contents. It is thus expected that the models in the future will help both to improve organic farming and to support the national administration and political system in evaluating the effects of organic farming on several indicators, including productivity, biodiversity and nitrogen losses to the environment. Last but not least, the models will also be of great value in future organic farming research as they can be used for initial testing of new hypotheses, or help the generation of new hypotheses, thereby contributing to the goal orientation and proper focussing of experimental and empirical research.

C. Midterm results and progress

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

WP1. Adaptation of a model for competition between undersown crops and main crops.

An experiment on the growth of undersown crops has been conducted in an organic crop rotation at Foulum during 2001 and 2002. Detailed growth analyses have been done for two different main crops (spring barley and oat) and three different undersown crops (ryegrass, white clover and chicory). Measurements have been done eight times during the growing season, and 3 times after harvest of the main crop. On each date measurements of soil water, plant dry matter, green/yellow leaf area index, nitrogen uptake, reflectance (RVI) and photosynthetic active radiation (PAR) within the canopy were made. Data from 2001 and partly from 2002 have been incorporated into a database (deliverable D1).

The experiment has clearly demonstrated the importance of soil fertility, main crop and sowing time (figure 1). In 2001, the soil was highly fertile due to previous clover-grass catch crop while soil fertility was low in 2002. This resulted in very different growth patterns in these two years, where the competition from the main crops was very high in 2001, while in 2002 the catch crop was better established due to smaller competition from the main crop. In 2002 the experiment also demonstrated that oat, due to a longer growing season, compete more strongly against the undersown crop that barley. During both years, the time of sowing was of great importance, as early sown catch crops had the highest growth rates after harvest.

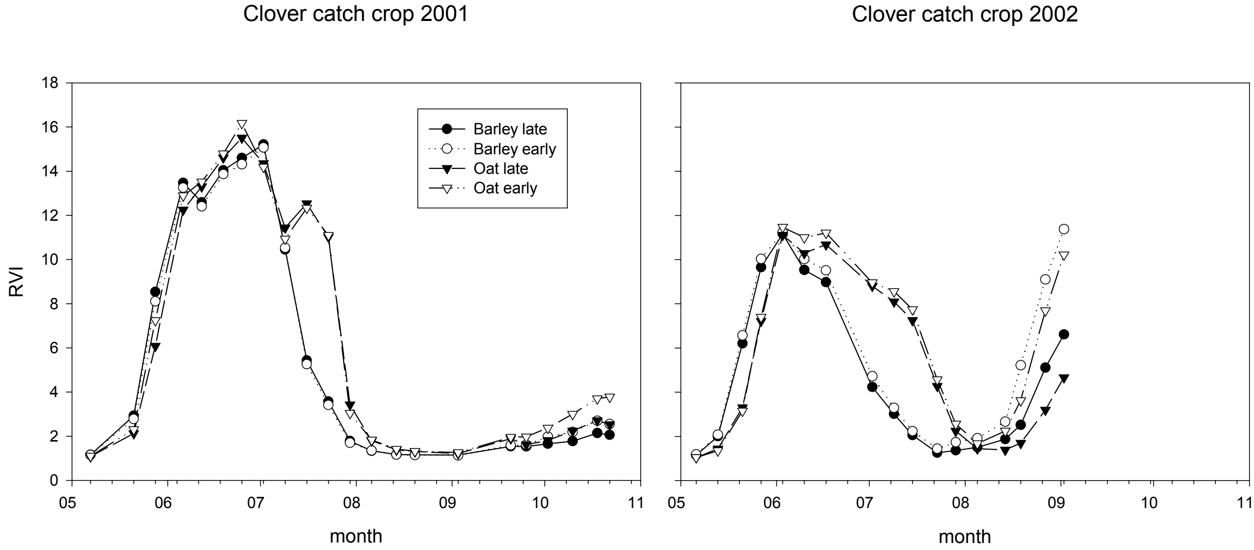

Figure 1 Reflectance index (RVI) for the clover catch crop undersown in either Barley og Oats (sown early or late) in 2001 and 2002 .

In addition to the above dataset, establishment of a clover/grass ley undersown in barley in 2000 have been collected in a database (deliverable D2).

Data obtained from these experiments will be used to verify FASSET's interspecies competition sub-model and to calibrate the simulation of the growth of undersown crops.

WP2. Improvement of root growth model.

Experiments on root growth of winter wheat, spring barley, and sugar beets have been repeated in 2002. The measurements are not finished yet as the beets are still growing, but for wheat and barley the field experiment is now completed.

Preliminary analysis of the data for depth development of the crops show large differences in rooting depth, from on average 98 cm for barley, to 167 cm for wheat and probably about 200 cm for sugar beets, though the last data are not ready yet.

These differences in final rooting depth are found in spite of surprisingly small differences in the rates of rooting depth development among the three crops and two sites. In general, the depth development was linearly related to temperature sum from sowing with a basis temperature of 0 °C, through most of the growing season. The average rate of depth development was 0.94 mm $(\text{day }^{\circ}\text{C})^{-1}$, and the small differences observed among the crops are hardly significant. The data indicate that the depth development rate was c. 10% higher in Årslev than in Foulum.

With similar rates of depth development, the differences in final rooting depth is due to differences in the duration of the active root growth phase, which is much longer for winter wheat and sugar beet than for spring barley.

Estimates of root density have not been made yet, but it is likely that they will show larger differences among crops and sites. Previous results have shown very clear differences in the depth distribution of root density of monocot and dicot species (Thorup-Kristensen, 2001).

WP3 (including NITMOD DP1)

During the previous reporting period, the calibration tool ("CN-TOOL") was completed. This tool is coupled to a database and optimisation module, and has been extensively utilised during this reporting period. It has been expanded with some additional features, including an automated graphical display of all simulations and optimisations.

The database is now completed, and to our knowledge represents the largest existing assembly of field- and laboratory experiments concerning turnover of organic matter. Some of the data sets originally planned for inclusion were discarded due to various reasons. For example it turned out that data-sets including dynamic development of mineral N must have accompanying CO_2 measurements in order to optimise parameters with acceptable confidence intervals. Both for this reason, and the desire to include as many data sets as possible, we included experiments well beyond the number originally planned in the application. Besides comprehensive soil and treatment information, the measurements include the following, which all can be simulated by the CN-TOOL model complex: organic C, organic N, CO_2, NO_3, NH_4, total mineral N, ^{15}N in various pools, ^{14}C total and in various pools, microbial C and ^{14}C, microbial N and ^{15}N. Utilising this number of experiments, containing all these types crobial N and ^{15}N. Utilising this number of experiments, containing all these types of variables is unique in the context of SOM model development.

The ^{14}C analyses from Aarhus University were unfortunately delayed half a year due to staffing problems. These data were primarily intended to resolve the matter of input levels to bare fallow, a central issue for parameterisation of SOM-models. It turned out to be excellent data, which might lead to re-assessment of fundamental assumptions underlying parameters in many SOM models. The data clearly indicate that the carbon input level at bare fallow is 5 - 10 times larger than previously assumed, and makes it likely that ^{14}C developments hitherto considered unexplainable errors (Jenkinson & Coleman, 1994[1]), are simply consequences of this large input level. With this new finding, it was possible to re-estimate long-term parameters for the SOM model (Petersen *et al.*, 2002a, first draft enclosed).

Using the parameters primarily related to long-term development, it was possible to continue with the short-term parameterisation. It soon turned out that our working hypothesis, that a simple model (see Fig. 2a, taken from the "NITMOD" application) is capable of simulating the short-term data series satisfactorily, could be clearly falsified. The working group then went through a time consuming process of testing a very large number of combinations of model structures and principles, a few of these sketched in (Petersen *et al.*, 2002b, first draft enclosed). The working group used approx. 9 months where every tested combination proved to have one or more clearly unacceptable aspects, until a satisfactory model was developed (Fig. 2b). Furthermore, not only the structure of the model, but also the abiotic functions in the model have been modified somewhat, in particular the clay effect on soil organic matter turnover. Coil clay content is assumed to have two effects: 1) on the humification and 2) on the longevity of soil microbial biomass. The biological effect this aims to mimic, is a reduced protection of the soil microbial biomass when the clay content is low.

In the middle of this process, Lars Stoumann Jensen went for his 5 months scheduled sabbatical leave in New Zealand, and the working group discussions were not as effective during this period; however during May – August this year meeting activity and communications have been very intensive.

The challenge of constructing a satisfactory model on the one hand has delayed the work significantly, compared to the original plan. On the other hand this process has resulted in many new insights in both actual processes and problems related to their modelling.

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[1] Jenkinson, D.S. & Coleman, K., 1994. Calculating the annual input of organic matter to soil from measurements of total organic carbon and radiocarbon. *Eur. J. Soil Sci.* 45, 167-174.

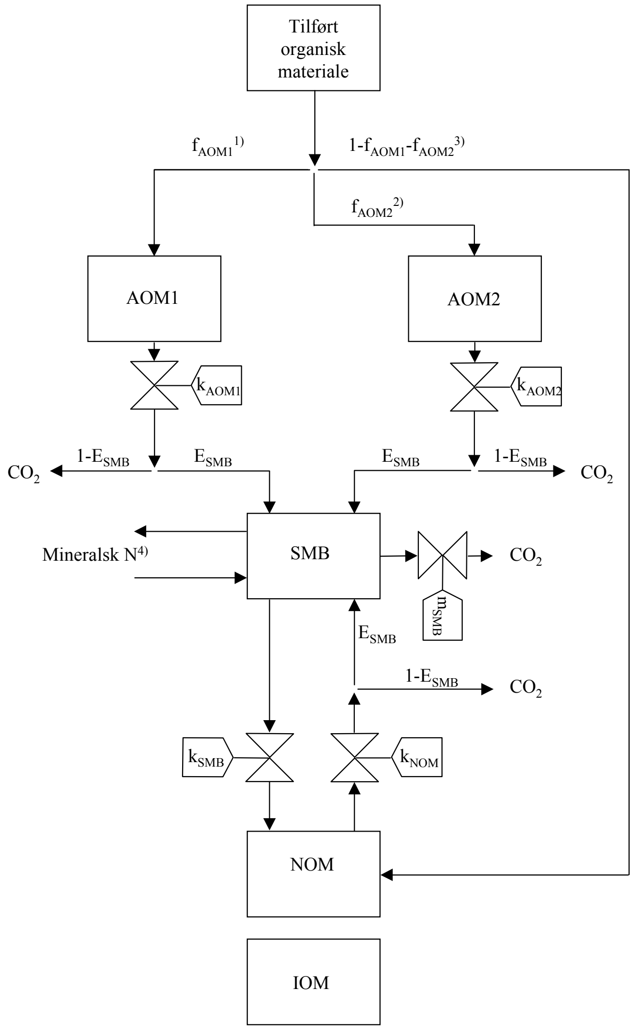

Figure 2 (a). Model structure from the original proposal (NITMOD).

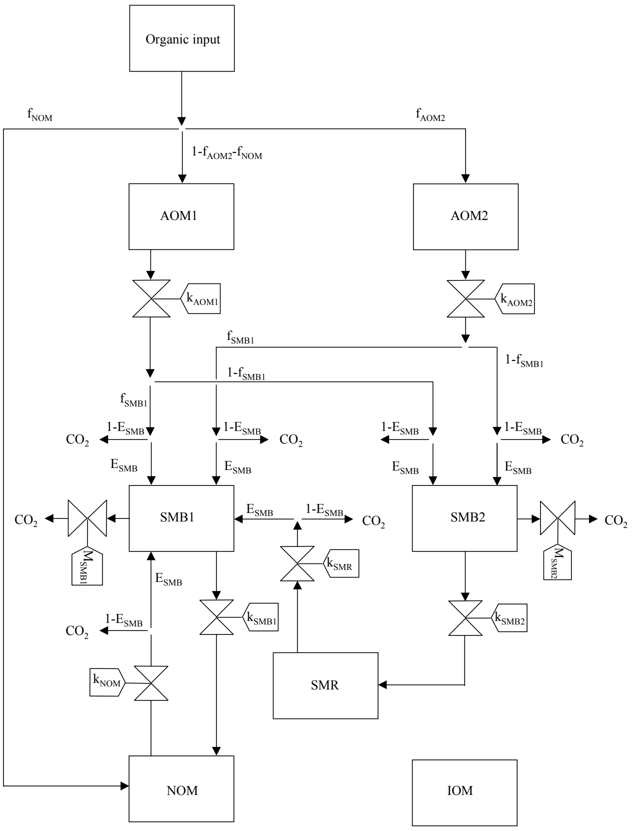

Figure 2 (b). Model structure for the final model.

The work has resulted in a new SOM model, which yields generally excellent simulations of long-term field experiments, and generally good to acceptable simulations of short-term laboratory experiments (Petersen *et al.*, 2002b, first draft enclosed).. It is developed on the basis of a data set of a magnitude larger that other SOM models, and is the first model, which fulfils all of the following criteria: 1) parameterisation by extensive aid of statistically based methods, including confidence intervals for parameters, 2) use of *in situ* data from several countries and sites, 3) integration of short- and long-term modelling capabilities, 4) extensive use of C and N isotope measurements for development.

In order to allocate the necessary resources to develop the prime product of this work package, namely an improved SOM model, and to implement it in FASSET and DAISY, the scientific reporting of the findings have had to be postponed according to Table C2

WP4

Two sites, one on sandy soil (Brørup) and one on loamy sand (Assentoft), including grazed grass-clover in rotation on dairy farms have been selected for detailed measurements of a large number of parameters. On each site a grass-clover field have been selected and this field has been split in two giving the following two rotations, which are used for measurements.

Field	2000	2001	2002
1	grass-clover	spring barley	spring barley
2	grass-clover	grass-clover	spring barley

The cereal fields were split into three plots at each site, two plots are given manure in either normal or double normal rate and one is not given manure. The nitrate leaching is only measured in the plot, which has been given normal manure rate. The measurement programme has been set up in collaboration with the DINOG project under DARCOF-II. This measurement programme can be outlined as:

- *General farm data.* The feed production, feed use and production of milk, meat and manure at the farm level is recorded.
- *Manure*. Amount and quality of applied manure.
- *Soil characterisation*. Soil profiles were characterised in spring 2001, including soil texture, soil water retention and N and C content.
- *Climate*. A weather station is placed at each site.
- *Soil mineral nitrogen and microbial biomass*. Soil samples from the soil profile 0-100 cm have been collected five times during the period Feb.2001-Feb.2002 for determination of mineral N. Soil samples from the soil profile 0-100 cm have been collected three times during Sep. 2001-April 2002 for determination of microbial biomass by chloroform fumigation.
- *Below-ground and above-ground biomass in grass-clover.* Samples for root and grass determination (dry matter, total C and N and lignin) have been collected from the grass sward of field 1 just before ploughing in March 2001, and of field 2 in the autumn 2001 and before ploughing in April 2002.
- *Above-ground crop biomass and yield in cereals.* Samples of above ground biomass in the cereals in each of the three manure treatments were taken twice during the growing season and at harvest. Grain yield and nitrogen content was measured.
- *Earthworms*. Samples of earthworms have been taken three times during each season. The number of earthworms is relatively low (<150 m^{-2}).
- *Nitrate leaching*. Soil water sampling stations were established at each field in December 2000 – January 2001. Each sampling station consists of 12 suction cups installed at a depth of 100 cm and covering an area of approximately 100 m^2. At field 2 additional suction cups were installed in June 2001 because the grass growth did not recover sufficiently after the installation of the sampling stations in the winter. Water samples have been taken every second week. Samples from the individual suction cups are analysed for nitrate-N, whereas pooled samples from each station are analysed for NH_4-N and total-N. Pooled samples are also analysed for ortho-P and K as an indicator of preferential flow, and for TOC with the purpose of describing organic matter conversion. Percolation through the root zone has been modelled by means of the EVACROP model. Nitrate leaching is calculated on basis of the modelled percolation and measured N-concentrations in soil water.
- *N-fixation and denitrification (DINOG project)*. N-fixation and nitrous oxide emissions were measured 3-4 times during the season in 2001.

At the loamy soils at Randers the clover-grass ensured a very low nitrate leaching (14 kg N/ha) during the run-off period in 2001/02, whereas conversion of the clover-grass field resulted in a large increase in nitrate leaching (212 kg N/ha) during the same period (Table 1). At the coarse sandy soils at Brørup with high rainfall there was a considerable nitrate leaching

(79 kg N/ha) from the clover-grass field in 2001/02, and conversion of clover-grass also lead to increased leaching (200 kg N/ha). There appeared to be no effect on nitrate leaching of the poor recovery of the clover-grass of field 2 in the spring 2001. The grain yield showed no response to manure application in 2001. Grain yields from 2002 are not yet available.

Table 1 Grain yield and nitrate leaching at the two experimental sites in 2001.

Location	Field	Grain yield 2001 (t/ha with 85% DM)			N leaching (kg N/ha/yr)
		0 N	1 N	2 N	2001-02
Brørup	1	5.0	4.5	4.8	205
	2				79
Assentoft	1	4.9	6.0	6.3	212
	2				14

The measurements of leaching will be continued during the winter 2002/03 and the data will be transferred to WP5 for use in model validation. A joint refereed paper with the model results is planned.

WP5: Whole-model calibration, validation, inter-comparison and scenario analyses

Some of the whole-model calibrations and comparisons have been very much dependent on the finalisation of the re-structured and re-parameterised C and N turnover model from WP3, which was ready by the middle of 2002, as described under WP3. Once this was completed, all the work focus of all three partners has been focussed on the whole-model calibrations and comparisons. However, some of the work on the individual models is independent and has been initialised in the first half of 2002.

5.1 Model calibration

The Food Web Model.

The model has been constructed to simulate the interactions between soil tillage, soil structure, micro-flora, soil fauna, nitrogen mineralisation and crop yield. The food web model is a (Gutierrez type) multitrophic, stage structured, physiological driven population dynamic model that is driven by the different organisms' temperature dependent food demand. The trophic interactions determine how much supply the organism can acquire, and the population growth is controlled by the supply/demand ratio. Nitrogen can be released two ways in the model: 1) respiratory nitrogen which is the nitrogen content of the "food" used for respiration, and 2) if the food contains more nitrogen than needed. This means that the degradation of organic matter, and in turn the release of nitrogen is dependent on biological activity.

The Food Web model was first calibrated on the Bygholm data set, which originates from an earlier DARCOF-project and consists of measurements of the effects of two different kinds of tillage on the soil fauna, the soil microflora and the soil structure. The two tillage types were ploughing to 20 cm and a non-inverting tillage consisting of rotovation, deep soil loosening to 35 cm and sowing in one operation. In the ploughed treatment sampling was carried out once before the tillage event (1 October) and 5 times after, and in the non-inverting treatments sampling was carried out once before and 3 times after tillage. The ploughing data set (6

sampling dates) was used to calibrate the search rate of the different organisms and the non-inverting data set (4 sampling dates) was simulated without changing anything but the input densities and input weights of the animals.
The simulations were started on the 24 of september and ran 250 days. The species in the simulations were the earthworms *Allolobophora longa*, *Aporecotodea caliginosa* and *Lumbricus terrestris*; the collembola *Isotoma anglicana*, *Isotoma notabilis* and *Folsomia fimetaria*; a fungus representing the microflora, two kinds of organic matter (OM1 = dead plant or fungus matter and OM2 = dead animal matter). The model did not simulate plant growth in these simulations, and it does not have the capacity to simulate leaching, but only nitrogen mineralisation. Therefore, the only way nitrogen can disappear when it has been released is through immobilisation in the microflora. It was possible to simulate the data with good satisfaction, although there were a few data points that was not captured by the model. The simulations of the data set from the non-inverting tillage system were rather good – in some cases better than the simulations of the ploughing data set, but it is also less challenging because there are only four sampling dates.

The Daisy model

The work on setting up the *Daisy* model for calibration on the vegetable crop rotation using data from Årslev Experimental station from the period 1996 to 2001 (Thorup-Kristensen, 1999; pers. comm.) was started in 2002. Data from a full six-course rotation is used with vegetables in three of the fields in the rotation (Green peas, Spring barley with undersown Grass-clover, Grass-clover fallow, White cabbage/Leeks, Spring barley with green manure, Onions/ Carrots). Data are available from the use of different types of catch crops or green manures following the peas and the spring barley. This data include biomass and nitrogen uptake in crops and time sequences of mineral nitrogen content in soil.

In order to simulate the whole crop rotation, the initial calibration work has focussed on the development of a crop module for White cabbage and on verification of a preliminary grass-clover module. For *Daisy* ver.1.0 a rudimentary cabbage crop module had earlier been developed, but with the new crop module structure of the new *Daisy* ver.2.0, the data utilised earlier could be exploited further for a better and more correct White cabbage crop module. Figure xx shows good correspondence between measured and simulated leaf area and dry matter production in leafs and storage organ. Furthermore, the crop module now enables planting of seedlings, which was not feasible in earlier versions.

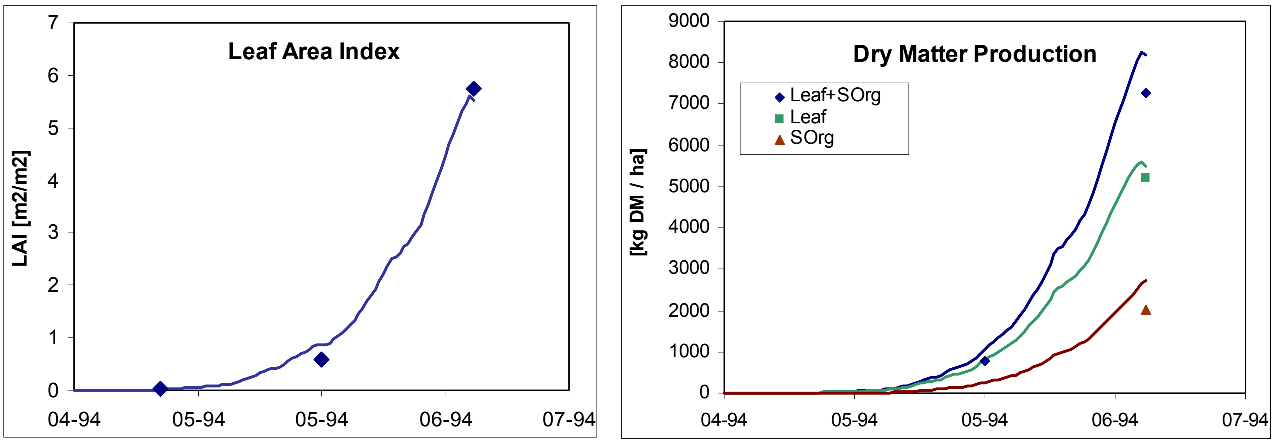

Figure 3. Simulations (lines) of leaf area index development and dry matter production (leaf and storage organ) in white cabbage.

Implementation of the new SOM submodel in Daisy and FASSET and preliminary comparison between FASSET/DAISY and the Food Web Model

The work on implementing the new organic matter model developed in WP3 into FASSET and Daisy was initiated in the middle of 2002. This implied both a revision of model structure, default parameters and additionally the new clay function, the latter requiring a substantial code rewrite in Daisy in particular.

Simulation of the "bare soil situation".

In order to compare all 3 models without interference from differences in other submodels (which differs between FASSET and Daisy), the new SOM submodel was tested on a simple experiment to verify that the model response in Daisy and FASSET was as expected. Simulations with the Food Web model were included based on the same input and environmental conditions, to compare how well the two model types correspond with respect to added organic matter decomposition, build up of microbial biomass and release of nitrogen.

The soil was taken from the experiment at Burrehøjvej and after 0.5 years simulation, an input of 4000 kg C ha^{-1} with a C/N ratio of 20 (similar to ryegrass) was incorporated. To make the comparison as simple as possible, the climatic variation was removed. Thus, the temperature was held constant at 8 °C and the water content at constant field capacity. The input parameters for the Food Web model (search rates) found through the calibration of the Bygholm data sets were used in the Food Web model and the start number of animals in this simulation was reduced to normal levels in order to simulate a situation as close to normal as possible.

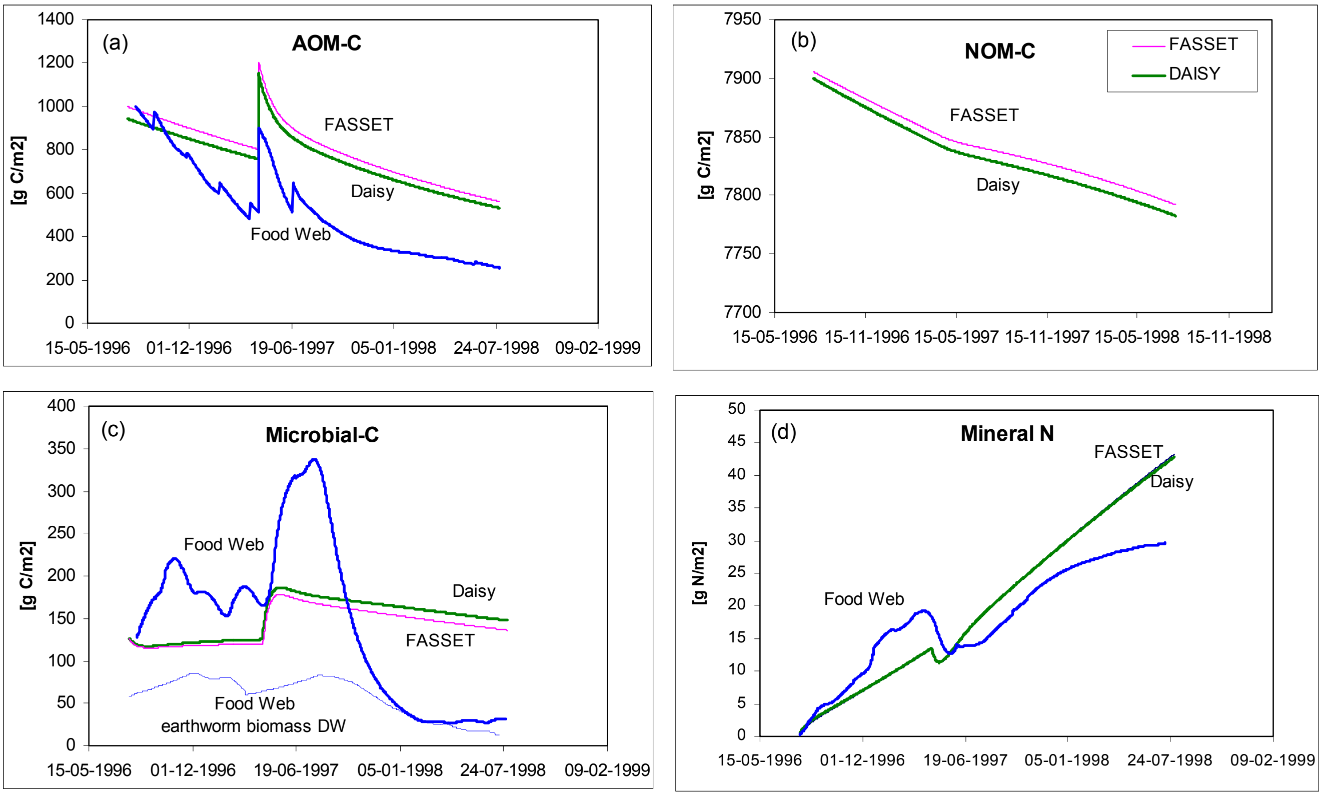

Figure 4. Comparison of FASSET, Daisy and Food Web model simulations of:

a) remaining added organic matter (AOM), for DAISY and FASSET the graphs show the sum of AOM1 and AOM2. For the food web model the graph shows the sum of dead plant matter (main part) and dead animal matter.
b) native organic matter (NOM), inert organic matter (IOM) is not shown but was constant at 4400 g C m^{-2}. The Food Web model does not simulate native organic matter.
c) soil microbial biomass (SMB), for DAISY and FASSET a sum of the pools SMB1 and SMB2, the food web model does not operate with active and inactive microbial biomasses. Furthermore, the simulated biomass (DW) of earthworms from the food web model is shown.
d) mineral N release (positive slope) or immobilisation (negative slope)

The simulations of DAISY and FASSET are almost identical with respect to added and native organic matter, soil microbial biomass and N mineralization (Fig. 4a-d), minor deviations are due to other small model differences and this verifies that the overall application of sub-model structure in the entire models is identical. However, the degradation of organic matter in the food web model is quicker both in the first phase and after the addition of fresh plant material and the amount of organic matter (remaining plant matter and dead animal) by the end of the simulations is clearly lower in the Food Web model output (Fig. 4a). The microbial biomass also shows an increase in the first phase, a very strong response to the addition of fresh plant matter and a rather strong decrease in the late phase of the Food Web simulations, compared to the two other models (Fig. 4c). This is because the Food Web model responds more quickly to reduced amounts of organic matter in the system. Thus the Food Web model also simulates a faster release of nitrogen before the addition of fresh plant material and a slower release after the addition (Fig. 4d). This is caused by a larger N immobilisation of the soil microflora and earthworms in the Food Web model than in the two other models. Furthermore, the N mineralisation by the Food Web model levels off with time, which is not the case for DAISY and FASSET.

The two types of models may after some further adjustments of the Food Web model be equally capable of simulating nitrogen release from added organic matter, but whether this will be valid under more complex conditions still needs to be seen, and will be the subject of study when the dynamic coupling of FASSET and the Food Web model has been completed.

Model calibration on the Burrehøjvej experiment

A central part of WP5 is to calibrate and validate the new SOM model on field scale experimental data. Data from a pasture experiment (termed "Burrehøjvej") by Eriksen (2001)[2] have been chosen as a first test.

Both FASSET and Daisy has been set to simulate the initial three years with grazing of grass-clover or pure grass and the following three years with cereals. The overall model set-up of initial SOM pools, grazing management and testing of N budgets is still in progress, and the important aspect of correctly simulating the residual effect of pastures evidently still requires some more fine-tuning, however, the number of factors and parameters involved is very large and often highly intercorrelated. Figure 5 shows FASSET and Daisy simulated and measured nitrate concentrations in suction-cups below the grazed, low N surplus, grass-clover pasture treatment, with either nil or 230 kg total slurry N/ha applied each of the three subsequent

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[2] Eriksen, J., 2001. Nitrate leaching and growth of cereal crops following cultivation of contrasting temporary grasslands. Journal of Agricultural Science 136, 271-281.

years following plowing of the pasture. Although both models capture the peak in nitrate concentration in Nov. 1998 correctly, both models have difficulties in other periods and in simulating the difference between slurry rates. Since the two models soil organic matter submodule is identical (as documented from bare soil simulations above), these differences must derive from other sub-module (water, crop), which differ in structure and parameterisation. For the Daisy model (Figure 5, right), the high amount of nitrate over winter-spring 1998, 1999 and 2000 is due to an inappropriate simulation of the ryegrass catch crop (2-5 times smaller simulated N uptake than measured), a problem located in the undersown ryegrass crop module of Daisy; FASSET on the other hand has a slight overestimation of catch crop N uptake in winter 1998 and simulates low soil solution nitrate concentrations. The FASSET model also simulates a much too large peak in nitrate concentrations in the winter 1997, and an explanation for this peak might be that the simulated C input is too low and thereby too much N is released. To investigate this problem a detailed C and N budget will be made.All these issues are currently under intense investigation in the FASSET and Daisy groups and will be so for the rest of 2002.

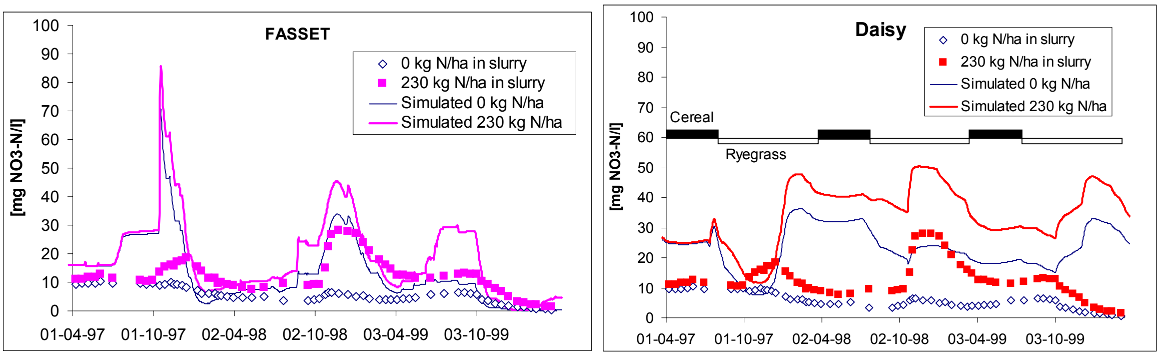

Figure 5. Comparison of FASSET (left) and Daisy (right) simulations of nitrate concentration in suction-cups (at 100 cm) after incorporation of the sward (1.4.97) in the grazed, low N surplus, grass-clover pasture treatment of the Burrehøjvej experiment, with either nil (1) or 230 kg total slurry N/ha (3) applied each of the three subsequent years following plowing of the pasture.

In Table 2 the crop yield increase of the cereal crops grown after incorporation of the grass-clover is shown. It is noticed that the response to N in slurry shows the same trends, with no increase in yield between 115 and 230 kg N/ha application observed the first two years, while a significant increase is observed the third year.

Table 2. Observations and FASSET simulation of crop yield after ploughing the grazed, low N surplus, grass-clover pasture treatment.

	Year1		Year2		Year3	
	Spring barley		Spring wheat		Barley silage	
Total N input, kg/ha (in cattle slurry)	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.
	Yield increase (g DW/m2)					
115	34	40	37	14	133	122
230	54	44	27	14	176	130

For the Food Web Model, the input data from the simulations of the Bygholm data sets were also used as input to the Burrehøjvej data simulations. The input data to the simulations of barley was found in the literature and the input data for ryegrass and white clover originated from unpublished growth analysis data from an older project at the National Environmental Research Institute.

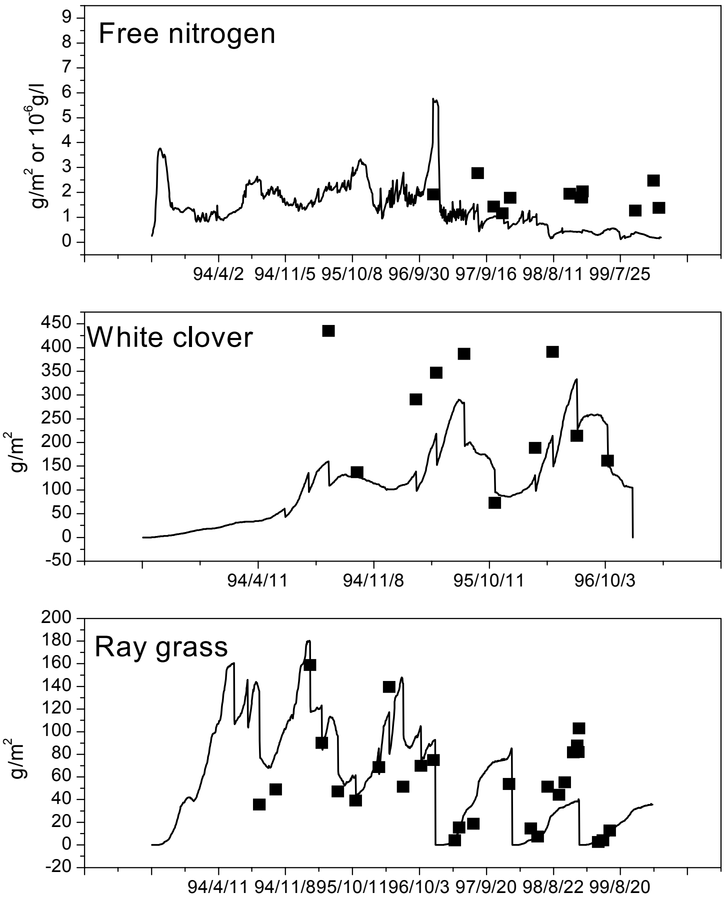

Figure 6. Comparison between simulations by the foodweb model and observations from the Burrehøjvej data set. (Top) Free nitrogen, (Middle) White clover – total above ground biomass, and (Bottom) Ryegrass – total above ground biomass.

The simulation was started on the 1 April 1993 and stopped after harvest in 1999. The model was able to simulate the growth of ryegrass and white clover rather well, but the simulation of the free nitrogen is underestimated (Figure 6). This has the effect that the simulated yields of subsequent cereal crops (data not shown) are underestimated.

There are two possible reasons (not mutually exclusive) for the underestimation of available nitrogen. 1) the food web model at present does not take the native organic matter, or "humus", into account in these simulations. As the main part of the organic nitrogen is situated here the release of nitrogen from this pool may make the difference. This will be included as start input as soon as possible, since the model already includes the stage “old organic matter”, which can be regarded the “humus”, or 2) the root part of the plant module in the food web model needs a better calibration, because the accumulation of organic matter from dying roots appears to be too low. However, with the planned integration and coupling of the FASSET and Food Web models (see H), these issues should be resolved.

WP 5.2 Model validation, inter-comparison and scenario analyses

This task of the project has not yet been initialised, apart from the preliminary inter-comparison between the models on a bare soil simulation, but during several project meetings this year we have agreed on a more detailed time schedule for this part. Major points will be listed under H.

WP6. Parameterisation of rhizodeposition

Existing rhizodeposition studies have been reviewed and a model for carbon and nitrogen rhizodeposition has been developed. A fraction of the translocated carbon is lost as rhizodeposition, and the rest is used for growth of the root system. The fraction translocated to the root depends on the phenological development of the crop, as young crops are known to translocate more than mature crops. Decay of the root system is performed on a daily basis and is lost as rhizodeposition.

A main objective of the rhizodeposition model was to develop a very simple and robust model. Thus, the model developed has only four parameters and the values of these parameters are the same for several crops. Despite this simple structure the model have proved to be able to simulate the overall tendency found in the literature. The model has also been able to simulate response to nitrogen stress successfully. Both simulations and experiments show that crops allocate about 5% more carbon to the root system when crops are nitrogen stressed.

The model development is finished and all parameters have been estimated. The model has been reported on the FASSET homepage (www.fasset.dk)

WP7. Validation and development of a solute-transport model

Existing solute transport models have been reviewed and the TeTrans model has been chosen for further testing. The model has been implemented into FASSET and has been tested on several data sets. These data sets include literature data from Denmark, Sweden and England. In addition, collaboration with a research group at INRA has been established and a large data set with transport of nitrogen, chloride and ^{15}N has been obtained. This study was conducted on a bare field, and is thus excellent for studying the interactions between the transport model and the new nitrogen turnover model developed in WP3. Results from mineral nitrogen in two horizons and ^{15}N concentrations in suction cups at three depths are shown in Figure 7 below.

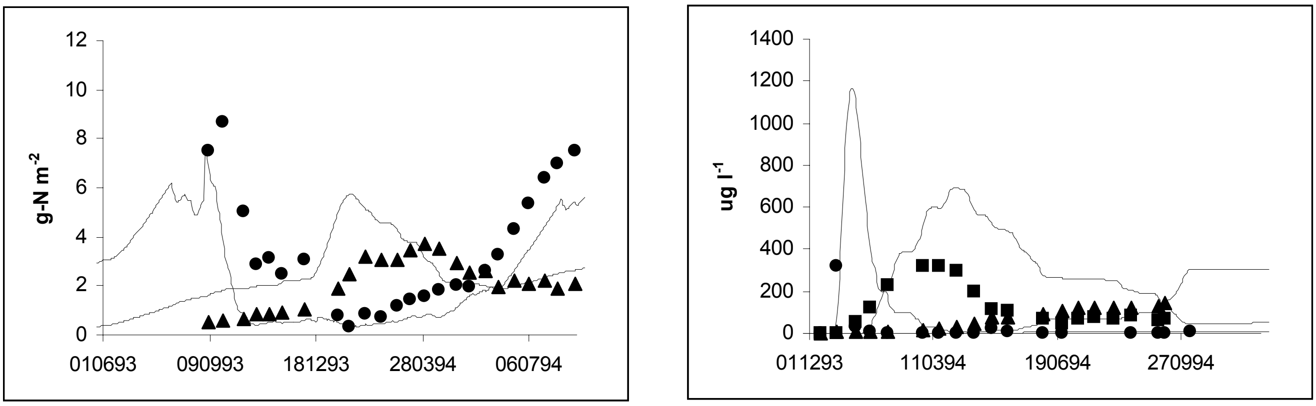

Figure 7 Measured (points) and simulated :
Left: mineral N content in 0-30 (circles) and 120-150 cm (triangles) depth
Right: ^{15}N in 20 (circles), 75 (squares) and 150 cm (triangles) depth

The development of the transport model is finished but the model parameters needs further validation, on all the available data sets. In addition, the robustness will be tested on typical Danish soils. This work will be completed within the next two months.

WP8

The impacts of crop rotation and input of organic matter on crop yield, nitrogen uptake and microbial biomass and activity was studied in a crop rotation experiment initiated in 1997 at Research Centre Foulum. The parameters studied included substrate-induced respiration (SIR) from where microbial biomass C was calculated, hydrolysis of fluorescein diacetate (FDA), arylsulfatase activity (ASA), N mineralisation, N_2O emission, and soil respiration. These measurements were carried out in bare soil plots to measure the effects of previous crops and input of organic matter. In 2001 measurements were carried out in four treatments where the crops in 2000 were winter wheat (W-w), pea-barley (P-b), grass-clover (Gr-cl), and pea-barley undersown with ryegrass (P-b/gr). In the first two treatments no grass-clover was included in the crop rotation, whereas grass-clover and catch crops was included the last two treatments. The treatments thus represent low and high inputs of organic matter. The development of the 2001-crops was followed in neighbouring non-fertilised plots by measuring the aboveground biomass and nitrogen uptake six times during the growing season.

Generally, the treatments with low input of organic matter gave lowest scores for all measured parameters (Table 3), and W-w was significantly lowest except for soil respiration and N_2O emission, which showed high spatial variation.

Table 3 Measured crop and soil biological data

Level of organic matter input	"low"		"high"	
Crops in 2000	Ww	P-b	Gr-Cl	P-b/gr
Crops in 2001	Sb	Wr	Ww/gr	Sb/gr-Cl
Mesurements on 2001 crops:				
Total above ground dry matter, t ha^{-1}	6.2	8.0	11.0	8.6
Total N uptake, kg N ha^{-1}	60	62	104	89
Measurements on bare soil:				
N-mineralization, kg N ha^{-1}	78	100	105	103
Soil respiration, tons C ha^{-1}	4.2	5.3	5.0	5.2
N_2O-emission, kg N_2O-N ha^{-1}	2.6	2.6	2.7	3.3
SIR, µl CO_2 g^{-1} soil h^{-1}	4.8	7.6	7.3	7.6
Microbial biomass C, µg C g^{-1} soil	230	305	305	304
FDA, µg flourescein g^{-1} soil	89	90	120	107
ASA, µg NP g^{-1} soil	22	24	31	27

The results are currently being prepared for a paper in Nutr. Cycl. Agroecosyst.

C.2 Fulfilment of deliverables and milestones

WP1: Adaptation of a model for competition between undersown crops and main crops.	Time schedule according to application	Deviations, if any*
Task		
Deliverables		
1 A data set for adaptation of FASSET's simulation of establishment of clover grass	2001/10	Delivered
2 A data set for adaptation of FASSET's interspecies competition sub-model	2002/10	Delivered
3 A calibrated interspecies competition sub-module of FASSET	2003/2	
4 A paper on modelling competition between main crops and undersown crops	2003/6	
Milestones		
1 Data on establishment of clover/grass ley	2001/10	Achieved
2 Preliminary version of undersown crop module for FASSET available	2002/6	Achieved
3 Data on growth of catch crops	2002/10	
4 FASSET's interspecies competition sub-model calibrated and tested by use of the experimental data	2003/2	
WP2: Improvement of root growth models		
Deliverables		

Data and parameter estimates for root growth of the three species, and the effect of the soil types, to be used in the modelling	2002/12	
Validated root growth model for DAISY and FASSET	2003/03	
Paper on modelling root growth in relation to crop species and soil types	2003/06	
Milestones		
Models calibrated on existing root growth data	2001/11	Postponed
Preliminary version of root growth model available	2002/03	Postponed
Data on root growth of main crops available	2002/12	
Adaptation and testing of root growth model completed	2003/03	
WP3 + NITMOD DP1. Parameterisation of the soil organic matter turnover submodules of DAISY and FASSET (New dates taken from NITMOD application)	Time schedule according to application	Deviations, if any*
Deliverables		
Database consisting of C/N experiments	2001/06	Delivered
Poster with preliminary results	2001/09	Delivered
Paper with analysis of long-term SOC data	2001/12	1)
Paper regarding new C-N model	2002/03	2)
Milestones		
Model structure determined	2001/08	Achieved
Calibrated C-N model	2002/01	Achieved
Implementation of new SOM model in DAISY and FASSET	2002/12	Achieved
WP4: Crop production, nitrogen balance, nitrate leaching and biodiversity in crop rotations on private farms		
Deliverables		
Yearly datasets from two dairy farms for validation of models. These data sets contain both detailed field level data and less detailed farm level data	05/2001, 05/2002, 05/2003	Delivered (except 2003)
A report on nitrogen turnover on two dairy farms	10/2003	
Milestones		
Selection of two farms, establishment of farms as Pilot Farms, installation of field equipment	09/2000	Achieved
End of measurement campaign	08/2003	
WP5. Whole model calibration, validation intercomparison and scenario analyses		
Deliverables		
Papers on calibration and validation of the models for different crop rotations	2003/10	
A paper on inter-model comparison of the three models for a dairy crop rotation	2003/12	
Papers on scenario analyses for three different crop rotation types	2003/12	

A report with tables of results of scenario analyses for use in advisory work	2003/12	
Milestones		
Compilation and set-up of calibration data sets completed.	2001/10	Achieved
Preliminary whole-model calibration completed.	2002/04	Achieved
Final whole-model calibration completed.	2003/04	
Model validation runs completed.	2003/06	
Model scenario runs completed	2003/10	
WP6. Parameterisation of rhizodeposition		
Deliverables		
1 Database with literature data	2001/11	Delivered
2 Crop parameters	2002/6	Delivered
WP7. Validation and development of a solute-transport model		
Deliverables?		
1 Database with literature data	2001/11	Delivered
2 New model with parameters	2002/10	
3 Article or conference poster	2002/12	
WP8. Field data on C and N-turnover in organic crop rotations		
Deliverables		
Database with all data for use in modelling	2002/03	Delivered
Report/article on experimental data	2002/12	
Milestones		
Experiments completed	2001/10	Achieved
Data stored in database for use by modelling	2002/03	Achieved
Article on experimental data	2002/12	

** Deviations are to be further discussed in D*

D. Description of deviations and subsequent adjustments of plans

WP1. As the results from 2001 in the WP1 field experiment in WP1 only showed a small growth of catchs crops due to a strong competing main crop, it is decided that the experiment should be repeated. Thus some VIP months was converted to TAP months and the experiment was repeated in 2002. These results showed much more growth of the catch crops.

WP2.
The modelling activities are delayed, and have not started yet. Priority has been given to the modelling activities in WP3 and WP5, and Jørgen Berntsen has therefore not had the time to do the root modelling. The modelling work will be made during winter and early spring 2003, to be ready to be included in the model for the subsequent testing and scenario studies.

WP3
This workpackage is proceeding scientifically very satisfactory, though with some delay in publication due to the circumstances described above. The findings in this workpackage are

expected to contribute to the discipline of SOM modelling at an international level. Due to the many findings worthy of reporting, the expected number of reviewed papers from this work-package were raised from 3 to 5. These two additional publications are mainly made possible due to supplemental funding for BMP's Ph.D. study from DARCOF.

1. The analyses of long-term SOM development will result in two articles, one taking its basis in (Petersen & Berntsen, 2002) utilising a very simple and versatile SOM model with only three "free" parameters, and the second comparing simulations of long-term SOM data with RothC and the original DAISY (Petersen, B.M., Heidmann, T., Christensen, B.T., Rasmussen, K.L. & Heinemeyer, J. In prep. An analysis and comparison of two soil organic matter models based on simulations of long-term carbon and radiocarbon development). The first article will be submitted to a still undecided journal 2003/06, and the second to "Geoderma" 2003/02.
2. This deliverable will consist of the two articles, for which the very first drafts are enclosed. They will both be submitted to "Soil Biology and Biochemistry" 2002/1

E. Project publications and other products

1. Articles in international, scientific journals with review procedures

Petersen, B.M., Olesen, J.E. & Heidmann, T. 2002. A flexible tool for simulation of soil carbon turnover. *Ecological Modelling*, 151, 1-14. **(WP3)**

Petersen, B.M., Berntsen, J. & Jensen, L.S. 2002a. CN-SIM - a model for the turnover of soil organic mattter. I: Long term carbon development. First draft (enclosed). **(WP 3)**

Petersen, B.M., Jensen, L.S., Berntsen, B., Hansen, S., Pedersen, A., Henriksen, T.M., Sørensen, P. & Trinsoutrot, I. 2002b. CN-SIM - a model for the turnover of soil organic mattter. II: Short term carbon and nitrogen development. First draft (enclosed). **(WP 3)**

Larsen, T; Schjønning, P and Axelsen, J.A. (*almost ready for submission*) The impact of soil structure on euedaphic Collembola. (*final draft, awaiting comments from all authors*). **(WP 5)** (50% financed by this project)

Larsen, T.; Ravn, H.W. and Axelsen, J.A. (*almost ready for submission*). Simplified methods for extraction and quantification of ergosterol from fungi in soil. (*final draft, awaiting comments from all authors*). **(WP 5)** (50% financed by this project)

Bach, L.; Jørgensen, H.B. and Axelsen, J.A. (in prep). Effect of collembolan grazing on interspecific competition between microfungi, decomposition of organic matter and bio-available nitrogen. *(final draft, awaiting comments from external examiner)* **(WP 5)** (50% financed by this project)

Bach, L.; Jørgensen, H.B. and Axelsen, J.A. (in prep). Effect of different levels of collembolan grazing on interspecific competition between microfungi, decomposition of organic matter and bio-availability of nitrogen. *(final draft, awaiting comments from external examiner)* **(WP 5)** (50% financed by this project)

2. Papers presented at congresses, symposiums, etc.

Vinther, F.P., Hansen, E.M. & Olesen, J.E. (2002). Relationship between crop rotation and microbial biomass and activity including field CO_2 and N_2O fluxes and N mineralisation. NJF Seminar 342: Agricultural soils and greenhouse gasses in cool-temperate climate. **(WP8)**

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 Agricultual Sciences, Research Centre Foulum, Denmark. pp 22. **(WP3)**

Pedersen A., Bruun S., Jensen L.S. and Hansen S. 2001. Simulating Soil Organic Matter Transformations with the New Implementation of the Daisy Model. Poster at 11th Nitrogen Workshop, 9-12 September 2001, Reims, France **(WP3)**

Müller T., Jensen L.S., Magid J., Nielsen N.E., Hansen S., Thorup-Kristensen K. (2002) Catch crops in organic farming systems without livestock husbandry – model simulations. In: Transactions of 17th World Congress of Soil Science, Bangkok, Thailand. p 830.1-830.9. **(WP5)** (25% financed by this project)

3. Reports, articles in agricultural journals, etc.

4. Oral presentations, public meetings, field days, etc.

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. **(WP3)**

F. Scientific education

BMP is, concurrent with participating in BIOMOD, making a Ph.D. on the modelling of soil organic matter.

Masters theses:

Larsen, T, 2002. The impact of soil structure on euedaphic Collembola and simplified methods for extraction and quantification of ergosterol from fungi in soil. Masters thesis, University og Aarhus, May 2002.

Bach, L.. 2002. The impact of Collembola grasing on the interspecific competition between microfungi, decomposition of organic matter and bio-availability of nitrogen. Masters thesis, University of Aarhus, October 2002.

G. National and international cooperation

National and international cooperation

- **Cost-631, Understanding and Modelling Plant-Soil Interactions In the Rhizosphere Environment:** Kristian Thorup-Kristensen is a member of the Management Comity of Cost-631.
- **EU-ROTATE, Development of a model based decision support system to optimize nitrogen use in horticultural crop rotations across Europe:** Kristian Thorup-Kristensen is a partner in this project, which will start January 2003. In this project, a main DIAS responsibility is development of the root growth part of the model, thus the two projects will support each other. This project will start in the beginning of 2003.
- **FØJO2-project VegCatch (I.10):** Root data and data showing interaction between root growth and soil N depletion from this project will be included in the work on developing and validating the root model.
- **SJVF-project: Uptake of nitrogen by deep roots – the key to reducing nitrogen leaching losses from agriculture (*Optagelse af kvælstof i dybe rødder – nøglen til reduktion af kvælstofudvaskningen fra jordbruget*):** In this project in Årslev, the relationship between root parameters and actual N uptake from various soil layers will be measured. Such results will be of obvious relevance to the BioMod project.

H. Critical reflection on the project

The major focal point for this project has been the improvement of both our understanding and predictive capability regarding the dynamics of nitrogen, crop production and soil biodiversity. Several difficulties in integrating all these aspects in WP5 have been encountered during the first half of the project:

- The thorough revision, restructuring and recalibration of the soil organic matter modules of Daisy and FASSET in WP3 turned out to be much more complex and difficult than anticipated. Furthermore, the anticipated simplification of model structure proved to be rejected if the required accuracy and detail in simulation of critical soil properties (N and C dynamics) was to be achieved. However, due to the data quantity and quality included we believe that the revised model will have a much more solid and rigouous foundation than earlier versions. Although refinements and adjustent may still be needed, the whole project group has agreed on a SOM model final deadline (1 October 2002, see workplan below) after which all dependant tasks can continue. In this way we hope to avoid any delays in the overall progress of the project. Furthermore, the revised model structure performance will be compared with the performance of the original model structure to
- As evident from the comparison of simulations of the Burrehøjvej data with the Daisy and FASSET model, many differences in simulations of whole crop rotation data may appear as the result of a multitude of factors in the simulation; pasture model, main crop model, catch crop model, soil solute transport model. We are determined to unravel these differences and their causes because only in doing so can we expect to achieve robust and comparable full-scale models, and this work is currently ongoing.
- The calibration of the Food Web model to the Bygholm data set is the first whole

model calibration carried out on this model. Furthermore, the comparison with the Burrehøjvejdata is the first whole model validation. Therefore, it is reasonable to aim at a stronger calibration and validation of the Food Web model, so it has been decided to use a data set from research centre Foulum (DARCOF I, 7), which includes measurements of Nitrogen, earthworm and Collembola densities (this work has been initiated). Furthermore, a validation/calibration against a large data set from GSF in Munic and laboratory data sets has been planned.

- The comparison of models differing entirely in structure and underlying theoretical foundation (e.g. the FASSET/Daisy vs. the Food Web Model) in WP5 has been difficult, mainly because the Food Web Model was not *a priori* constructed with the purpose of simulating nutrient dynamics, and many of the properties and pools simulated by the traditional 1st order decay models, does simply not have a parallel in the Food Web model. Therefore the project group has agreed on a more specific definition of the objectives with the FASSET/Daisy vs. the Food Web Model comparison:
    1. to estimate whether differences in the population size and succession of soil fauna following cultivation of grass-clover pastures has a marked influence on N turnover and plant availability
    2. to elucidate effects of different cropping strategies on biodiversity of soil fauna.

In order to keep the number of independent variables to a minimum, it has been decided to resume the work with integration of FASSET and the food web model, which was stopped last autumn due to problems with the food web model itself. These problems have now been removed. An integration of the two models, where the mineralisation can be simulated by either the FASSET module or the foodweb model, will make it possible to find out, whether the simulations can be improved by including a more detailed description of the biological activity.

To ensure successful completion of the project, the following time schedule has been set up for the remaining 15 months of the project:

2002:	
3.-4. Sept.	First version of Burrehøjvej data simulations (included in this status report)
1. Oct.	Deadline for WP3 – SOM module adjustments for FASSET/Daisy
15. Oct.	Additional data from crop rotation experiment (CRE) Jyndevad to be available in the database
1. Nov.	Dynamic coupling of FASSET and the Food Web model completed Second version of Burrehøjvej data simulations completed Project group meeting
15. Nov.	Additional data from the old grass-clover experiment (nutrient balance, DARCOF project IV EXUNIT) at Foulum to be available in the database

2003	
January	Internal calibration and validation of the Food Web model to be completed. First version of CRE, EXUNIT and Årslev data simulations completed Project group meeting on these, and brainstorm and planning of scenario analyses (WP5.2).
March	Work on scenario analyses (WP5.2) initiated
April	Second version of CRE, EXUNIT and Årslev data simulations completed

	Project group meeting on these, scenario analyses and plan for publication of model comparison
May	Measurements from WP4 to be completed and available in the database
August	First version of WP4 simulations for full-scale model validation
Autumn	Second version of WP4 simulations Publication

Finally, the BIOMOD project plans to organise an international workshop in spring 2004 in collaboration with the EXUNIT project. The working title of the workshop is "Nutrient dynamics, crop production and biodiversity of organic crop rotations". The workshop will primarily focus on understanding of the dynamics of organic crop rotations and the interactions between different components, include trade-offs between the effect of various management options on the functional behaviour of the different elements in the system, including nutrients, crop production, weeds and soil fauna.

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 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months						
Scientific personnel	47,7	39	35.5			122
Technical personnel	36	29.5	5			70.5

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries						
Scientific personnel	1745	1338	1608			4691
Technical personnel	836	767	184			1787
Other operational costs	617	244	115			976
Equipment						
Others (please specify)	15	10	10			35
Direct costs	3213	2360	1917			7489
Indirect costs (20% of direct costs)	644	470	384			1498
Total	3857	2830	2301			8988

Comments:

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project Jørgen A. Axelsen	National Environmental Research Institute	30/9 2002	

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

Name of Institute: National Environmental Institute, Silkeborg

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months	30	20	13			63
Scientific personnel	16	8	8			32
Technical personnel	14	12	5			31

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries						
Scientific personnel	615	283	325			1223
Technical personnel	303	337	150			790
Other operational costs	265	78	60			403
Equipment						
Others (please specify)						
Direct costs	1183	698	535			2415
Indirect costs (20% of direct costs)	237	139	107			483
Total	1420	837	642			2899

Comments:

Name of Institute and department: Danish Institute of Agricultural Science

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months						
Scientific personnel	25.7	19	21,5			66
Technical personnel	22	17.5	0			39.5

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries						
Scientific personnel	868	635	1044			2547
Technical personnel	533	430	34			997
Other operational costs	323	156	45			524
Equipment						
Others (please specify)						
Direct costs	1724	1222	1123			4069
Indirect costs (20% of direct costs)	346	243	225			814
Total	2070	1465	1348			4883

B. Budget for each participating department (1.000 DKK)

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

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	Total
Man-months	6	12	6		24
Scientific personnel	6	12	6		24
Technical personnel					

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	Total
Salaries	*262*	*420*	*239*	0	*921*
Scientific personnel	262	420	239	0	921
Technical personnel	0	0	0	0	0
Other operational costs	29	10	10	0	49
Equipment	0	0	0	0	0
Others (travel)	15	10	10	0	35
Direct costs	*306*	*440*	*259*	0	*1005*
Indirect costs (20% of direct costs)	61	88	52	0	201
Total	367	528	311	0	**1206**

Comments:
WP3 & 5 (KVL): The budget was revised in 2001 with the inclusion of funding from the NITMOD project (96 kkr). Furthermore, transfer of 95 kkr from 2000 to 2001, and 225 kkr from 2001 to 2002 has also been included. The accumulated budget for 2002 will be consumed this year.

Name of Institute and department: Danish Institute of Agricultural Science, Department of Horticulture

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months						
Scientific personnel	1,5	1	3			5,5
Technical personnel	2,5	2	0			4,5

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries	130	101	155			386
Scientific personnel	66	48	149			263
Technical personnel	64	53	6			123
Other operational costs	40	2	3			45
Equipment						
Others (please specify)						
Direct costs	170	103	158			431
Indirect costs (20% of direct costs)	34	21	31			86
Total	204	124	189			517

Comments:

Name of Institute and department: DJF – Department of Soil and Plant Physiology

Year:	Consumption before 2002	Expected 2002	2003	2004	2005	Total
Man-months						
Scientific personnel	12.2	10	14.5			37
Technical personnel	18.5	14.5	0			33

Year:	Consumption before 2002	Expected 2002	2003	2004	2005	Total
Salaries						
Scientific personnel	418	337	749			1504
Technical personnel	444	352	28			824
Other operational costs	210	113	40			363
Equipment						
Others (please specify)						
Direct costs	1072	803	817			2692
Indirect costs (20% of direct costs)	215	159	164			539
Total	1287	962	982			3231

Comments:
The budget has reflects that 3.5 VIP month have been transferred from 2002 to 2003 and that 7.3 VIP month has been converted to 12.5 TAP month, so that the WP1 experiment could be repeated.

DJF-JBS (Afdelingen for Jordbrugssystemer)

Year:	Consumption before 2000	2000	2001	2002	2003	2004	Total
Man-months		2	10	8	4	0	24
Scientific personnel		2	9	7	4		22
Technical personnel			1	1			2

Year:	Consumption before 2000	2000	2001	2002	2003	2004	Total
Salaries		51	358	275	146		830
Scientific personnel		51	333	250	146		780
Technical personnel			25	25			50
Other operational costs		2	71	41	2		116
Equipment							0
Others (please specify)							0
Direct costs		53	429	316	148		946
Indirect costs (20% of direct costs)		11	86	63	30		190
Total		64	515	379	178		1136

Comments:
In the status report for year 2001, the man-months in 2003 were forgotten. In 2003 two scientific months should have been included, and only 2 months in 2000.
In WP4 1 month is moved from 2002 to 2003 in order to calculate farm-N balances for the complete period 1989-2003.
In WP3 1 month is moved from 2002 to 2003 in order to complete the scientific reporting of the findings.

D. Budget for each participating department (1.000 DKr)

Name of Institute and department: DMU -FEVØ

Year:	Consumption before 2000	2000	2001	2002	2003	2004	Total
Man-months		2	12,5	11,5	6,7		33
Scientific personnel		2	3	1,5	1,4		8
Technical personnel		0	9,5	10	5,3		25

Year:	Consumption before 2000	Consumption 2000	Consumption 2001	budget 2002	budget 2003	budget 2004	Total
Salaries							
Scientific personnel		65	121	50	70		306
Technical personnel		0	210	280	150		640
Other operational costs		90	110	73	40		313
Equipment							
Others (please specify)							
Direct costs		155	441	403	260		1259
Indirect costs (20% of direct costs)		31	89	80	52		252
Total		186	530	483	312		1511

Comments:

For 2002 we request to transfer 66.000 kr. from scientific to technical personnel as stated in the budget

For 2003 we request to transfer 50.000 kr. from scientific to technical personnel and 30.000 kr. from operational costs to technical personnel as stated in the budget

Name of Institute: Natural Environmental Research Institute, Dpt. of Terrestrial Ecology

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months	15.45	8.47	6.26	0	0	30.18
Scientific personnel	11.32	6.02	6.26	0	0	23.6
Technical personnel	4.13	2.45	0	0	0	6.58

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries						
Scientific personnel	429	233	255	0	0	917
Technical personnel	93	57	0	0	0	150
Other operational costs	65	5	20	0	0	90
Equipment				0	0	
Others (please specify)				0	0	
Direct costs	587	295	275	0	0	1.156
Indirect costs (20% of direct costs)	117	59	55	0	0	231
Total	704	354	330	0	0	1.388

Comments:

The consumption before 2002 was 74 kkr. higher than the budget which is the reason why the total amount is 1.388 and not 1.314.

We request to transfer 15 kkr. from “Other operational costs in 2002 into “Saleries Scientific personnel in 2003. The “Other operational costs” in 2002 are changed from 20 kkr. to 5 kkr. and “Saleries for Scientific Personnel” are changed from 240 KKR to 255 KKR in 2003.

We request to transfer 24 KKR from “Saleries Technical personnel” in 2003 to “Saleries Technical personnel” in 2002. This means 57 kkr. “Saleries Technical personnel” in 2002 and 0 Kr. for Saleries Tehcnical personnel in 2003.

Indirect costs are regulated due to the requested transfers. Totalbudget is still the same.

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

Name of Institute:

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months Scientific personnel Technical personnel						

Year:	Consumption before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries Scientific personnel Technical personnel						
Other operational costs						
Equipment						
Others (please specify)						
Direct costs						
Indirect costs (20% of direct costs)						
Total						

Comments: