Danish Research Centre
for Organic Farming

Status Report 2004 and Application for Continuation in 2005

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

Development of organic vegetable cultivation methods, and the use of catch crops to improve the production and protect the environment
Number: I.10

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6. Project period (month, year)

Start of project:	2000
End of project:	2004 (Revised to 2005)

7. Midterm description of the project, its results and progress, and application for continuation in 2005

A. Project summary

The development of organic vegetable production in Denmark is delayed by the fact that only a few species have been grown successfully in substantial amounts. To be able to fulfil the consumer demand for organic vegetables, all the major species must be produced in significant amounts. Such a diversification is now apparently taking place, and it is a major aim of the project to contribute to this. The major problems limiting the production of some of the main vegetables can be identified to be insufficient nutrient availability, difficulties with pest and disease management, and product quality. There is a lack of knowledge on cultivation methods adapted specifically for handling these problems in organic vegetable production. Several interactions exist between these problems and neither of them can be handled in isolation.

In this research project the major objective is therefore to create better opportunities for an increased organic production of a wider range of vegetables and other crops. The partial objectives address three important problem areas and their interaction and are to improve: i) nutrition of the crops, ii) handling of pests and diseases and iii) quality of the produce.

Development of cultivation techniques aimed at crop protection and quality and an improved basis for selecting well-adapted varieties will be very important for the development of organic vegetable production, and these subjects are addressed in the project. A major management option to handle a number of problems is to use catch crops and autumn green manures strategically in the crop rotation. The studies on catch crops involve a number of topics ranging from improving their effects on N leaching losses and on N supply for main crops, to beneficial effects on other major plant nutrients as K, S and P, and to aspects of soil biology relevant for crop protection.

Furthermore, catch crops may have other beneficial or undesirable effects on pests or diseases and these subjects are also addressed in the project. It is obvious that if other advantages, apart from improved N husbandry can be gained from the catch crops, this would encourage farmers to grow them more often. Therefore, improving the N effects, and improving the chances to use catch crops for other purposes at the same time can reduce leaching losses to the environment and improve the living conditions for soil organisms, which may serve as predators for pests.

The focus on catch crops and green manures may seem limited in a project on organic vegetable production, where animal manures often constitute an important part of the nutrient supply. However, we choose this focus for several reasons. Most of the vegetables are produced on plant production farms, where the access to farmyard manure and other manures will be limited. On such farms catch crops and green manures offer the possibility to utilise internal farm resources to improve the system. Lots of work has been done on the effects of farmyard manure during many years, and other DARCOF projects deal with this. We therefore believe that by focusing on the catch crops and green manures, we could contribute more new and innovative tools for management of plant nutrition and other aspects of organic production in sales crop rotations, and work with methods which hold the potential to improve the environmental as well as the agronomic aspects of the system at the same time.

Below is a list of the 9 work packages included in the project. After that, a short description of the activities planned within each of the work packages is included, which can be consulted when reading about the progress and results of the work packages under *C. Midterm results and progress* below.

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

Work-package No	Work package title	Responsible participant	Budget	Start	End
1	Nitrogen relationships of vegetable crops, and project co-ordination	Kristian Thorup-Kristensen	1.91	2000	2004
2	Entomopathogenic nematodes in organic cropping systems	Holger Philipsen	1.25	2000	2003
3	Varieties, growing stability, disease resistance and quality	Gitte Kjeldsen Bjørn	1.24	2000	2004
4	Catch crops as a tool for increasing P bioavailability on soils of low P status	Lars Stoumann Jensen	0.67	2001	2003

5	Influence of autumn green manure crops on club root (*Plasmodiophora brassicae*)	John Larsen	1.24	2002	2004
6	The effect of catch crops on soil mesofauna and earthworms	Jørgen Aagaard Axel-sen	0.57	2000	2004
7	The effect of catch crops on N and K leaching and crop production, with focus on coarse sandy soils.	Margrethe Askegaard	1.62	2001	2004
8	Very deep-rooted crops and catch crops in the crop rotation, N dynamics and modelling	Kristian Thorup-Kristensen	1.82	2000	2004
9	The effect of catch crops on sulphate leaching and availability of S for the succeeding crop	Jørgen Eriksen	0.95	2001	2002

Objectives and work description for each work package

WP1: Nitrogen relationships of vegetable crops, and project co-ordination.

Objectives

1) To co-ordinate the VEGCATCH project.
2) To acquire information about rooting depth during growth, soil N depletion, N uptake dynamics, N residues left in the soil, and the amount and quality of crop residues by a number of vegetable crops. For some vegetable crops where this is relevant, rooting depth and soil depletion below 1.0 m will be studied.
3) To supply data on N root growth and N dynamics for model simulations (Project BIOMOD) and for development of the decision support system on the use of catch crops (WP8).
4) To test the value of green manure crops incorporated in the late spring, as an N source and alternative to full year green manure for N demanding vegetable crops.

Description of work

Coordination of the project includes the production of status reports etc.. Further, it includes securing that general information about the project is communicated. This will be done through articles about the project and arranging a workshop for farmers, advisors, and others. A yearly workshop, where the participants of the project will meet and exchange results and ideas will also be arranged. Finally, the coordination includes follow up on the single work packages.

Crops of Chinese cabbage, celery, red beets, sweet corn, iceberg lettuce and leek will be grown and their root growth will be studied with a minirhizotron system. Samples will be taken during the growing period to determine biomass production, leaf area and N uptake and related to root growth (depth and distribution). At harvest yield, N uptake, N in crop residues and amount and depth distribution of N residues in the soil will be measured. The vegetable crops will be grown after autumn and spring incorporated green manure crops, to study the interactions between rooting depth and N demand and variable soil N profiles. Three of the crops will be studied during the years 2000 and 2001, and the other three will be studied during 2002 and 2003.

For carrot and white cabbage root growth and soil depletion will be followed to at least 2.0 m depth, this study will be combined with catch crop studies (see WP8). These vegetable crops will be grown in 2001 and 2002.

Two legumes will be established as undersown crops in spring cereals, and left to grow in the autumn, and then incorporated either in March before growth resumes in the spring, in early May or in late May. Biomass production, N content and C/N ratio in the legume material will be measured in November and at the time of incorporation. White cabbage will be established in early June, and growth, yield and N uptake measured, and compared to plots without preceding legumes. N_{min} will be measured in the late summer in subplots where no cabbages were grown. The legumes will be established by undersowing in spring cereals in the spring of 2000 and again in 2001, and their effect on N supply for vegetable crops will thus be measured in 2001 and in 2002.

WP2: Entomopathogenic nematodes in organinic cropping systems

Objectives

1) To study differences between cropping systems - especially systems including catch crops - and the ability of the different systems to support growth or maintenance of entomopathogenic nematodes.
2) To study whether specific crops (especially cabbage and carrots) can benefit from entomopathogenic nematodes occurring in the above mentioned systems

Description of work

1) Interactions of entomopathogenic nematodes, pest insects and plants in the organic cropping system at Årslev.

In each of the six fields in the Årslev system, plots of 4-9 square meters will be marked and monitored for naturally occurring entomopathogenic nematodes in April 2000. Depending on the results, a proportion of the test plots will be inoculated with entomopathogenic nematodes of one or more species to ensure measurable amounts of nematodes in the given plot. The test plots will be selected to enable studies on the impact of main crops and catch crops on entomopathogenic nematode population dynamics. The number of entomopathogenic nematodes in each of the test plots will be quantified in April/May, July/August and October/November in each year by baiting soil samples with *Galleria mellonella* and *Tenebrio molitor* followed by dissection to reveal the numbers of entering nematodes. Each year at the end of each growing season, crop production and the number of pest insects at the plants in the carrot and cabbage fields will be estimated. In addition the occurrence of indifferent or beneficial insect species will be quantified in test areas with high and low success in nematode establishment.

2) Comparing levels of entomopathogenic nematodes on neighbouring farms with different cropping systems.

Neighbouring farms will be selected that are identical in regard to as many parameters as possible but with different growing systems. Selected farms with short and long organic farming history will be compared to their neighbouring farms in relation to nematode prevalence. The main focus will be put on organic growers including vegetables in their rotation system. Up to 10 pairs of farms will be studied by taking soil samples. Each of the samples will be baited and nematodes will be quantified and identified and correlated to cropping system, soil type and number of years with organic farming.

3) Screening of plant species for their value of supporting populations of entomopathogenic nematodes.

At KVL experimental farm Snubbekorsgård different plant species (mainly selected catch crop species from WP8) will be screened for their ability to preserve populations of entomopathogenic nematodes. The plants will be chosen among plants being regarded as valuable catch crops in the rotation system. Soil samples will be taken and nematode numbers quantified as described above (part 1).

4) Susceptibility of beneficial arthropods to entomopathogenic nematodes.

Through out the years beneficial arthropods will be collected and their susceptibility to entomopathogenic nematodes will be tested in the laboratory. As a minimum 10 species will be tested each year.

WP3: Varieties, growing stability, disease resistance, and quality

Objectives

1) To help the organic growers to choose the most stable and well-adapted varieties in crops like cauliflower, carrots and onions, and to make guidelines for choosing varieties with optimal characteristics for organic growing.
2) To study the significance of various pests, diseases and quality defects in vegetables grown in organic or conventional production systems, and if possible to identify pests or disease which are less severe in organic than in conventional vegetable production for future studies of natural regulation of pest organisms.

Description of work

Varieties of the most important vegetable crops (e.g. Carrot, cauliflower and onion) will be tested in the organic rotation in Årslev, parallel to the conventional variety trials normally performed in Årslev.

Varieties of the three crops will be tested each year from 2000 to 2004 to get reliable information of differences or similarities in the two growing systems. We plan to include varieties of more vegetable species (e.g. broccoli and Chinese cabbage) in the tests, but not all five years; the final choice of species will depend on which ones are to be tested conventionally anyhow.

From emergence to harvest a number of parameters will be registered: Leaf top size (relevant for weed competition), growth duration, harvest spread, yield, product quality, damages by diseases (e.g. Downy mildew, Cavity spot, scab and Alternaria) and pests (e.g. cabbage root fly, carrot fly, aphids, caterpillars and cutworm). After harvest carrots and onions will be placed in cold-storage to register the susceptibility to storage disorders (e.g. watery soft rot, crater rot, neck rot and liquorice rot). Samples will be taken in the two growing systems to quantify the amount of entomopathogenic nematodes (WP2) that may be one reason for possible differences in damage by important pests.

WP4: Catch crops as a tool for increasing P bioavailability on soils of low P status

Objectives

1) To test selected catch crop species for their P uptake capacity on a low P status soil.
2) To quantify the influence of these catch crops on subsequent main crop yield and P uptake
3) To quantify possible interactions between catch crop species, the crop rotation (with or without grass-clover ley) and additional P supply for the main crop.

Description of work

Studies will be carried out in a field experiment over two years. Catch crop species will include a fallowed control, ryegrass and 3-5 selected species. This selection will be closely co-ordinated with the catch crop experiments at Årslev and may draw on results of the wide screening of potential catch crops carried out by Rydberg (1998). Species known to have special abilities for P acquisition (e.g. lupin, buckwheat) will be considered.

Experimental plots will be located at the Agricultural University Experimental Farm, Taastrup, in the *Long-term nutrient depletion trial*, an 8.5 ha sandy loam field, which has been cultivated continuously with spring barley and N, but no P and K fertilizer for more than 30 years (1964-1996), producing relatively low P and K test values (approx. 10 mg bicarbonate-P and 50 mg extractable-K pr. kg soil). In 1996 a new field trial was laid out in approximately ¾ of the field and two crop rotations were started, each with seven nutrient treatments and two replicates (block design). Each major plot is approx. 1250 m^2. In the remaining part of the field, the continuous spring barley cropping has been carried on with N, but no P and K fertilizer.

Plots will be placed in one of the rotations where the last preceding crop was a second year grass-clover ley, and the plot will subsequently be sown to spring wheat or barley, in which the selected catch crops will be undersown.

The catch crops will be placed in three treatments, differing in P availability and whether grass-clover ley preceded the spring wheat: i) treatment ***B*** (moderate NKS, but no P fertilisation, grass-clover ley preceding year), ii) treatment ***D*** (moderate NPKS fertilisation, grass-clover ley preceding year) and iii) ***Outside*** (adequate N, but no P and K fertilisation, continuous cereal cropping). The treatments will be carried out in 3 replicated, randomised minor plots within one of the major plots. In the following year, the catch crops will be undersown in spring barley in the other major plot replicate, to avoid confounding.

Sampling and analyses will include i) biomass production and C, N and P content of the catch crops in late autumn and early spring, ii) soil bicarbonate P_i and P_o in early spring and iii) main crop biomass production and P content two or three times in the initial growth stages and once at harvest.

WP5: Influence of autumn green manure crops on club root (**Plasmodiophora brassicae*****)***

Objectives

1) ***To identify crucifer species or genotypes with full or partial resistance to* Plasmodiophora brassicae**
2) ***To identify crucifer catch crops that can be grown without increasing subsequent disease pressure of* P. brassicae *or can actually reduce subsequent disease pressure.***

Description of work

Resistance of different Brassica species to P. brassicae

A wide range of cruciferous crops, including exotic *Brassica* species suitable as a green manure crop are tested for susceptibility to *P. brassicae* under controlled growth condition using natural homogenized infested soil. Direct estimation of resting spores in the soil will be performed using the method described by Botz *et al.* (1988).

Brassica species with high tolerance to *P. brassicae* or and reducing effect on the number of resting spores are selected for test in field experiment.

Test of different Brassica and perennial green manure crops on disease pressure of P. brassicae

In field-experiments, the influence of a number of crucifer and perennial green manure crops on the survival of *P. brassicae* will be investigated. A bioassay method (Wallenhammar, 1996) using susceptible bait plants is used to estimate the infection capacity of *P. brassicae* in autumn before sowing the green manure crop and then again next spring before planting the cash crop e.g. red cabbage. The effect of the different green manure crops on the red cabbage is evaluated by measuring the infection level by scoring for club root symptoms and yield (quantity and quality) in the following growth season.

WP6: The effect of catch crops on soil mesofauna and earthworms

Objectives

1) To describe the effect of growing catch crops on the populations of a number of soil living animals, and to test whether important differences exist among catch crops in their effect on the soil fauna.
2) To obtain data on the effect of catch crops on the soil fauna which can be used for modelling purposes in the BIOMOD project.

Description of work

The effect of catch crops at different levels of nitrogen and potassium on the soil fauna.

The soil fauna will be sampled in the fields used by WP7. Sampling will take place regularly over the entire cropping season in order to get information on the population development during the growth phases of both the catch crop (autumn) and the following main crop (spring and summer). The data will be analysed in relation to the catch crop species, chemical measurements from WP7 and crop yield.

The effect of deep-rooted catch crops on the soil fauna.

The soil fauna sampling will take place in the fields used by WP8. Sampling will start in autumn and continue until the following summer. Results will be analysed in relation to catch crop species and the data measured in WP8

The effect of undersown catch crops in cereals on the soil fauna

Sampling will start already in the cereal where the undersown catch crop is being established and continue until the harvest of the following main crop. Results will be analysed in relation to catch crop species and the data measured in WP8

The results will be used to validate the food web model in the project “Interactions between nitrogen dynamics, crop production and biodiversity in organic crop rotations analysed by dynamic simulation models”, if both project come through.

Sampling

Microarthropods will be sampled with a 5 cm diameter core sampler and extracted in the laboratory by a high gradient extractor. Earthworms will be washed out from 25×25×25 cm soil samples taken with a spade. Collembola and earthworm will be identified to the species level and mites to the group level.

WP7: The effect of catch crops on N and K leaching and crop production, with focus on coarse sandy soils.

Objectives

1) To test whether catch crops can significantly reduce K leaching losses on a coarse sandy soil, and whether legume catch crops will reduce K leaching more than non-legumes, as their growth is not N limited.
2) To test whether undersown legume catch crops can supply enough N to sustain continuos grain production on a coarse sandy soil.
3) To identify legume- and non-legume catch crop species suitable for undersowing on coarse sandy soil.

Description of work

The investigation is carried out on two locations: on a coarse sandy soil low in exchangeable K at Jyndevad experimental station and on a sandy loam at the organic vegetable workshop area at Research Centre Årslev.

Jyndevad:

Field experiment 1: An experiment with three catch crop treatments: Clover, ryegrass and no catch crop will be established. These treatments are tested under two N-levels (i.e. undersown in barley or lupine) combined with two levels of K availability originating from K fertilisation at the start of the experiment. Dry matter yields and nutrient content in the catch crop, are measured. The following spring a cereal crop will be established and the yield measured. Soil analysis of mineral nitrogen, the different K fractions and other relevant soil parameters are carried out. This experiment is carried out in collaboration with a research project focusing on protein crops (see collaborative partners).

Field experiment 2: Two types of persistent catch crops, a non-N_2-fixing and N_2-fixing, are established each year in a four year continuos spring cereal rotation. Dry matter yields in the catch crops, grain yield, nitrate and potassium leaching, N_2-fixation among other essential plant and soil parameters are measured.

Field experiment 3: A number of different non-N_2-fixing and N_2-fixing catch crops and their mixtures are undersown in a spring cereal. Dry matter yield and nutrient content of the catch crop and grain yields of the cover crop and the succeeding spring cereal are measured among other essential plant and soil parameters.

Yield and leaching results from the treatments with and without catch crops in an ongoing project at Jyndevad “Crop rotations for cereal production in organic farming” (see collaborative partners) will be used in the data analysis in order to relate the results to a crop rotation level.

WP8: Effects of very deep-rooted crops and catch crops on N dynamics and modelling

Objectives

1) To test the significance of including crops and catch crops with very deep rooting into cropping sequences on the N dynamics in the soil, especially the effects on N dynamics in soil layers below 1.0 m (to 2.0 m or to 2.5 m if possible). Special emphasis will be given to the significance of differences in root growth among species which all have effective rooting depths of 1.0 m or more.
2) To obtain data on root growth and soil N dynamics which can be used to validate model simulations of deep soil N dynamics.
3) To identify plant species with very deep rooting which can be established as undersown catch crops in cereals.
4) To utilise current knowledge and results obtained through objectives 1)-3), and simulation modelling to build a decision support system for optimal catch crop strategies.

Description of work

An experiment at Årslev with three year long cropping sequences including species with very different rooting depth will be made to study the effect of very deep rooting on N dynamics especially in the subsoil. The experiment will start with catch crops in the autumn at a high leaching position in the crop rotation, where plots will be grown with Italian ryegrass, fodder radish or no catch crop. In the following year leek, carrot and white cabbage will be grown, and in the third year barley will be grown with either no catch crop, or catch crops of ryegrass or chicory (or another species which has been found to have very deep rooting, see Objective 3). We will not grow all 27 possible combinations, but 10 selected to allow us to make the most relevant comparisons. The experiment will be repeated twice (one series started in the autumn of 2000 and the next in the autumn of 2001) and have two replicates each year.

In the experiment, rooting depth of the crops will be measured with the minirhizotron system, where minirhizotrons extending to a depth of approx. 2.2 m will be used. Soil sampling to a depth of 2.5 m will be made in the late autumn and again in the spring and the content of nitrate-N determined, with a final sampling in the spring of year 4 to estimate the effect of the undersown catch crops. Some of the soil samples will be analysed for sulphate as well (see WP9) or soil water will be extracted and analysed for content of important ions (see WP7).

An experiment will be made to identify very deep-rooted plant species, which can be grown as undersown catch crops in spring barley. Chicory and other relevant dicot species (including some interesting legume species) with potentially deep rooting will be grown as undersown catch crops in barley, and compared to plots with perennial ryegrass and control plots. The experiment will be made on a field where significant amounts of available N will be present in the subsoil. In November soil samples will be taken to 2.0 or 2.5 m. Root growth will be tested with 2.2 m deep minirhizotrons on the species which are found to be most interesting; in the first year at least on ryegrass and chicory. N uptake and C/N ratio of the catch crops will be determined in the late autumn, and N_{min} will be measured in the following spring to test whether the catch crops can supply N for a succeeding crop as well as reduce leaching losses. We want to test approx. 20 crops, but do not have the capacity to test that many at once, thus the experiment will start in 2000 and be repeated four times, but only the two control treatments (no catch crop and ryegrass) will be included every year. Some of the species will be studied for their effect on S leaching and subsequent S mineralization (see WP9), whilst other of the species will be studied for their ability to mobilise soil P (see WP4) as well.

Development of a decision support system will be initiated with a synthesis of existing knowledge about the effects of catch crops on crop rotation N dynamics, as it can currently be described by the dynamic simulation model DAISY (Jensen *et al.*, 1999). This will involve close co-operation with the modelling project (BIOMOD), but in addition more detailed calibration of crop modules for various vegetable crops will have to be performed as well as preliminary calibration of deep root development. All the scenarios described for the experimental activities of this WP will then be simulated and the response matrix for the different strategies used as a basis for drafting the structure of decision support system. Once experimental data from this WP and the scenario analyses of the modelling project (BIOMOD) are available in the later stages of this project, further validation and refinement of the decision support system can be carried out.

WP9: The effect of catch crops on sulphate leaching and availability of S for the succeeding crop

Objectives

1) To determine the ability of catch crops to reduce soil sulphate concentrations during autumn and winter
2) To determine the ability of catch crops to make S available for the succeeding crop through mineralization.

Description of work

At the workshop area in Årslev a number of different catch crops and catch crop strategies are tested (see WP8). With emphasis on the cruciferous species, these experiments are used as the basis for studying the effect of catch crops on sulphate leaching and availability of S in the succeeding crop in combination with pot experiments. The investigation is focussing on two aspects:

1 The ability of catch crops to reduce soil sulphate concentrations during autumn and winter

The soil sulphate content is determined in the soil profile under catch crops during autumn and winter by soil sampling in 25 cm intervals in 0-150 cm. Concurrently, plant material is sampled to determine the S-uptake in catch crops. The plots will be Italian ryegrass, fodder radish or no catch crop. Additionally Chicory and other dicot species will be used (see WP8).

2 Mineralization of catch crop S

The mineralization of S in catch crops is investigated by soil sampling in the field. To estimate the straight effect of S, catch crops are furthermore incorporated in pot experiments under natural temperature conditions (Eriksen *et al.*, 1995) where other main nutrients are available. In pots without plant cover the timing of the S release is followed by soil water sampling and in pots with plant cover its relation to plant needs is determined. Factors capable of improving this synchrony (incorporation time, method and crop species) are investigated. As test plant spring barley is used from which harvest yields will show differences in S availability.

B. Objectives and expected achievements

The major research objectives of this project are to create better opportunities for an increased organic production of a wider range of vegetables and other crops.

As shown in figure 1, we want to work with some of the main problems limiting current organic vegetable production, i.e. pests and diseases, nutrient limitations and the interactions between them. The partial research objectives have therefore been formulated to address these important problems and their interaction as outlined in figure 1:

Improve nutrition of the main crops through strategic and integrated use of catch crops and green manures and study both their direct effects on nutrient retention and mobilisation as well as indirect effects through impact on soil fauna.

Handle pests and diseases through improved cultivation strategies, including the effects of catch crops and green manures on pathogen pressure and natural fauna of predators of pest insects.

Improve the quality of the produce, through adapted cultivation methods, variety choices and interactions with both diseases/pest and nutrition status

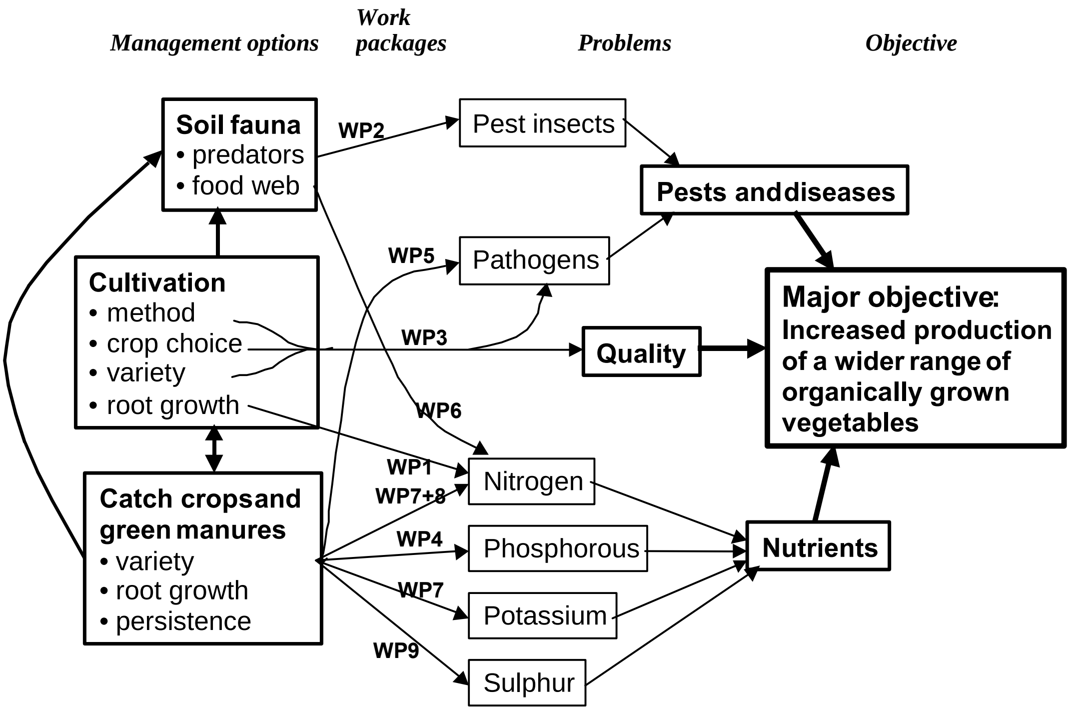


Figure 1. Overview of the major problems, management options and their interaction in relation to an increased production of organic vegetables. The figure is not a representation of all interactions, only the most important ones addressed in this project have been included. WP refers to the work packages described in section 4 and 6.

To pursue the objectives a number of work packages have been designed. With these work packages we have aimed at tackling some, but not all, of the important problems identified in figure 1.

With the results from this project, a major achievement will be the improved recommendations to farmers, advisors, and agricultural students. We expect the project to have a large impact on actual production practices, as the major part of the research will be conducted in a functioning and well-known vegetable crop rotation experiment (Thorup-Kristensen, 1999). The dissemination of results naturally includes communication of already existing knowledge, most directly through the development of a decision support system. New and already existing knowledge will also be communicated through the project home page, through articles and lectures for farmers and advisors and through education of students at the Royal Veterinary and Agricultural University. We plan to attach a number of agricultural students to the project for doing their MSc projects.

Apart from fulfilling the defined objectives of the project, the results could be valuable in other contexts as well. If catch crops become more widespread in organic crop production, we believe that we have not only contributed to an increase in organic production, but also done so in a way that is very well in line with the basic ideas behind organic farming. Growing catch crops is a biological method to handle problems, and by growing a number of different plant species as catch crops we use the internal resources on the farms, and introduce a higher biological diversity. Further, catch crops can be expected to favour soil organisms and other species in the agricultural areas, and to contribute to maintain or build up soil organic matter.

Some of the results could also be very valuable to conventional farming. With increased environmental concern, and regulations on the use of pesticides and N fertilizers, alternative methods for crop protection, selection of more tolerant varieties and better understanding of how to design N efficient crop rotations could be used directly in conventional farming. New legislation (since 1998) aimed at reducing N losses from agriculture requires Danish farmers to grow catch crops on part of their area. Results from this project, which make catch crops more useful for reducing N losses, increasing N supply for main crops and achieving other goals could be valuable both for farmers directly, and for future adjustments of the legislation.

Most scientific attempts to quantify N leaching losses are based on the assumption that the effective rooting depth is approximately 1.0 m. This assumption is used both when collecting soil water to study the leaching experimentally, or when using simulation models to estimate N leaching in various scenarios. If some crops or catch crops have effective rooting depths, which are significantly deeper than 1.0 m, conclusions based on this assumption could be misleading, not only quantitatively, but also give wrong conclusions when comparing the effect of various crops or other scenarios. The results from this project could help evaluate the validity of the hypothesis that 1.0 m can reasonably be assumed to be the bottom of the rooting zone, or whether other approaches must be used to arrive at the right conclusions.

C. Results and progress

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

The project is now almost finished. It was scheduled to be finished by the end of 2004, but last year an extension of a minor part into 2005 was accepted. This year we apply for the transfer of some more funding to 2005, so that work will continue into 2005 within 3 of the WPs. However, two of the work packages have already been finished (WP2 and WP9), and most of the others will finish by the end of 2004.

To present the project results internationally, we are planning a workshop to be held at FIBL in Switzerland in 2005, on rotational effects, and effects of fertility building crops in cooperation also with SLU in Sweden and HDRA from the UK. At this workshop we plan to make presentations from several of the WPs of the VegCatch project, and to give a presentation of the VegCatch project as such, and the main ideas behind it.

Many interesting results have been produced. A main idea behind the project was to study the effect of crops (main crops, nitrogen catch crops or green manures) on succeeding crops in a rotation, as “pre-crops” must be established, before the measurements of pre-crop effects can be made. In a few of the experiments the same plots are followed for three years to study such effects during longer cropping sequences. Therefore, some of the field experiments have just been finished, and final data analysis are just beginning.

In studying the pre-crop effects of main crops, the studies must concentrate on the crop species, which are normally grown, as these crops are chosen by farmers based on the marked and the economic results to be expected. When growing catch crops and green manures on the other hand, we have found it obvious also to study species, which have not normally been grown. Catch crops and green manures are grown for their effects on the soil, and the choice of plant species are not limited by factors such as marketability.

In some of the experiments very significant effects of catch crops have been observed, sometimes with striking differences among the catch crop/green manure species. This is the case with rooting depth of catch crops, their N and S uptake, the C/N, C/S and C/P ratios in their biomass and release of N and S for succeeding crops as well as the effects of catch crops on the population density and species composition of mesofauna and earthworms in the soil and their susceptibility to *Plasmodiophora brassicae* (club root). We expect further interesting results to be found in the experiments on catch crop effects on P dynamics, on K dynamics and losses on sandy soil, on the occurrence of *Plasmodiophora brassicae* (club root).

The results of WP2 indicate that catch crops may have a limited effect on the occurrence of entomopathogenic nematodes (EPN) in the soil, but there seem to be clear effects of the choice of main crops. Interestingly, a full year green manure crop did actually reduce the occurrence of EPN in crops. Interestingly, a full year green manure crop did actually reduce the occurrence of EPN in the soil, whereas rapeseed, carrots, cabbage and peas increased it. Highly significant effects of different main crops in a cropping sequence has also been found in WP8 where the potential benefit of introducing very deep rooted crops such as cabbage at the right place of a crop sequence has been shown. Studies of root growth and N dynamics of a number of vegetable crops in WP1 will make these results more useful for vegetable crop rotations.

In some of the work packages more general “system effects” have also been found. Studies of EPN in the soil of organic farms and at conventional neighbour farms showed large differences. Also the study of different varieties of cauliflower, onion and carrot grown both organically and in conventional farming show system differences. Some diseases and pests are less problematic in the organic production than in conventional production. With one of the crops (carrots) this has actually led to higher saleable yield in organic production, especially due to a lower incidence of the cavity spot disease.

Many of the participants in the projects have been working on organic farming research for a number of years before the project, e.g. on previous DARCOF projects. This have helped the dissemination of the project results during the early stages of the project, where the ideas of the project and the results obtained within the VegCatch project are thereby included together with results from previous work in presentations and publications aimed at farmers, advisors and agricultural students.

Based on the progress and the results until now, we believe that the project will be able to reach its main goals, and to produce a number of results which is interesting both scientifically and for practical use in organic farming.

WP1 Nitrogen relationships of vegetable crops

1.1. Experiments with root growth of six vegetable crops

The first round of experiment including red beet, celeriac and sweet corn was finished in 2001. In 2000, the sweet corn crop failed, but apart from this, the experiment has been successful. Red beet reached rooting depths of between 150 and 200 cm, whereas celeriac reached less than 50 cm. In 2001 sweet corn grew to between 90 and 120 cm. Detailed analysis of the root distribution have shown that the crops do not distribute their roots equally well in the soil; the root system of red beet was much more evenly distributed in the soil than that of celeriac. This indicates a more optimal root distribution of red beet than of celeriac, also within soil volumes well rooted by both crops.

In 2001 there was a clear effect of incorporation time of the preceding green manure crop on rooting depth of the vegetable crops. Rooting of sweet corn and red beet was approx. 50 cm deeper after autumn incorporation of the green manure than after spring incorporation (figure 1.1). A similar effect was only indicated in the results of 2000. Combined with previous results, and similar observations for white cabbage in WP 8, this observation show, that presence of available N in deeper soil layers may increase rooting depth of some crops. A scientific paper on this experiment has been submitted.

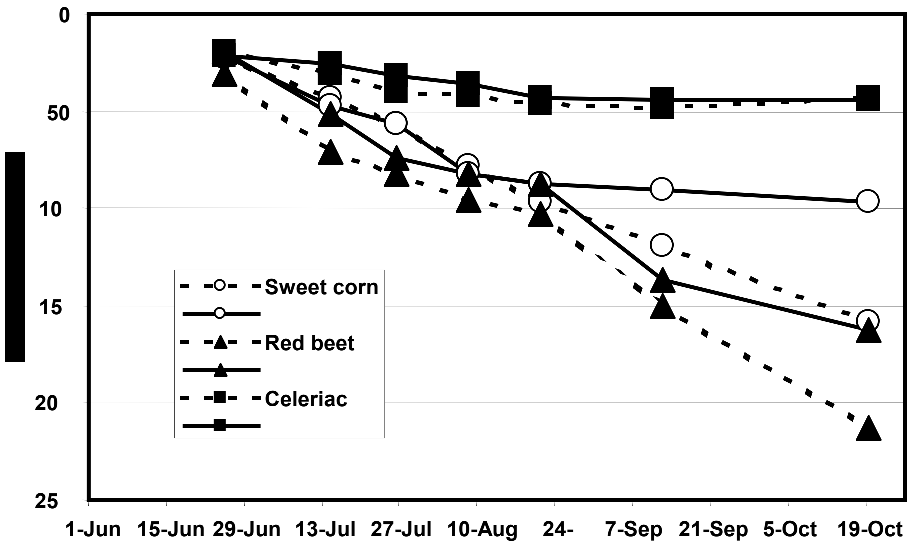


Figure 1.1. Rooting depth development of three vegetable species during 2001. Dashed lines show development were the preceeding catch crop was incorporated in November, full lines where it was in corporated in April.

N_{min} measurements showed a clear relationship between the observed rooting depth, and the ability of the crops to deplete N_{min} from the different soil layers during the growing period. Red beet depleted the upper 150 cm of the soil to only approx. 20 kg N_{min} ha^{-1}, whereas celeriac left approx. 75 kg N ha^{-1}, and the N uptake of the crops corresponded to the difference in soil depletion. Results obtained in WP8 show a clear example of why this sort of information is important for design of crop rotations with high N use efficiency and low N losses to the environment.

In 2002 and 2003 the experiment was continued with three other vegetable crops, potatoes, Chinese cabbage, and squash. The results show potatoes to have rooting depths of roughly 70 cm, with clearly weaker rooting between crop rows than in the crop rows. Chinese cabbage showed fast root growth, but with a short growing season its rooting depth was less than 150 cm at harvest, whereas squash which continue their growth into early September show rooting depths of more than 200 cm, combined with very high root intensities. For squash as well as Chinese cabbage root growth between the crop rows was as intensive as root growth directly under the crop rows, even though the row distance of squash was as high as 75 cm.

A masters thesis (*Root systems of vegetables and root development in relation to nitrogen distribution in the soil profile*) have been made and defended in 2002 working in detail with the root and N_{min} data from 2000. In 2003 a bachelor thesis (*Three vegetable crops grown after green manure incorporated at different dates, - Effect on rooting depth, yield and the risk of nitrate leaching* loss) made by two students on the more general effects of incorporation time, N_{min} and root growth on yield and N dynamics have been made using data from 2000 and 2001 have been successfully defended.

1.2. Experiments with spring green manure

The 2001 version of this experiment mostly failed, as previously reported, but the 2002 version of the experiment went well. The results are somewhat surprising. The green manures grew strongly during the spring, and at the later dates of incorporation there were much more green manure biomass and N to be incorporated in the soil. All green manure treatments increased white cabbage growth and N uptake as expected, but surprisingly there were no differences between incorporation dates on N_{min} in the soil, or on cabbage growth and N uptake, irrespective of the large differences in biomass production in the spring.

The conclusion must be that it is not recommended to allow legume green manures to grow in the spring, and it may induce problems due to water use in the spring, and problems with main crop establishment due to late incorporation of substantial amounts of organic matter. More positive results from especially USA may be due to green manures which were established later and achieved little growth during the autumn, they are more dependent of spring growth for a significant result.

WP2 Entomopathogenic nematodes in organic cropping systems

All activities have been finished and the following conclusions can be given:

1) EPN were in general at a low level or absent (0-20 % positive cores). This was the situation for the neighbouring farms and for Årslev whereas Snubbekorsgård generally had a high level (30-80 % positive cores). The species *Steinernema feltiae* and *S. affine* were observed.
2) EPN abundance changed over time at Årslev and Snubbekorsgård. The changes corresponded to the availability of insect hosts. Crops with high numbers of insects (pea, oil seed rape and partly cabbage) increased the level of EPN and minor effects of different catch crops were also seen.
3) The low level of EPN at Årslev could be artificially raised by inoculation of EPN and the off-spring of released nematodes were also re-isolated in the latest survey (1½ year after inoculation).
4) Quantification of insect pests at Årslev showed that root pests were at a low level in cabbage, carrot and clower/alfalfa whereas pea was heavily infested by weevils (*Sitona lineatus*)
5) Regulating effects of EPN on pest insects could not be tested as the initial levels of EPN were to low to enable this analysis. EPN-infected *S. lineatus* were, however, observed.
6) The side effects of EPN on ground beetles appeared to be low as most tested species generally had a low mortality. However, a closer study, varying the test conditions and including the larval and pupal stages of selected ground beetle species is recommended. A relevant candidate for such a such could be the carabid, Pterostichus melanarius.

Apart from the papers already published, the following are being prepared:

Otto Nielsen, Anne Anttila, Holger Philipsen. Susceptibility of ground beetles to entomopathogenic nematodes under laboratory conditions (manuscript almost ready for submission – awaiting comments from colleague abroad).

Otto Nielsen, Holger Philipsen. The influence of main crops and catch crops on the abundance of Steinernema feltiae (manuscript refer to the first and second manuscript above and will be submitted as soon as these manuscripts are in press).

Otto Nielsen, Holger Philipsen. Insektpatogene nematoder i danske jorde. Forekomst og samspil med insekter. Manuscript in preparation.

WP3 Varieties, growing stability, disease resistance and quality

Over a 4-year period (2000-2003) 5 varieties of onions, carrots and cauliflower has been grown organically and conventionally. In 2003 broccoli was studied instead of onions.

Onions

The main conclusions is that even though yields and bulb size are smaller among organically grow onions, then discarding in general is lower and growth stability is just as good compared to conventionally grown onions.

After storage, the average marketable yield over 3 years of organic onions was 38.5 % (weight) lower than corresponding conventional onions. Some of the explanation is to be found in the establishment of the onions. Organic onions are sown in single rows to make weed control easier, whereas conventional onions are sown in double rows. Furthermore the organic onions are sown later because of the establishment of false seedbeds for weed control in the organic fields. This arrangement causes a shorter growth period in the organic fields compared to the conventional resulting in is smaller bulbs and smaller total yields. On average, onions grown organically were healthier than the onions grown conventional after storage; otherwise the difference between the two growing systems would have been bigger (figure 1).

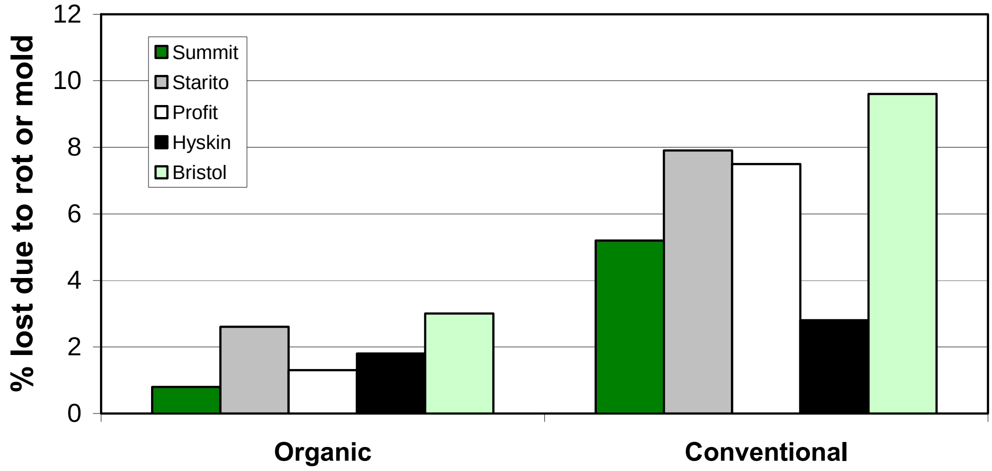


Figure 1. Effect of onion variety and cropping system on storage losses due to diseases.

Infection of downy mildew (*Peronospora destructor)* was typically three weeks later in the organic fields. One explanation is that the onions here have a lower plant density and have more space and air circulation within the canopy, which reduce humidity and thereby the establishment of the mildew spores. We have not found significant interactions between varieties and cropping system.

Cauliflower

Results of the midsummer cauliflower experiments are finished. It seems possible to grow the same amount of marketable curds in organic production as in conventional production - provided that the organic plants are covered with insect net all up till the first harvest. The organic curds were slightly smaller than the conventional, but well above the minimum size for sale. On average (2000 – 2002) the organic curds measured 13 cm and weighed 794 g. The conventional curds measured 14 cm. and weighed 926 g.

The results reveal no significance in discarding among the two systems. In the conventional system approx. 24% (amount) was discarded and in the organic 27%. The main reason for discarding in conventional curds was hollow stem. On average 10% of the conventional curds were discarded on this reason, whereas only 2% of the organic curds had this failure. The main reason for discarding among organic curds was the occurrence of loose florets, as 4% was discarded for this reason, whereas less than 1% of he conventional curds were discarded due to loose florets. The organic cauliflowers were not growing quite as fast as the conventional, and that's why we don't see so many curds with hollow stem.

In 2003, 29% was discarded in the organic trial and 61 percent was discarded in the conventional trial. This was because of pest attacks (*Contarinia nasturtii* and *Lygus rugulipennis*), and other quality defects. The organic trial was covered with insect net and were not damaged by these insects, and the level of other quality disorders were lower as well.

Broccoli
5 varieties of broccoli were grown in organic and conventional systems in 2003. The organic trial was covered with insect net all up till the first harvest. As was the case for cauliflower, the yield of conventional broccoli was also very low due to pest attacks, and the marketable yield was very low (figure 2).

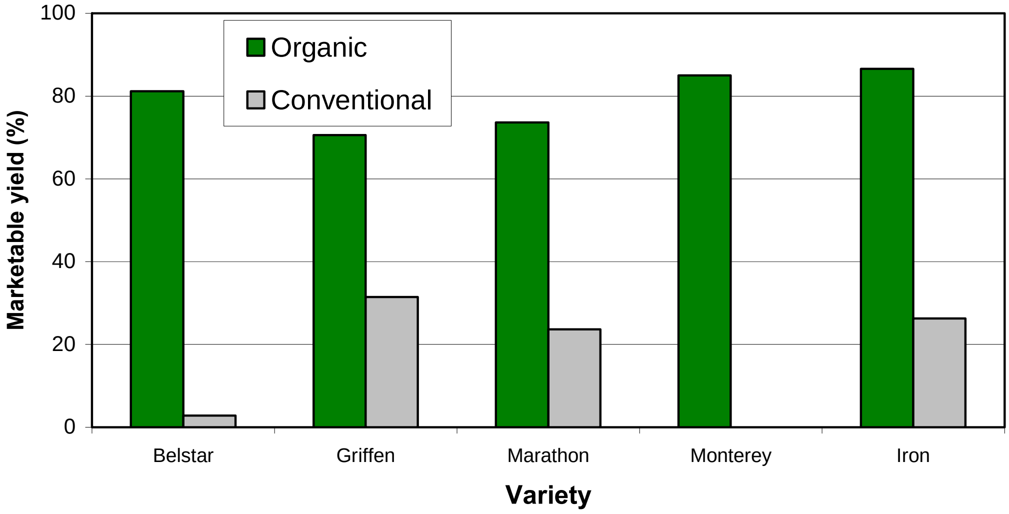


Figure 2. Effect of variety and cropping system on marketable yield in broccoli 2003.

Carrot
All four years, gross yields have been the same in conventional and organic production of carrots. In 2001 and 2002 there was a slightly higher discarding at harvest in the conventional carrots compared to organic carrots, though in 2002 the quality was very good in either growing system. In all four years conventional fields tend to host more carrot flies and therefore reveal most attacks (table 1). Discarding because of cavity spot was lower in organic fields, and therefore the marketable yield was higher than in conventional production. In 2000 and 2001 organic carrots revealed a poor shelf life after storage.

		2000	2001	2002	2003
Organic	**Bolero**	**0,0**	**1,4**	**0,8**	**4,5**
	Rodelika	**0,2**	**2,1**	**0,7**	**2,1**
Conventional	**Bolero**	**2,8**	**10,7**	**1,9**	**9,2**
	Rodelika	**3,9**	**13,3**	**2,6**	**6,7**

Table 1. Effect of cropping system on carrot fly attack (% carrots attacked).

WP4 Catch crops as a tool for increasing P bioavailability on soils of low P status

The field experiments have been carried out over two years (2001-2002, 2002-2003) in the Nutrient Depletion Trial at KVL's Research Farms in Taastrup, a site that hasn't received P or K containing fertilisers or manures for more than 30 years. In 1996 a new field trial was laid out in part of the field, with two crop rotations and seven nutrient application treatments. In selected treatments (0P and 0K, 0P and 60K, 10P and 60K, all with 60N) 5 selected catch crops (Ryegrass, Lupin, Chicory, Rumex and Kidney Vetch) were undersown in spring barley; a control with no catch crop was also included. The catch crops were incorporated in winter/early spring and the effect of the incorporated catch crops quantified in a subsequent spring barley (cultivar Otira, known to be sensible to P deficiency due to short root-hairs).

Sampling and analyses have included biomass production and N, P and K uptake of the catch crops (and weeds in the control) in late autumn and main crop two or three times in the initial growth stages and once at harvest (in 2003 only for catch crop treatments chicory, ryegrass and control). In addition, the catch crop effect on autumn and spring mineral N content was measured. The experimental work was finalised in 2003 and all analyses have now been completed in 2004.

In 2001 catch crops were poorly establish because of late sowing and adverse soil conditions during spring, whereas in 2002 establishment was better. This was to some extent reflected in higher N accumulation and P uptake of some of the catch crops in November 2003 (Fig. 1), in particular Lupin, Ryegrass and Kidney Vetch performed better than in 2002. There was no significant difference in catch crop N or P uptake between the nutrient level treatments. However, generally P uptake of the catch crops in either year was relatively moderate (0.8-4.6 kg P ha^{-1}), and it should be noted that the weeds in the control in many cases took up nearly as much N and P as the catch crops. This reflects the relatively infertile soil of the nutrient depletion trial.

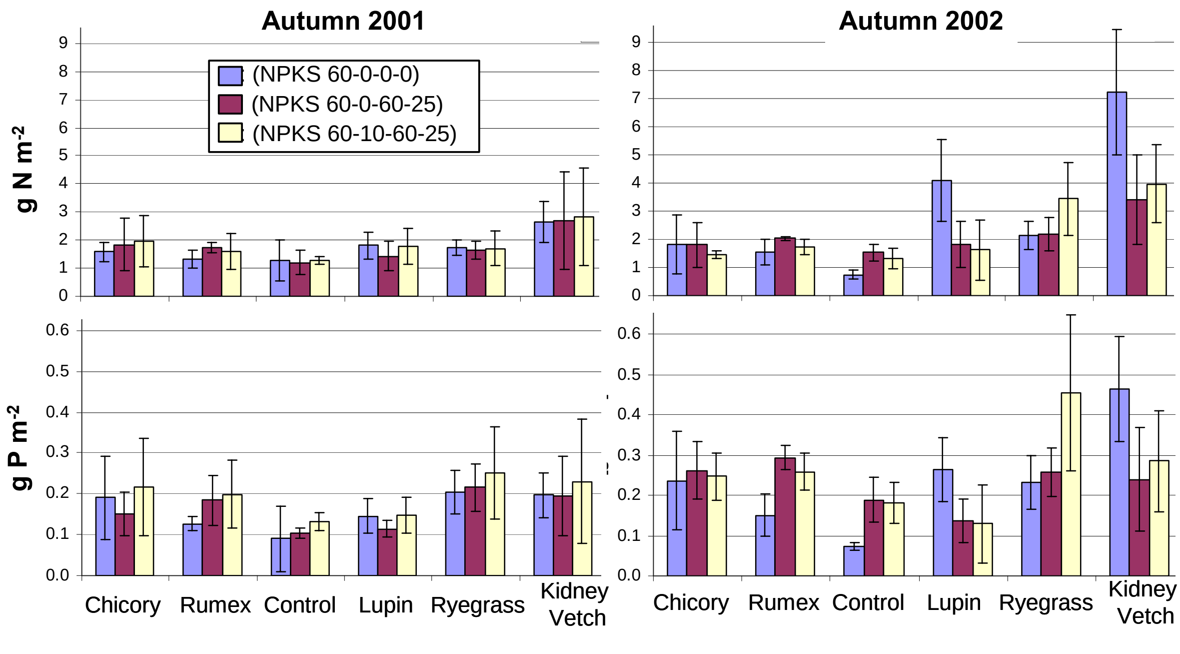


Fig. 4.1. Content of N and P in above ground biomass for the various catch crops in the three nutrient treatments (measured in late autumn of 2002 and 2003).

The P concentration was higher for Rumex than for any of the other species in all treatments and both years and the C/P ratio thus accordingly the lowest (Fig. 4.2). Both lupine and kidney vetch had low P concentrations, less than 50% of the concentrations found in Rumex, and their concentration was much less affected by the soil depletion treatments. These two species appear to be P efficient as they can grow with low concentrations of P in the biomass and can acquire P even at strongly depleted soil. However as suppliers of P for succeeding crops they may not be very good, as their C/P ratios are very high.

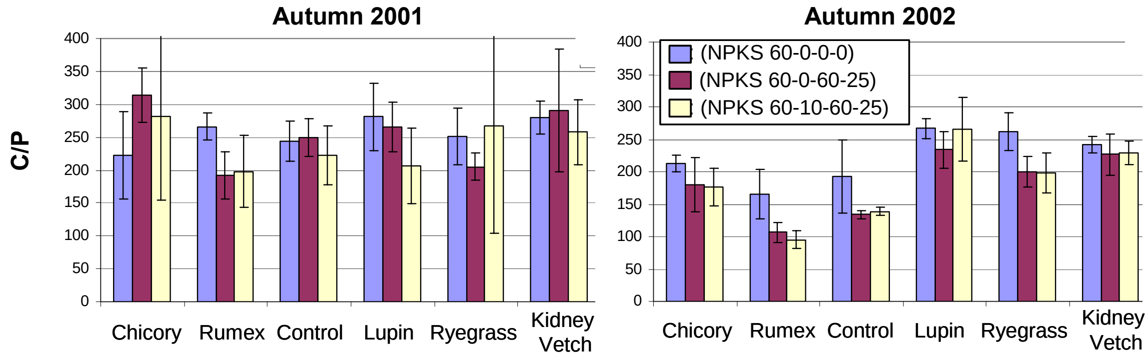


Fig. 4.2. C/N and C/P ratios of the above ground biomass for the various catch crops in the three nutrient treatments (measured in late autumn of 2002 and 2003).

Yields and N, P and K uptake in the subsequent spring barley crops revealed no significant effect of any of the catch crop treatments in either of the experimental years, in spite of the somewhat better catch crop growth in 2002. The spring barley grain yield responded significantly to both P (60-10-60) and K (60-0-60) treatments in both years, and P uptake was significantly higher for the P treatment (Fig. 4.3. top), but no effect of catch crops compared to control. Sampling during the growing season did not reveal any “starter effect” of the catch crops in the no P and K (60-0-0-) treatment for either of the experimental years (Fig. 4.3. bottom).

In conclusion, our results from this relatively infertilie soil did not indicate any beneficial effect of catch crops on crop P supply.

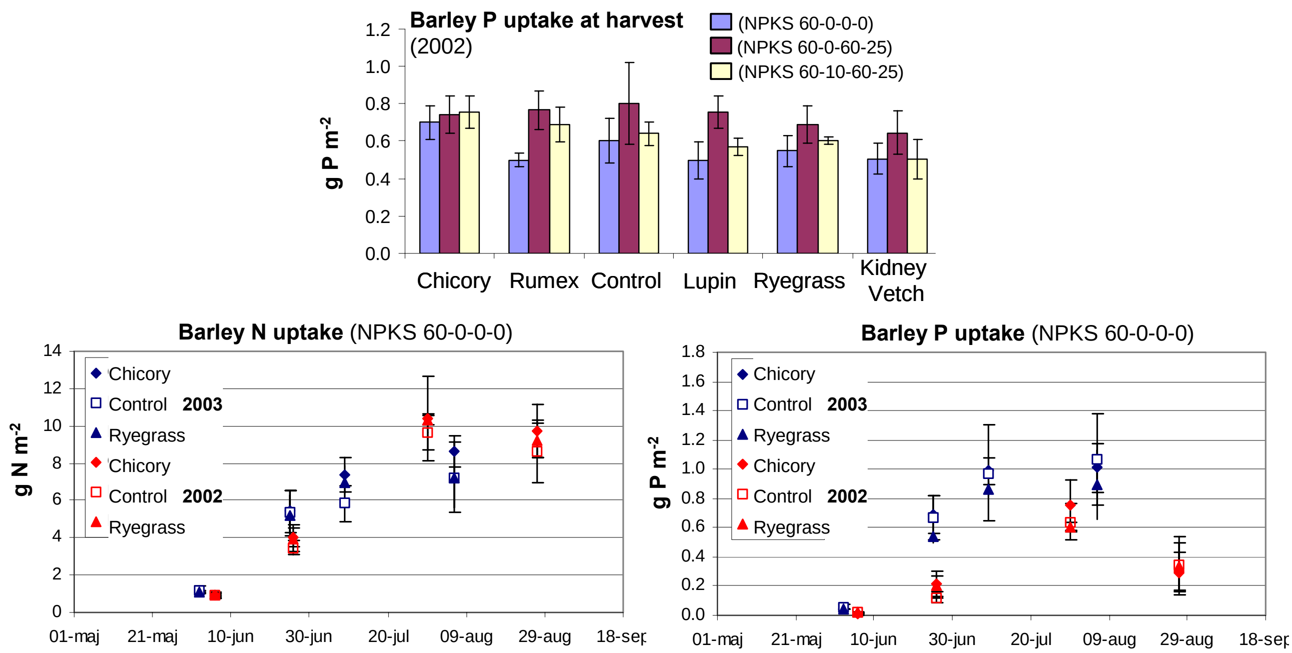


Fig. 4.3. Content of N and P in above ground biomass for the various catch crops in the three nutrient treatments (measured in late autumn of 2002 and 2003).

WP5 Influence of autumn green manure crops on club root

A pot experiment was made with *Brassica rapa, Sinapsis alba, B. napus, R. sativum, B. oleracea, B. campestris, Isatis tinctoria.* Club root infested soil from a cabbage grower was used as inoculum. This inoculum was mixed in to a semi-sterile soil:sand mix corresponding to 0, 10, 25, 50 or 75 % of the total amount of soil in each pot (1600 g). Plants were harvested six weeks after sowing and the following parameters were measured: shoot and root dry weight, numbers of plants with clubbed roots and the amount of arachadonic acid in root tissue. Arachadonic acid was measured with the whole cell fatty acid procedure where all fatty acids are extracted from the root tissue and analysed using gas chromatography.

R. sativum had significant lower frequency of plants with clubbed roots than the other plant species. Approximately every second plant had clubbed roots in this species, whereas all roots were clubbed in all the other plant species. Moreover, growth of *R. sativum* was also less affected by *P. brassica* inoculation in terms of plant growth depression. Clubbed roots contained the fatty acid arachadonic acid which was absent from healthy roots (figure 5.1) indicating that this fatty acid might be used as a biomarker for *P. brassica* in root tissue.

The concentration of arachadonic acid was lowest in *R. sativum* which support the potential use of arachadonic acid as a biomarker for *P. brassica* as *R. sativum* also had less clubbed roots than the other plant species. To our knowledge fatty acid based biomarkers is a novel methodology in club root research and might also be used to quantify soil inoculum potential by measuring the concentration of arachadonic acid in soil.

The same plant species as in the green house experiment and two additional species (ryegrass and oat) were sown in a club root infested area. Due to adverse weather conditions only the following four plant species got established at an acceptable level: *B. rapa, R. sativum, S. alba* and *B. campestris*. Three month after sowing twenty plants from each replication were collected and scored for presence of club root. As in the pot experiment *R. sativum* developed less plants with clubbed roots than the other three plant species (figure 5.2).

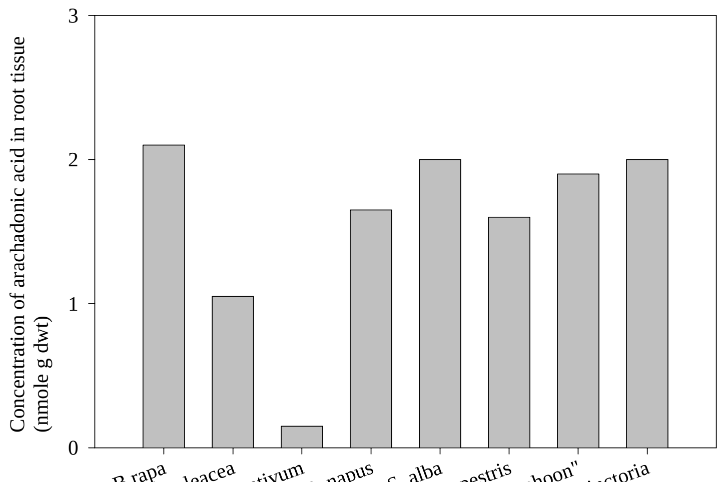


Figure 5.1. Concentration of the *Plasmodiophora brassica* biomarker arachadonic acid (20:4) in root tissue from cruciferous plant species grown in soil inoculated with club root infested soil (10 %).

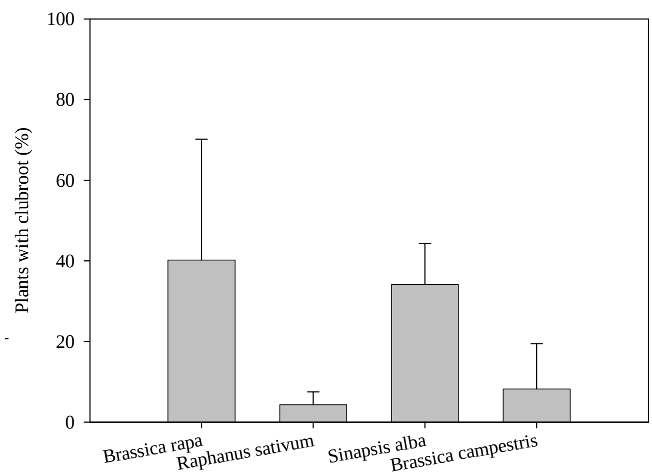
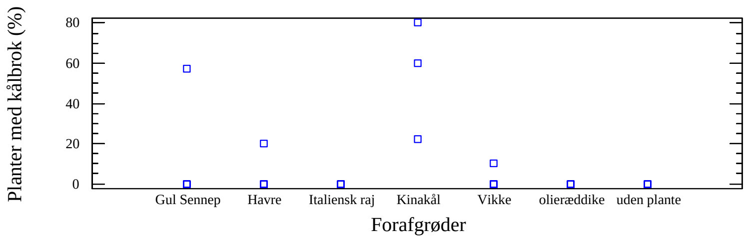


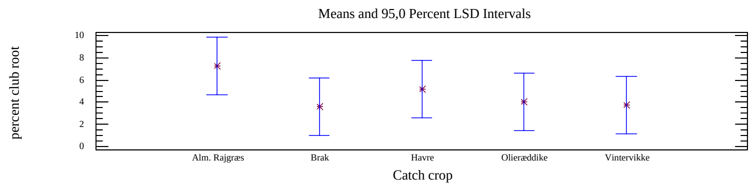
Figure 5.2. Percent plants from the field experiment with clubbed roots (n=20)

The main objective of the experiments of 2004 was to study the influence of cruciferous catch crops on the soil inoculum potential for a following cruciferous crop, both in field and pot experiments. In a pot experiment conducted in the greenhouse during the winter 2003/04 it was found that *P. brassicae* susceptible plants increased the inoculum potential of the soil, whereas the more resistant species *R. sativum* did not increase the inoculum potential (figure 5.3).



Figur 5.3. Scatterplot of "percent plants with club root" in Chinese cabbage grown after incorporation of various pre-crops in the pot experiment. (n=5, except with Chinese cabbage where n=3).

A field experiment was made at Knud Vincent to test the influence of *R. sativum* and three non-cruciferous catch crops on *P. brassicae* soil inoculum potential. No highly susceptible catch crops were included. In the field experiment the infectious potential of the soil was much higher than in the pot experiment, where the field soil was diluted. The effect of the four catch crops was tested next spring with crops of Chinese cabbage and *R. sativum*. High infection was found in Chinese cabbage and low infection in *R. sativum*, but no effect of precrop were found (figure 5.4). Soil from this experiment was used in a dilution experiment where the infected soil constituted 0%, 5%, 25%, and 50% of the soil mixture in the pots. However, even at the 5% infected soil, the test plants were all infected, thus this experiment gave no further information on infection potential.



Figur 5.4. Percent club root in *R. sativum* grown after preceeding catch crops on a club root infested area at kålavler Kund Vincent (n=6).

A final experiment is planned, to study the possibility of using the fatty acid arachadonic acid as a bio-indicator of club root infectious potential in soil. The content of arachadonic acid will be tested in three soils known to be infested with club root and three soils known not to be infected. The results will be correlated to results from a plant assay using Chinese cabbage.

WP6 The effect of catch crops on soil mesofauna and earthworms

The sampling of mesofauna and earthworms in the undersown catch crops in cereals at Research Centre Årslev was made five times from June 2000 until April 2001 to measure populations of Collembola and mites in the soil. At two autumn dates also the effect of undersown catch crops on the earthworm fauna was studied.

The densities of mites and Collembolas are remarkably high (up to 140,000 m^{-2}). Undersown catch crops caused a large increase in Collembola densities compared to the control. Some of the species occurring in high numbers are surface living and are important preys for polyphagous predators (spiders and carabid beetles), that play an important role in natural control of aphids. Concering the mites the picture is different. The densities are very high, up to about 125,000m^{-2}, but there is no clear difference between the plots with undersown catch crops and the control.

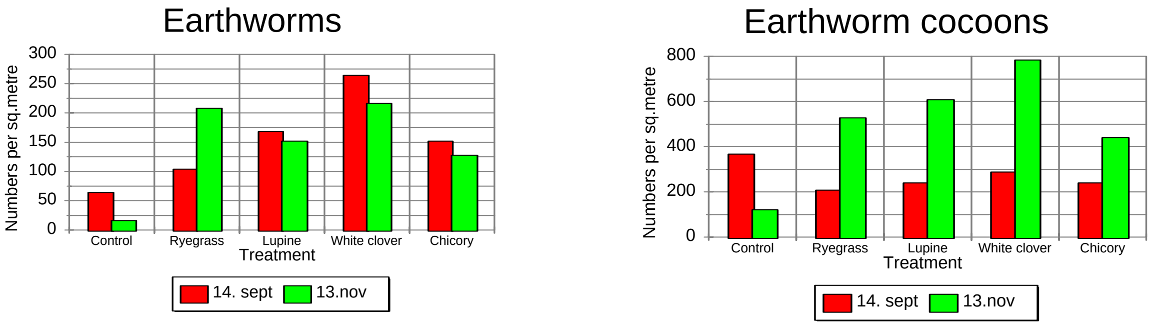
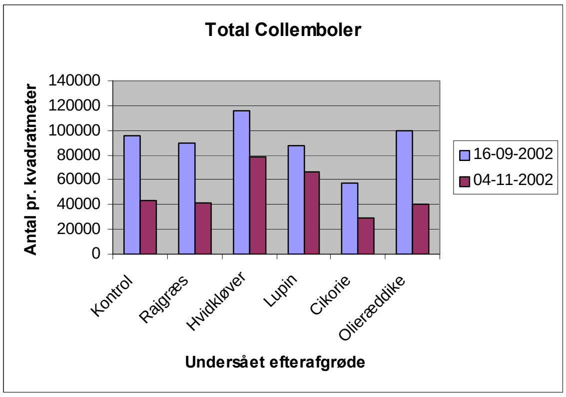


Figure 6.2. The densities of earthworms and earthworm cocoons in plots with undersown nitrogen catch crops at Research Centre Årslev during the autumn 2000.

The occurrence of earthworms was not especially high for organic fields but is clearly affected by the undersown catch crops, as the densities were higher in the catch crop plots than in the control plots. In mid November the difference is close to a factor 10. The most interesting results concerning the earthworms are probably the large effect on cocoon density on 13 November. These results indicate a considerable potential for high earthworm numbers the following year.

In the autumn 2001, soil fauna in deeper soil layers were studied (down to 2 m) under the undersown catch crops. The rationale behind this investigation was the extremely high densities in the upper soil layers, and that some of the crops grow very deep root systems (se WP 8). The results showed no mesofauna below 1 m. In the layer between 50 cm and 1 m the densities were low ranging between 0 and 700 springtails m^{-2} and between 0 and 3000 mites m^{-2}. The high value of 3000 m^{-2} was found under Rumex but due to large variation the difference to other catch crops was not significant.

The impact of undersown catch crops on the soil mesofauna was investigated on sandy soil in Jyndevad in the autumn of 2002, and the results were surprising in two respects. They were surprising by showing very high densities of both springtails and soil living mites. There were up to 120,000 springtails per square metre in the plot with undersown white clover, while the other catch crop plots had densities of about 100,000 individuals per square meter. Only chicory had a clearly lower density. The control plot had also a density of about 100,000 m^{-2}, which was the other surprise. This means that we could not se a strong effect of the catch crops (statistical analysis has net yet been performed), most likely because the densities were extremely high even without the catch crops. Furthermore, we saw decreasing densities during the autumn which the opposite of the observations from Aarslev in 2000.



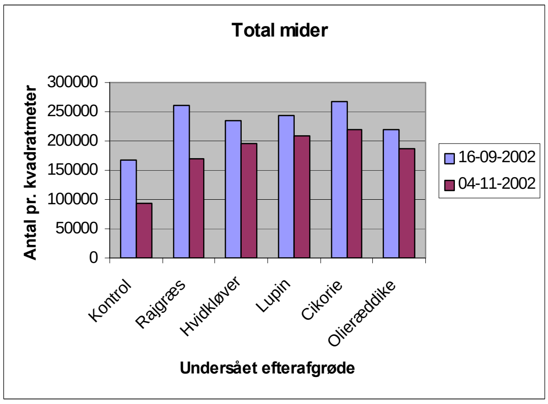


Fig. 6.1. The densities of springtails (Collembola) and mites in the plots with undersown catch crops on sandy soil in Jyndevad.

The dominating species was Isotoma tigrina, which is a surface living species and may play an important role as prey for polyphagous predators. The densities of mites in the plots with undersown catch crops are higher than the control and the difference is most likely significant. The mite densities of about 250,000 m-2 are extremely high and range among the highest observed densities in agricultural soils in the world.

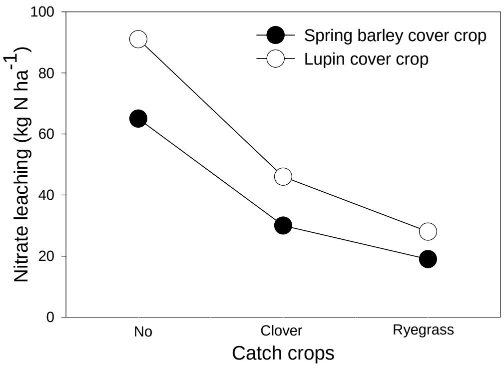
A masters student from University of Aarhus is going to carry out a masters project on the abundance of springtails and polyphagous predators in catch crops on private farms. During her project she will investigate the correlation between the large numbers of spring-tails and predators on the soil surface. The sampling will be carried out on private farms in order to investigate whether the high densities observed at the research station also can be found on private farms.

The experiments are now finished, and the work now concentrates on publication. Based on the results obtained, only one scientific paper is planned, presenting the data from experiments at both sites/soil types.

WP7 The effect of catch crops on N and K leaching and crop production on coarse sandy soils

7.1. Comparison between legume catch crops and non-legume catch crops under different N and K conditions

The hypothesis of this experiment is that legume catch crops are better than non-legume catch crops to reduce K leaching losses under conditions with a low N level in the soil. A low and a high N-level were established using a grain and a legume crop, respectively and the two K levels were obtained by K exhaustion prior to the experiment and by application of KCl fertilizer. Suction cups were installed after harvest of the cover crop in 2001 and again in 2002. In 2003 a barley crop was established to measure the effects of the different catch crops. The activity is carried out in collaboration with Project 1.5 "Grain legumes and cereals – new production methods for increased protein supply in organic farming systems", WP 2. Figure 1 shows the N leaching of the first year period, 2001/2002. Clover catch crops decreased the nitrate leaching significantly but less than the ryegrass in the low N system where spring barley was the cover crop.



7.2. Legume catch crops as the only N-source.

The hypothesis of this experiment is that the N_2-fixation in the clover-mixture catch crop will be able to replace the N supply in slurry as the N source to non-fixing crops. The effect of the catch crop was absent in 2001 due to the lack of catch crops the year before. The clover catch crop developed significantly in the autumn and in 2002 the barley yield was similar in treatment 2 and 3. In 2003 the barley yield in treatment 3 decreased to the level in treatment 1, due to a weak development of the catch crop in autumn 2002. There appears to be "wave effect" where production levels in the spring barley cover crop and in the succeeding clover catch crop alternate.

Table 7.1. Grain yields of spring barley 2001, 2002 and 2003.

			Yield, t DM ha^{-1}		
Treatment	Catch crop	Slurry	2001	2002	2003
1	No	+	3.8^{a}	2.4^{b}	2.2^{b}
2	Ryegrass	+	3.6^{a}	3.2^{a}	3.2^{a}
3	Grass clover mixture	-	2.2^{b}	3.1^{a}	2.3^{ab}

7.3. Screening of catch crops

We measured significant differences between the catch crops in their autumn production in 2001 and 2002 and in the growth of the following barley crop in 2002 and 2003. It appears that 1) the N-release from of the best clover varieties, white and red clover, was similar to application of about 100 kg N ha^{-1} in mineral fertilizer, 2) a high production of dry matter in the autumn does not necessarily cause a high production in the following barley and 3) that the non-N_2-fixing catch crops was not able to release enough N for the barley on this coarse sand.

WP8 Very deep-rooted crops and catch crops in the crop rotation, N dynamics and modelling

8.1. Experiments with cropping sequences including very different rooting depths

Very convincing results have been obtained showing very large differences in rooting depth of catch crops and main crops. Catch crops grown in the first year of the sequences showed differences from rooting depths of less than 100 cm (ryegrass) to more than 200 cm (fodder radish). Vegetables grown in the second year of the sequences showed even larger differences. Leek had a rooting depth of only 50 cm, red beet of roughly 150 cm, whereas the rooting depth of white cabbage exceeded the maximum measurement depth of 240 cm (figure 8.1). Catch crops undersown in spring barley in the third year of the rotation again showed differences from approx. 100 cm for ryegrass to more than 200 cm for chicory.

Whereas radish in the first year and white cabbage in the second year have been able to deplete the soil effectively to 250 cm depth, chicory in the third year was not quite as effective as indicated by the root measurements. Still, even though it did not deplete the deep soil layers effectively, it did clearly take N from soil layers below 100 cm and it left less N in the 100 to 250 cm soil layers than ryegrass.

The N_{min} data show very clear effects of crop species, but also strong interactions with preceding catch crops or main crops. This was most clearly shown in the second year of the sequences, where vegetable crops followed catch crops. In the spring before the vegetables, catch crops had strongly altered the soil N_{min} profile (figure 8.1a). Without a catch crop, much more N_{min} was found in deep soil layers than where catch crops had been grown. White cabbage with its very deep root growth were able to deplete the soil N_{min} down to 250 cm in any case, but red beet were not able to deplete soil layers below 100-150 cm, and left much N_{min} in the soil where no catch crop had been grown but left only little N_{min} in the same soil layers when grown after a catch crop, as little N_{min} was available there (figure 8.1c). The effect was very clear in both experimental years, and red beet left on average 75 kg N/ha more in the soil when grown after a catch crop than when it was grown after winter bare soil.

The result show that growing a catch crop *before* a crop which is not able to deplete the soil efficiently may be as least as effective as growing the catch crop afterwards, and it shows that crop effects on N_{min} in deep soil layers are retained in the soil for a longer time than effects on the upper soil layers. The longer duration of N_{min} effects in the subsoil is a partial confirmation of the hypothesis behind the experiment. However, N_{min} in the soil layers below 100 cm depth was highly dynamic, N_{min} increased relatively fast when N_{min} were present in the topsoil in the autumn or winter, and there were only limited indications that N_{min} effects from the first year could still be observed in the third year. So while N_{min} effects in deep soil layers proved to be more durable than in N_{min} effects in the topsoil layers, they were still more dynamic than expected.

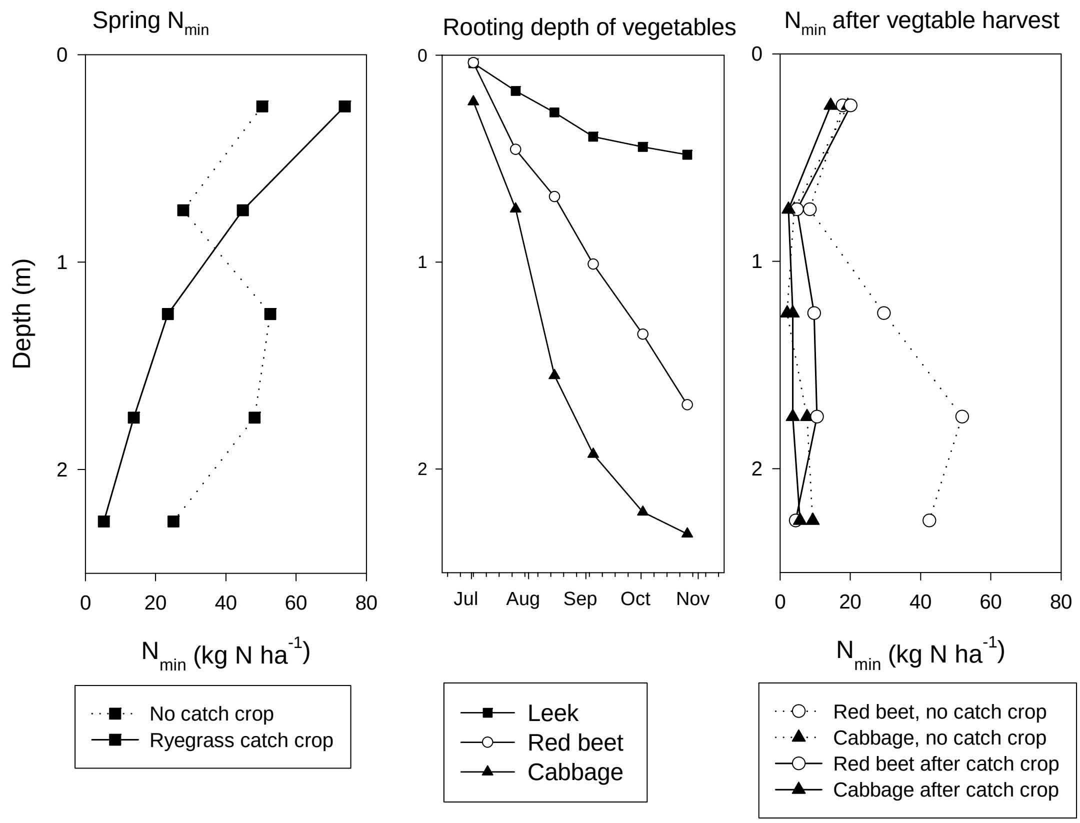


Figure 8.1. Spring N_{min} (kg inorganic N ha^{-1} per 0.5 m soil layer) before establishment of three vegetable crops, rooting depth development of the vegetables and N_{min} after vegetable harvest (only cabbage and red beet after control (bare soil) or ryegrass catch crop shown)

8.2. Undersown catch crops with deep rooting

We have tested more than 20 plant species for their ability to grow as undersown catch crops, and measured their root growth, N uptake and depletion of the soil N pool to 2.5 m depth. Several species have been identified which work well as catch crops. The data also show large differences in rooting depth. Ryegrass and the legumes which have been tested seem only to have significant root growth within the top 100 cm of the soil during the autumn. Some of the other dicot species have shown deeper rooting, and typically reaching about 150 cm during the autumn (e.g. *Oenothéra, Sanguisorba, Taraxacum*), and a few reach deeper (*Rumex,* Chicory, *Isatis, Echium*).

Ryegrass and chicory have been included in all years. Chicory have shown very deep rooting, and higher N uptake than ryegrass (86 kg N ha^{-1} vs. 57 kg N ha^{-1}). Chicory have also clearly reduced N_{min} in soil layers below 100 cm, though not as effective as expected from its root growth. Results from 2002 indicate that other types of chicory could be significantly better than the chicory variety ´Puna´ which has been used in most of the experiments.

As the catch crops have been undersown in spring barley, N_{min} in the top 100 cm were generally low, and not too strongly affected by catch crop species (from 20 to 46 kg N/ha in 2002). N_{min} in the soil layers from 100 to 250 cm were higher as barley did not deplete these soil layers, and they were very strongly affected by catch crop species (from 25 to 133 kg N/ha in 2002). Generally the depletion of deep soil layers has been correlated to catch crop rooting depth, and many species show better subsoil depletion than ryegrass or legume catch crops.

In the experiment of 2003 the level of subsoil N_{min} were very low, and though the results confirmed the correlation between rooting depth and subsoil depletion, the effects were small and not very clear. Therefore we decided to repeat the experiment once more in 2004, including only the most promising species (*Rumex, Isatis* and three types of chicory) and ryegrass for comparison.

Data show that catch crops for undersowing with effective rooting depths of more than 200 cm can be found. The different species have various advantages and disadvantages in terms of ease and cost of establishment, risk of becoming weeds and effect on main crop yield. At the moment *Isatis* has clearly shown the most promising results. It had the strongest rooting of the subsoil of all the tested crops and the best soil depletion (it removed 86 kg N ha^{-1} more from the soil than ryegrass in 2002). In has also shown a better precrop effect than the other non-legume species, in 2002 the yield of barley after *Isatis* was between 1 and 1,5 t/ha higher than after control or catch crops of ryegrass or several of the other non-legume species. A much lower C/N ratio than ryegrass, chicory and many of the other species is part of the explanation, but there may also be other reasons, e.g. effects on S (see WP 9).

Isatis have not shown any tendency of becoming a weed problem. Chicory has also shown interesting results, and testing other types than ´Puna´ have indicated that genotypes with stronger subsoil N depletion and which cause less weed problems can be found. A fifth and last replicate of the experiment is currently growing in the field, including the most promising species identified until now, and it will be very interesting to se whether they confirm the results.

A bachelor thesis (*Do the root development of chicory, pastinaca and ryegrass affect their suitability as catch crops*) has been made and defended in 2002 as part of this study.

8.3. Model simulation of the effect of deep-rooted crops and catch crops

This work will be continued during the first half of 2005 with simulation studies of a number of crop rotations including deep or shallow rooted crops and catch crops. These simulations are carried out in close collaboration with the SOAR PhD project of Anders Pedersen, and the EU project EU-Rotate_N, and build on calibration work on the EXUNIT Aarslev data.

Generally, the results from WP 8 have confirmed that studies of deep root growth are important for understanding N dynamics of crop rotations. It is not only clear that some species may have highly significant root activity in soil layers below 100 cm, it is also clear that large differences in crop effects may be totally overlooked when measuring to only 100 cm depth. Figure 8.1a and 8.1c illustrate this clearly, the conclusions from this study would have been completely different if the soil layers below 100 cm had not been included in the measurements. When comparing undersown catch crops, ryegrass was as efficient as the others in the top 100 cm of the soil, again the large differences observed among the species would not have been found if only the top 100 cm of the soil had been studied.

WP9 The effect of catch crops on sulphate leaching and availability of S for the succeeding crop

Soil and plant sampling were carried out in the workshop area in Årslev in November 2000 and 2001 to determine the effect of catch crops on the content of leachable sulphate in the soil and the potential for S stabilisation in crops. Furthermore catch crops were sampled at Jyndevad Experimental station in 2001. The catch crops from both autumn 2000 and 2001 showed a very wide range in chemical composition regarding S content (0.13-1.03% S) and C/S ratio (40-329). There was variation in the S-content of the same catch crop depending on location. On the sandy Jyndevad location S-contents were generally lower than on the Årslev sandy loam soil. Generally, the crucifers and legumes were the able to retain most S.

In spring 2001 and 2002 pot experiments were established to determine the mineralisation of S from the different catch crops. The results indicate the availability of S in the catch crops is related to the C/S ratio of the material (Figure 9.1). It is interesting that the catch crops with the highest C/S ratios and consequently the lowest S-availability are all legumes. This may have consequences for the choice of catch crops on S-deficient soils.

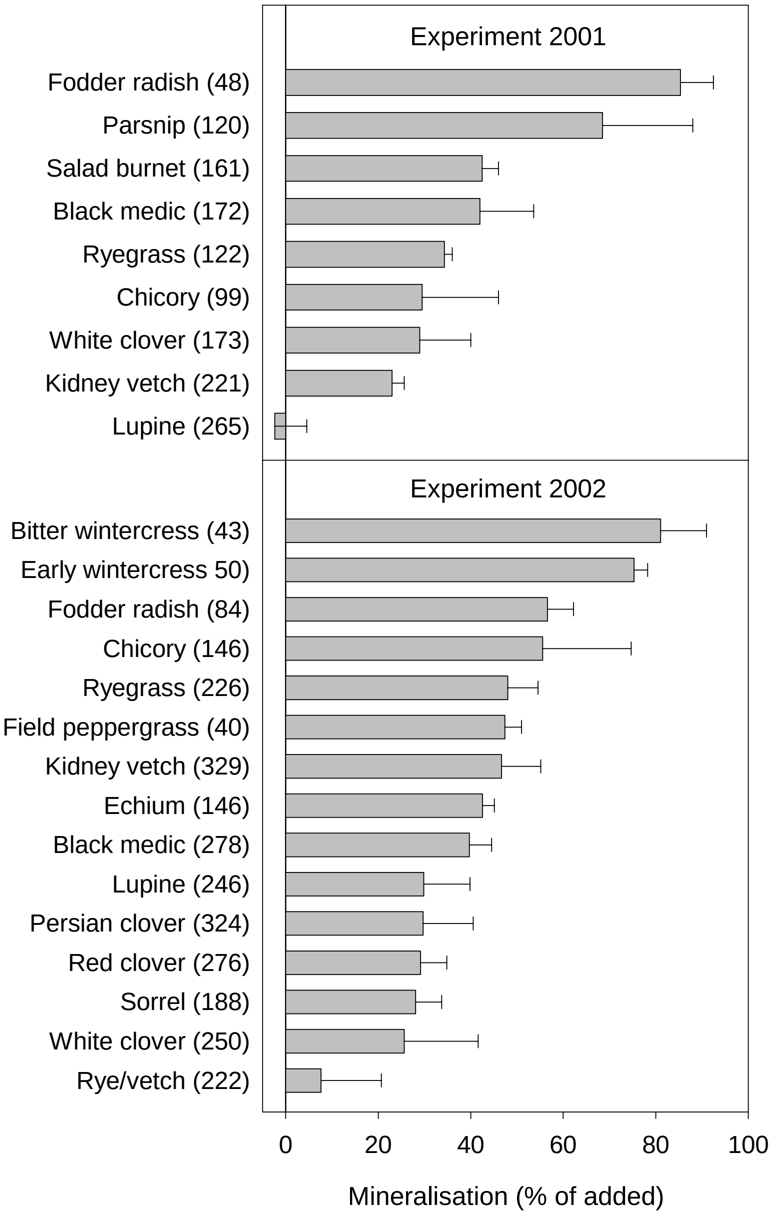


Fig. 9.1. Mineralisation of catch crop S during the growing season of spring barley. Inserted in brackets are catch crop C/S ratios. Error bars: SE.

In a laboratory experiment was determined the gross transformation rates of S in soils amended with different catch crops – a technique that has been widely used in N studies but never before for S. This was carried out by incorporating the plant material with labelled sulphate and the mineralisation rates are then determined from the dilution of labelling in the sulphate pool. The advantages of this technique is that it only takes a few days to determine mineralisation rates (compared to a growth season in the pot experiment) and it provides measures of both immobilisation and mineralisation instead of just net mineralisation. From this experiment the technique seems very promising for studying S cycling in soils, as there was good agreement between the S-uptake by plants and the mineralisation rates predicted in the laboratory.

C.2 Fulfilment of deliverables and milestones

(To be completed for each work package)

WP1 Nitrogen relationships of vegetable crops, and project co-ordination	**Time schedule according to application**	**Deviations, if any***
Task		
1 To co-ordinate the VEGCATCH project		
2 To study rooting depth during growth and N dynamics for 6 vegetable crops		
3 To supply data on N, root growth and N dynamics for modelling (WP8 and the Project BIOMOD)		
4 To test N effects of green manure crops incorporated in the late spring		
Deliverables and milestones		
1 Papers on growth, root growth, and N dynamics of the three vegetable crops grown in 2000 and 2001.	2002	Was submitted ultimo 2003
2 Papers on growth, root growth, and N dynamics of the three vegetable crops grown in 2002 and 2003.	2004	Postponed to 2005
3 A paper on root growth of cabbage, leek and red beet from the cropping sequence exp. (see WP8)	2004	Postponed to 2005
4 A paper on legumes that are allowed to grow and fix N in the spring before vegetable crops	2003	Cancelled

WP2 Entomopathogenic nematodes (EPN) in organic cropping systems	**Time schedule according to application**	**Deviations, if any***
Task		
1 Interactions of EPN, pest insects and plants in the organic growing system at Årslev	2000-2003	
2 Comparing levels of EPN on neighbouring farms with different growing systems	2000-2003	
3 Screening of plant species for their value of supporting populations of EPN	2000-2003	
4 Susceptibility of beneficial arthropods to EPN	2001-2002	
Deliverables and milestones		
1 Presentation of the entomopathogenic part of VEGCATCH at IOBC meetings	2001	✓ 2 papers
2 Paper directed to Danish farmers and advisors on entomopathogenic nematodes in organic growing systems.	2003	In preparation

3 Scientific paper on the ability of different catch crops to enhance and support populations of entomopathogenic nematodes.	2003	✓ 2 scientific papers accepted, two more almost ready for submission
4 Scientific paper on results from project with susceptibility of non target arthropods Presentation of results at The Danish Plant Protection Conference	2004	✓
5 Spring 2002, Selection of the most promising catch crops regarding their ability to enhance nematode populations.	2002	None identified

WP3 Varieties, growing stability, disease resistance and quality	**Time schedule according to application**	**Deviations, if any***
Task		
1 To test varieties and make guidelines for choosing varieties for organic growing		
2 To study the significance of various pests, diseases and quality defects in vegetables grown in organic or conventional production systems		
Deliverables and milestones		
1 An international scientific paper on the organic grown carrot, cauliflower and onion varieties	2004	Postponed to 2005
2 An international scientific paper on differences between organic and conventional growing of onion, carrot and cauliflower	2004	Published in: Forskningsnytt for økologisk jordbrug I Norden
3 A guideline for growers and advisors, describing the most important characteristics,	2003	No specific demands for cultivars for organic production identified
4 Preliminary publications, from the evaluation of carrot, cauliflower and onion varieties, every year.	2001-2004	

WP4 Catch crops as a tool for increasing P bioavailability on soils of low P status	**Time schedule according to application**	**Deviations, if any***
Task		
1 To test selected catch crop species for their P uptake capacity on a low P status soil.		
2 To quantify the influence of these catch crops on subsequent main crop yield and P uptake		
3 To quantify possible interactions between catch crop species, the crop rotation (with or without grass-clover ley) and additional P supply for the main crop.		
Deliverables and milestones		

1 Papers on the effects of undersown catch crops on P bioavailability for subsequent crops.	2003	To be completed in 2004/05
2 Papers for Danish organic farmers and advisors on the value of undersown catch crops as a P source in the crop rotation.	2002-2003	To be completed in 2004

WP5 Influence of autumn green manure crops on club root (*Plasmodiophora brassicae*)	**Time schedule according to application**	**Deviations, if any***
Task		
1 To identify crucifer species or genotypes with full or partial resistance to Plasmodiophora brassicae		
2 To identify crucifer catch crops that can be grown without increasing subsequent disease pressure of *P. brassicae* or can actually reduce subsequent disease pressure		
Deliverables and milestones		
1 Paper on pathogenicity of *P. brassicae* on a wide range of Brassica species. Species with high level of resistance are selected for the field trials 2003 and 2004	2002	Delayed
2 Results from the first year field experiment has been obtained.	2003	
3 Results from the second year field experiment has been obtained. Paper on effect of autumn green manure crops on *P. brassicae*	2004	
4 A guide line for using autumn green manure crops in relation to infestation level of *P. brassicae* has been publicised in a national paper Information IV has been included in the decision support system.	2004	

WP6 The effect of catch crops on soil mesofauna and earthworms	**Time schedule according to application**	**Deviations, if any***
Task		
1 To describe the effect of growing catch crops on the populations of a number of soil living animals, and to test whether important differences exist among catch crops in their effect on the soil fauna.		
2 To obtain data on the effect of catch crops on the soil fauna which can be used for modelling purposes in the BIOMOD project.		
Deliverables and milestones		
1 Scientific paper on the effect of undersown catch crops in cereals on the soil fauna	2001	Merged with deliverable 3
2 Scientific paper on the effect of deep-rooted catch crops on the soil fauna	2003	Mistake, same as 1
3 Scientific paper on the effect of catch crops at different levels of nitrogen and potassium on the soil fauna.	2004	
4 Popular scientific paper on the results.	2003	OK

WP7 The effect of catch crops on N and K leaching and crop production, with focus on coarse sandy soils.	Time schedule according to application	Deviations, if any*
Task		
1 To test whether catch crops can significantly reduce K leaching losses on a coarse sandy soil		
2 To test N supply from undersown legume catch crops for continious grain production		
3 To identify legume- and non-legume catch crop species suitable for undersowing on coarse sandy soil.		
4 To estimate the influence of catch crop rooting depth on cation leaching from the root zone on a sandy loam soil.		Cancelled
Deliverables and milestones		
1 Paper on the effect of non-N_2-fixing and N_2-fixing catch crops on nitrate and potassium leaching on a coarse sandy soil	2004	
2 Paper on the effect of non-N_2-fixing and N_2-fixing catch crops on the yields of succeeding crops on a coarse sandy soil	2004	
3 Paper on the cation and anion balances as affected by different catch crop types on a clay soil	2004	Cancelled
4 Papers in national agronomic magazines for information about the results	2003-4	

WP8 Very deep-rooted crops and catch crops in the crop rotation, N dynamics and modelling	Time schedule according to application	Deviations, if any*
Task		
1 To test the significance of including very deep-rooted crops and catch crops into cropping sequences		
2 To obtain data on root growth and soil N dynamics for validation of model simulations of deep soil N dynamics		
3 To identify plant species with very deep rooting which can be established as undersown catch crops in cereals.		
4 To utilise current knowledge and results obtained through objectives 1)-3), and simulation modelling to build a decision support system for optimal catch crop strategies.		
Deliverables and milestones		
1 Data from the cropping sequence experiment will be delivered for the BIOMOD project	2001, 2002 and 2003	
2 A paper on the effects of crops with different rooting in cropping sequences on N dynamics.	2004	Publications postponed to 2005, deliverable 2 and 4 will be merged

3 A paper on the rooting depth, soil depletion, N uptake and release of the undersown catch crops.	2004	
4 A paper on the value of very deep-rooted crops and catch crops in the crop rotation.	2004	
5 A paper on the developed decision support system.	2003	Delayed to 2005, se comment under point D
6 A decision support system on optimal use of catch crops	2003	As above
7 Early spring, 2002: Selection of deep-rooted catch crop species to be included in the last year of the cropping sequence experiment.	2002	
8 Review on catch crops and green manures for Advances in Agronomy, and for use in teaching agricultural students at RVAU about catch crops and green manures	Written 2002, printed in Advances of Agronomy 2003	Added deliverable
9 Contributed 3 of 5 chapters for a Danish book on catch crops and green manures published by "Jordbrugsforlaget"	To be printed ultimo 2004	Added deliverable
10 Contributed half of the text for a Danish advisory booklet on catch crops and green manures, to be published by "Jordbrugsforlaget"	To be printed Autumn 2004	Added deliverable

WP9 The effect of catch crops on sulphate leaching and availability of S for the succeeding crop	**Time schedule according to application**	**Deviations, if any***
Task		
1 To determine the ability of catch crops to reduce soil sulphate concentrations		
2 To determine the ability of catch crops to make S available for the succeeding crop through mineralization.		
Deliverables and milestones		
1 Paper on the effect of catch crops on sulphate leaching submitted to international refereed journal	2002	√
2 Paper on the sulphur supplying capacity of catch crops to the succeeding crop submitted to international refereed journal	2002	√
3 Paper to Danish farmers and advisors on the effect of catch crops on S utilisation	2002	√

** Deviations are to be further discussed in D*

D. Description of deviations and subsequent adjustments of plans

There are a number of deviations from the original plans of publication. Some publication plans have been delayed, and some have been cancelled as the experimental results are not judged to be very interesting or not possible to publish. In other examples more publications are now planned or published which were not a part of the original objectives (e.g. WP 2 and WP8), or the project have contributed to publications on related subjects (e.g. WP 9) or to the review on catch crops and green manures produced as part of WP8. All in all these changes are judged to be within the expected level of changes as the project progress.

In one part, WP8, the modelling activities have been seriously delayed. One main reason is interactions with the BioMod project. As the same persons are involved in the modelling work, problems and delays in the BioMod project has led to delays in the VegCatch project. Further, the modelling are now included in a SOAR supported PhD project, and thus we want to be able to delay these activities into 2005, where the work will also be carried out in collaboration with the EUROTATE project. Publication plans for WP1, WP3, and WP8 at DIAS Department of Horticulture are delayed, mainly due to maternity leave of Hanne Lakkenborg Kristensen during 2004. We apply for transfer of funding to 2005 to finish this publication work (see comments to the budget).

E. Project publications and other products

Submitted for peer-review but not yet accepted

English

Eriksen, J. (2004) Gross sulphur mineralisation-immobilisation turnover in soil amended with plant residues. *Soil Biology & Biochemistry*.

McNeil, A.M. and Eriksen, J. and Bergström, L. and Smith, K.S. and Marstorp, H. and Kirchmann, H. and Nilsson, I. (2004) Critical aspects of nitrogen and sulphur management in temperate agricultural systems with emphasis on organic nutrient sources. *Soil Use and Management*.

Nielsen, Otto and Philipsen, Holger (2004) Seasonal population dynamics of inoculated and indigenous steinernematid nematodes in an organic cropping system. *Nematology*.

Nielsen, Otto and Skovgaard, Ib Michael and Philipsen, Holger (2004) Estimating the incidence of entomopathogenic nematodes in soil by the use of bait insects. *Nematology*.*

Müller, Dr. Torsten and Thorup-Kristensen, Dr. Kristian and Magid, Dr. Jakob and Jensen, Dr. Lars Stoumann and Hansen, Dr. Søren (2003) Catch Crops in Organic Farming Systems without Livestock Husbandry - Simulations with the DAISY model. [preprint]**

Peer-reviewed and accepted

English

Eriksen, J. and Thorup-Kristensen, K. (2003) The effect of catch crops on sulphate leaching and availability of S in the succeeding crop, in Davidian, J.C. and Grill, D. and De Kok, L.J. and Stulen, H. and Hawkesford, M.J. and Schnug, E. and Rennenberg, H., Eds. *Sulfur Transport and Assimilation in Plants: Regulation, Interaction and Signaling*. Backhuys Publishers.

Thorup-Kristensen, Kristian and Magid, Jacob and Jensen, Lars Stoumann (2002) Catch crops and green manures as biological tools in nitrogen management in temperate zones, in *Advances in Agronomy*, page 227-302. Elsevier.*

Müller, Dr. Torsten and Thorup-Kristensen, Dr. Kristian (2002) Total N difference method and 15N isotope dilution methode - A comparative study on N-fixation. Paper presented at "Stabile Isotope in der Bodenkunde", Göttingen, March 2002; Published in *Mitteilgn. Dtsch. Bodenkundl. Gesellsch.,* 98, page 23-24.**

Thorup-Kristensen, K (2002) Utilising differences in rooting depth to design vegetable crop rotations with high nitrogen use efficiency (NUE). Paper presented at ISHS Workshop: Towards an ecologically sound fertilisation in field vegetables production, Wageningen, The Netherlands, 2000; Published in Booij, R and Neeteson, J, Eds. *Acta Horticulturae* 571, page 249-254. ISHS.*

Thorup-Kristensen, K. (2001) Root growth and soil nitrogen depletion by onion, lettuce, early cabbage and carrot. Paper presented at Environmental problems associated with nitrogen fertilisation of field grown vegetable crops, Potsdam, Germany, 30 August - 1 September, 1999; Published in Rahn, CR and Lillywhite, RD and De Neve, S and Fink, M and Ramos, C, Eds. *Acta Horticulturae* 563, page 201-205. ISHS.**

Eriksen, J and Thorup-Kristensen, K (2002) The effect of catch crops on sulphate leaching and availibility of S in the succeeding crop on sandy loam soil in Denmark. *Agriculture, Ecosystems and Environment* 90:247-254.*

Eriksen, J. and Thorup-Kristensen, K. and Askegaard, M. (2004) Plant-availability of catch crop S following spring incorporation. *Journal of Plant Nutrition and Soil Science*.

Sørensen, Dr. Jørn Nygaard and Thorup-Kristensen, Dr. Kristian (2003) Undersowing legume crops for green manuring of lettuce [Undersåning af bælgplanter til grøngødskning af salat]. *Biological Agriculture and Horticulture*.**

Not peer-reviewed

English

Eriksen, J (2001) Effects of timing of sulfur application and nitrogen fertilization on yield and quality of barley. Paper presented at COST Action 829 meeting Sulfur-Nitrogen Interactions in Plants, Oulu, Finland, 7-9 September 2001; Published in *Book of abstracts from COST Action 829 meeting Sulfur-Nitrogen Interactions in Plants*.

Eriksen, J. (2004) Organic manures as sources of fertiliser sulphur. Paper presented at Biogeochemistry of sulphur in agricultural systems, Pulawy, Poland, 21-22 April 2004; Published in *Proceedings of Biogeochemistry of sulphur in agricultural systems* II, page 52-70. Polish Fertilizer Society.

Eriksen, J. (2002) Svovl til husdyrgødet vårbyg og forfrugtseffekt af græsmarker. Paper presented at Gødningsseminarer, Nyborg, Viborg og Hovborg, 8-10 oktober 2002; Published in *Bilag til Gødningsseminar 2002*.*

Eriksen, J. (2001) Organic manures as sources of fertiliser sulphur. Paper presented at International Fertilizer society, Cambridge, UK, 16-17 December 2002; Published in *International Fertiliser Society Proceedings* 505, page 1-19.

Nielsen, Otto (2001) Entomopathogenic nematodes in agricultural cropping systems. Paper presented at 34th Annual Meeting for the Society of Invertebrate Pathology, Noordwijkerhout, Holland, August 2001; Published in *Conference abstract book*.**

Nielsen, Otto and Philipsen, Holger (2003) Abundance of naturally occurring entomopathogenic nematodes and establishment of inoculated Steinernema feltiae in an organic cropping system. Paper presented at 9th European meeting in the International Organisation of Biological Control, Salzau, Germany, May 2003; To be published in *IOBC Bulletin*.

Philipsen, Holger and Nielsen, Otto (2003) Host potential of insects from cruciferous crops to entomopathogenic nematodes and augmentation of nematodes through oil seed rape growing. Paper presented at 10th Meeting of the International Organisation of Biological Control, Athens, Greece, May 2001; Published in *IOBC Bulletin* 26(1), page 141-146.

Philipsen, Holger and Nielsen, Otto (2003) Host potential of insects from cruciferous crops to entomopathogenic nematodes and augmentation of nematodes through oil seed rape growing. Paper presented at Entomopathogens and parasitic nematodes: Current research and perspectives in pest control. 8th European Meeting in the IOBC/WPRS Working Group, Athens, Greece, 29 May - 2 June; Published in *IOBC Bulletin* 26(1), page 141-146.**

Eriksen, J and Thorup-Kristensen, K (2002) The effect of catch crops on sulphate leaching and availability of S in the succeeding crop. Poster presented at 5th Workshop on Sulphur Transport and Assimilation, Montpellier, France, 11-14 April 2002; Published in *Book of abstracts*, page 98.

Thorup-Kristensen, Dr. Kristian (2004) Crop cover improves the nitrogen status in vegetable crop rotations. In *DARCOFeNews*, No 1. DARCOF.

Thorup-Kristensen, Dr. Kristian (2002) Six years results from an organic vegetable crop rotation aimed at self-sufficiency in nitrogen. [oral] Presentation at *XXVIth International Horticultural Congress & Exhibition (IHC2002)*, Toronto, Canada, Agust 2002.

Pedersen, Anders and Thorup-Kristensen, Kristian and Kristensen, Hanne Lakkenborg and Berntsen, Jørgen (2004) Simulating root growth. Online at <http://www.darcof.dk/enews/june04/roots.html>. DARCOFeNews

Dansk - Danish

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

The experiments of the VegCatch project and the preliminary results have been presented orally at many occasions at public meetings or field days. In June 2003 "Field days for organic farming" (part of the DARCOF project EXUNIT II) were held in Årslev, where several of the project scientists from the VegCatch project presented their activities to a group of 30 agricultural advisors. The activities in Årslev on crop rotation, catch crops, green manures and root growth of vegetables has been presented as part of a TV series (Beretninger fra økoland) on organic farming. The combination of RVAU and DIAS researchers in the project promote the use of the results also for agricultural students at RVAU.

The results mainly from WP8 have been presented at the Ontario N forum in March 2004, where Kristian Thorup-Kristensen was invited to present the paper "Improved use of cover crops in N regulations", and Kristian Thorup-Kristensen has been invited to present the paper "Catch crops and green manures: Biological tools for N management" at the CSRI meeting "Root / soil Biology in Agriculture, Towards a new Conceptual Framework" to be held Canberra, Australia in November 2004.

To present the project results internationally, we are planning a workshop to be held at FIBL in Switzerland in 2005, on rotational effects, and effects of fertility building crops in cooperation also with SLU in Sweden and HDRA from the UK. At this workshop we plan to make presentations from several of the WPs of the VegCatch project, and to give a presentation of the VegCatch project as such, and the main ideas behind it.

F. Scientific education

Julie Schou Christensen, RVAU, made her masters thesis: *Root systems of vegetables and root development in relation to nitrogen distribution in the soil profile (Grønsagers rodsystemer og roducvikling i forhold til kvælstoffordelingen i jordprofilen)* on the experiment on root growth of red beet, celeriac and sweet corn in WP1. The thesis was defended in 2001. The supervisors were Lars Stoumann Jensen (RVAU) and Kristian Thorup-Kristensen (DIAS).

Karsten Bach, RVAU, made his bachelor thesis: *Do the root development of chicory, pastinaca and ryegrass affect their suitability as catch crops (Har rodudviklingen ved cikorie, pastinak og rajgræs betydning for deres evne som fangafgrøder)* on the screening experiment on undersown nitrogen catch crops in WP8. The thesis was defended in 2002. The supervisors were Andreas de Neergaard and Jacob Magid (RVAU) and Kristian Thorup-Kristensen (DIAS)

Oskar Sigmarsson og Morten Andersen, finished their study as engineers at Odense Teknikum with the thesis: *Measurements of nitrate in agricultural soil by measuring electrical conductivity (Måling af nitrat i landbrugsjord ved hjælp af ledningsevne)* using soil samples from WP8 for their measurements. The thesis was defended in 2002. The supervisors were Steffen Peter Skov (Odense Teknikum) and Kristian Thorup-Kristensen (DIAS)

Rikke Jensen and Hanne Gundersen (RVAU) have finished their bachelor thesis on two years results on root growth and N dynamics in vegetable crops from WP1. Supervisors were Lars Stoumann Jensen (RVAU) and Kristian Thorup-Kristensen (DIAS).

A student from University of Aarhus is going to carry out a masters project on the correlation between abundance of springtails and polyphagous predators in catch crops on private farms. Supervisor Jørgen Axelsen.

Haakon Søren Setterberg is doing his masters thesis: *Analyses and modelling of nutrient cyling and crop yield in the vegetable rotation experiment.* The supervisors are Lars Stoumann Jensen (RVAU), Anders Pedersen and Kristian Thorup-Kristensen (DIAS).

Johanne Koch Braskov is doing her bachelor thesis on four years results of growing onion, carrots and cauliflower conventional and organic (WP3). Supervisors are Vibeke Langer (RVAU) and Gitte K. Bjørn (DIAS).

Camilla Beck is doing her masters thesis on the effect of catch crops on club root, studying catch crops which activate the resting spores of club root, though they are not susceptible to club root. Birgit Jensen (RVAU) is the main supervisor.

G. National and international cooperation

Cooperation with other DARCOF projects:

There are cooperation with several of the other DARCOF projects, but mainly with:

- **DARCOF2-project Exunit (IV.23):** Most of the experiments within the VegCatch project are made within the crop rotation areas of the Exunit project. Especially the crop rotations at Recearch Centre Årslev (Vegetable rotation on sandy loam soil) and at Jyndevad (grain production rotation at sandy soil) are used. Data from the rotations will also be used, especially data from the Årslev rotation will be used in the modelling work in WP8.

- **DARCOF2-project BioMod (I.15):** Data on root growth from some of the activities within VegCatch (WP1 and WP8) will be used for modelling purposes in the BioMod project, and there will be co-operation also on the modelling activities (WP8).
- **DARCOF2-project Genesis (I.5):** The work on catch crops on N and K dynamics on sandy soil (WP7) is made in close cooperation with experiments within the Genesis project.

Cooperation with other Danish projects

- **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 the ability of a number of crop species to take up nitrogen from soil layers below 1.0 m will be studied by uptake of ^{15}N placed at various depths relative to the rooting depths observed by the minirhizotrons.
- **Testing of vegetable varieties:** At DJF, Department of Horticulture we are testing varieties of vegetable crops in co-operation with the Danish vegetable growers organisations and the see companies. The comparison of vegetable varieties in organic and conventional production (WP3) is done in close co-operation with this existing project.
- **Net covering of cauliflower:** The work on organic cauliflower production (WP3) is done in co-operation with a project on Net covering of cauliflower to prevent pest attack, financed by the Danish Environmental Protection Agency.

International cooperation

- **EUROTATE_N, Development of a model based decision support system to optimise nitrogen use in horticultural crop rotations across Europe:** Kristian Thorup-Kristensen is a partner in this project which will start January 2003. Data from a number of the experiments made in the VegCatch project will be used for development and validation of the model, and in this project further experiments will be made to study the carry over of N from one crop to next years crop. This project will start in the beginning of 2003.
- **Optimal crop rotation for yield and cropping stability in organic vegetable production (*Optimalt vekstskifte for sikker økologisk grønnsakproduksjon*):** Kristian Thorup-Kristensen is participating in this Norvegian project associated as advisor.
- **The ecology of the cropping system; green manure as a multifunctional tool in vegetable production *(Odlingssystemets Ekologi, gröngödsling som mångfunktionellt "redskap" i grönsaksodlingen)*:** In this project financed by the Sweedish research council (FORMAS), studies of the effect of cover crops or green manures between rows of vegetable crops will be made. The goal is to reduce the occurrence of pests and diseases, and to improve plant nutrient husbandry in organic crop rotations. Studies within this project of the competition between the vegetable crops and the cover crops, with particular reference to root competition will be made in Årslev. Birgitta Båth from the Sweedish Agricultural University, who is working as a Post Doc on the project, will come to work in Årslev for several periods during the project.
- **Cost-850, Biocontrol Symbiosis:** Otto Nielsen and Holger Philipsen are members of the management comity of Cost-850, Otto Nielsen is co-convener of working Group 4

"Interactions with Soil Biota". Holger Philipsen is convener of Working Group 5 "Socio-economic aspects".

- **COST action 829 "Fundamental, Agronomical and Environmental Aspects of Sulfur Nutrition and Assimilation in Plants":** Jørgen Eriksen is a member of the management comity of Cost-829.
- **Cost-631, Understanding and Modelling Plant-Soil Interactions In the Rhizosphere Environment:** Kristian Thorup-Kristensen and Niels Erik Nielsen are members of the Management Comity of Cost-631.

H. Critical reflection on the project

Most of the research within the VegCatch project was planned at a relatively detailed level already during the project application phase. This is due to two main factors. For most of the participants, the work within the project is part of a continued development of their main research area, therefore good planning and formulation of rather precise hypotheses was possible. Further, most of the field experiments run for at least two years, and to achieve replications also in years, they will thus take a minimum of three years to perform. This is very different from other sorts of experiments which can be performed within weeks or months, and where new experiments are planned on the basis of the results of the first. Experiments with a duration of years as most of the VegCatch experiments do not allow such an iterative process even within a five-year project period, i.e. the plans can and must be relatively firm from the beginning.

At present, the original plans have largely been followed. A few experiments have partly failed, and a few changes in the plans have been made due to results and new experience from the project itself or from other projects. We have not made any significant changes due to changes in "the world around us". The project is aimed at improving the possibilities for producing different species of sales crops, especially vegetable crops. Though some diversification of the number of vegetable crops produced seem to have occurred since the project application was made, we still believe that these possibilities need to be further developed, and that the approaches we take in the project are relevant. We have new ideas and problems we would like to work on, but we think that the originally planned experiments still are the most important scientific questions for us to pursue within the framework of the VegCatch project.

The project is related to a number of other projects that we participate in, some of which have been initiated after the VegCatch project (se part G on national and international cooperation above). In this way, new ideas are taken up, though not within the VegCatch project.

We believe that the interdisciplinary approach of the project is very valuable. Really interdisciplinary studies are made in some parts of the project, e.g. in the modelling activities, in the studies of the effect of catch crop treatments (WP7 and WP8) on factors such as soil fauna (WP2 and WP6) and effects on soil S dynamics (WP9). Not all parts of the project are working that closely together. Ideally, there should have been more really interdisciplinary work within the project. It would probably be ideal if all partners were involved in interdisciplinary activities, while at the same time they had room to work in depth with their own discipline. But even though VegCatch is a big project, the resources for each of the 9 work packages are limited and strict priorities had to be made.

Still, by being in the same project, important knowledge and understanding of other aspects of the system are being communicated among the participants. It also adds to the sense of the participants, that they are not just solving isolated problems, but are looking at solutions, which must function together with other factors to improve the system as a whole, and this is a very important element in organic farming research.

The project is now almost finished. Many publications have been made, though there are also many which still need to be written and published. Much is going to be published during the next few months, while some have been postponed until 2005. The project has led to specific publications of the results produced within it, but it has also contributed to other and to more general publications on catch crops, green manures, organic vegetable production etc. The experiments and their results have been presented orally to many users (farmers, advisors, agricultural students, etc.) at meetings, lectures and field days, and have thus already been made available to the users.

8. Budget

A. Account for any change in budgets

The figures in the column "Consumption before 2004" show lover spending than indicated in the budget in last year's status report. This is due to lower spending than budgeted during 2003 in two of the workpackages. In WP2 (RVAU, Section of Zoology) other funding have been available, and more of the DARCOF funding have been postponed to 2004 and 2005 for finishing the project. In WP1, WP3 and WP8 (DIAS, Department of Horticulture), work has been delayed due to maternity leave of Hanne Lakkenborg Kristensen. Already last year we applied to have a smaller part of the funding for RVAU for WP4 and WP8 postponed to 2005, now we apply to have further funding for RVAU and mainly for DIAS, Dept. of Horticulture postponed into 2005, see detailed comments under budgets for RVAU, Section of Zoology and DIAS, Dept. of Horticulture.

B. Budget for the whole project (1.000 DKK)

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

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	2556	1229	523	638	4906
Technical personnel	1408	618	271	60	2357
Other operational costs	1048	315	185	24	1593
Equipment	0	0	0	0	0
Others (please specify)	197	185	83	52	535
Direct costs	5209	2269	1140	774	9391
Indirect costs (20% of direct costs)	1039	427	254	158	1879
Total	6250	2694	1394	932	11270

Comments:

1. **Last year a transfer of kr. 254,000 to 2005 was accepted. We now apply for transfer of a further kr. 678,000 to 2005, in total kr. 932,000. The main reasons is the maternity leave of Hanne Lakkenborg Kristensen, and planning and participation of the workshop planned for 2005. Se comments on the budget of the two departments of the *Royal Veterinary and Agricultural University,* and for *Department of Horticulture, Danish Institute of Agricultural Sciences.***

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project			

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

Danish Institute of Agricultural Science

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	1436	958	399	386	3179
Technical personnel	1369	453	271	60	2153
Other operational costs	842	247	172	12	1273
Equipment	0	0	0	0	0
Others (please specify)	188	159	83	40	470
Direct costs	3835	1817	925	498	7075
Indirect costs (20% of direct costs)	765	359	188	102	1414
Total	4601	2175	1113	600	8489

Comments: We apply to have funding of kr. 600.000 postponed into 2005. The main reason is the maternity leave of Hanne Lakkenborg Kristensen during 2004, and the workshop planned for 2005. See detailed comments under Dept. of Horticulture.

Royal Veterinary and Agricultural University

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	873	216	36	252	1337
Technical personnel	39	118	0	0	157
Other operational costs	178	58	12	12	281
Equipment	0	0	0	0	0
Others (please specify)	9	26	0	12	65
Direct costs	1099	340	126	276	1840
Indirect costs (20% of direct costs)	219	68	25	56	369
Total	1319	407	151	332	2209

Comments: We applied last year to transfer kr. 256,000 to year 2005. We now apply to transfer a further kr. 76,000, in total 3kr. 332,000 to 2005. The main purpose is to reserve money for participation in the workshop planned to be held in Switzerland during 2005.

National Environmental Research Institute

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	247	55	88	0	390
Technical personnel	0	47	0	0	47
Other operational costs	28	10	1	0	39
Equipment	0	0	0	0	0
Others (please specify)	0	0	0	0	0
Direct costs	275	112	89	0	476
Indirect costs (20% of direct costs)	55	0	41	0	96
Total	330	112	130	0	572

Comments:

B. Budget for each participating department (1.000 DKK)

Danish Institute of Agricultural Science, Department of Horticulture

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	696	672	100	386	1854
Technical personnel	692	155	103	60	1010
Other operational costs	484	133	14	12	643
Equipment	0	0	0	0	0
Others (please specify)	188	89	71	40	388
Direct costs	2060	1049	288	498	3895
Indirect costs (20% of direct costs)	411	205	61	102	779
Total	2471	1254	349	600	4674

Comments: We apply for the transfer of kr. 600,000 to year 2005. The main reason is that it was planned that Hanne Lakkenborg Kristensen should have worked on WP1 and WP8 during mush of 2004, and done much of the publishing work from these two WPs. As she has been on maternity leave during almost the whole year of 2004, she has not been able to do this. Gitte Bjørn, who are working on WP3 has had to replace Hanne Lakkenborg Kristensen in another newly started project, and this has delayed her work on publishing results from WP3. Kristian Thorup-Kristensen has also, to a smaller extent, had to replace Hanne Lakkenborg Kristensen in other project work. All in all the publishing work from WP1, WP3 and WP8 have been much delayed. For partly the same reason, a small part of the experimental work in WP8 have also been planned to continue into 2005 (some root registrations and the measurement of pre-crop effects from the 2004 experiment with undersown cover crops).

A further reason is the workshop planned for 2005 at FIBL in Switzerland, where we will participate, and where Kristian Thorup-Kristensen will participate in the planning as well.

Danish Institute of Agricultural Science, Department of Plant Protection

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	104	89	140	0	333
Technical personnel	103	135	85	0	323
Other operational costs	82	77	155	0	314
Equipment	0	0	0	0	0
Others (please specify)	0	63	0	0	63
Direct costs	289	364	380	0	1033
Indirect costs (20% of direct costs)	57	73	76	0	206
Total	347	436	456	0	1239

Comments:

Danish Institute of Agricultural Science, Department of Crop Physiology and Soil Science

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	636	197	159	0	992
Technical personnel	574	163	83	0	820
Other operational costs	276	37	3	0	316
Equipment	0	0	0	0	0
Others (please specify)	0	7	12	0	19
Direct costs	1486	404	257	0	2147
Indirect costs (20% of direct costs)	297	81	51	0	429
Total	1783	485	308	0	2576

Comments:

Royal Veterinary and Agricultural University, Department of Ecology, Zoology section:

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	646	147	36	14	843
Technical personnel	39	40	0	0	79
Other operational costs	62	10	5	12	89
Equipment	0	0	0	0	0
Others (please specify)	0	23	0	7	30
Direct costs	747	220	41	33	1041
Indirect costs (20% of direct costs)	149	44	8	7	209
Total	897	263	49	40	1250

Comments: We apply to transfer kr. 40.000 to 2005 to allow preparation and participation in the planned workshop to be held at FIBL in Switzerland during 2005. As it is the budget for "Operational cost which has not been fully used up, and as the workshop will mainly involve personnel cost and some travel cost, we thus apply to transfer kr. 39.000 from "Other operational cost" to "Scientific personel"

Royal Veterinary and Agricultural University, Department of Agricultural Science, Plant and Soil Science Laboratory

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	227	69	0	238	534
Technical personnel	0	78	0	0	78
Other operational costs	116	48	6	0	170
Equipment	0	0	0	0	0
Others (please specify)	9	3	0	5	17
Direct costs	352	120	84	243	799
Indirect costs (20% of direct costs)	70	24	17	49	160
Total	422	144	101	292	959

Comments:
In 2003 a transfer of kr. 254,000 to 2005 was accepted. We now apply to transfer a further kr. 38.000, in total kr. 292,000 to 2005, mainly to allow preparation and participation in the planned workshop to be held at FIBL in Switzerland during 2005.

National Environmental Research Institute, Department of Terrestrial Ecology

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

Year:	Consumption before 2003	Consumption 2003	Expected consumption 2004	Budget 2005	Total
Salaries					
Scientific personnel	247	55	88	0	390
Technical personnel	0	47	0	0	47
Other operational costs	28	10	1	0	39
Equipment	0	0	0	0	0
Others (please specify)	0	0	0	0	0
Direct costs	275	112	89	0	476
Indirect costs (20% of direct costs)	55	0	41	0	96
Total	330	112	130	0	572

Comments:

Årslev 8. december 2004

Bilag til statusrapport 2004 for FØJO II projekt VegCatch (I.10), med uddybende beskrivelse af det forventede videnskabelige output i 2005.

I hendhold til kommentarerne fra FØJOs bestyrelse til statusrapport 2004 for VegCatch projektet, følger her en redegørelse for projektets publiceringsplaner for 2005:

I de delprojekter hvor vi har bedt om at dele af midlerne udskydes til 2005 er der ialt 7 publikationer hvor færdiggørelsen også er udskudt til 2005, se liste herunder. Publikationerne er naturligt den sidste del af projektarbejdet der færdiggøres, og det er næsten udelukkende publiceringsopgaver der er tilbage til 2005. Bortset fra en enkelt af disse 7 publikationer er der allerede gennemført en betydelig del af databearbejdningen, og for nogle af dem er skrivningen også påbegyndt. Så selvom det er en stor opgave vi har i 2005 med at få skrevet disse artikler, så er det en opgave vi kan løse.

I det svar jeg fik fra FØJO står der at ”*samtidig påkræves, at deliverables i form af videnskabelige publikationer opfyldes*”. Det er klart, at vi skal opfylde vores forpligtelser, men det gælder vel for alle forskningsprojekter, at ikke alt hvad man har planlagt lykkes som ønsket. Sådan er det også gået I VegCatch. Meget er lykkedes rigtig godt, og giver grundlag for videnskabelige publikationer i velanskrevne internationale tidsskrifter, men ikke alt kan publiceres på det niveau vi fra starten ønskede, enkelte dele har slet ikke givet resultater egnet til publicering.

I projektet er der i øvrigt lavet flere publikationer som slet ikke var planlagt fra starten. Der er bl.a. i 2003 publiceret et stort review om grøngødning og efterafgrøder i Advances of Agronomy, et review der klart har bidraget til at synliggøre FØJO indsatsen omkring grøngødning og efterafgrøder internationalt. I løbet af 2004 er der skrevet store bidrag til både en ny dansk bog om grøngødning og efterafgrøder og et tilsvarende rådgivningshæfte. Bog og hæfte vil udkomme på Landbrugsforlaget inden for de næste få måneder, og må forventes at synliggøre indsatsen overfor danske brugere og bidrage til at resultaterne anvendes i praksis.

Disse publikationer har krævet en stor indsats, men de var ikke en del af projektets oprindelige Deliverables. At bruge ressourcer på dem, er en prioritering jeg har foretaget undervejs. Denne prioritering betyder, at der er færre ressourcer til anden publicering, og betyder et lidt sænket ambitionsniveau omkring nogle af de andre publikationer der skal laves. Men jeg mener klart, at denne prioritering var rigtig, og har bidraget til at arbejdet med efterafgrøder og grøngødning i VegCatch (samt resultater fra flere andre tidligere og nuværende FØJO projekter) formidles så effektivt som muligt.

Liste med publikationer der forventes skrevet i løbet af 2005, med emner/titler og status.

Delprojekt 1: International artikel om: *Root growth, and N dynamics of organically grown potato, squash and Chinese cabbage*. Artiklen skal skrives af Hanne Lakkenborg Kristensen i 2005. Data er klar og den indledende databearbejdning er gennemført. Artiklen kan skrives meget over samme skabelon som den tidligere artikel om rodvækst af rødbede, selleri og sukkermajs. Vi er ikke sikre på at materialet kan bære en artikel i et internationalt videnskabeligt tidsskrift, det bliver muligvis publiceret i forbindelse med en videnskabelig konference eller lign. i stedet.

Delprojekt 1: International artikel om: *Root growth and N dynamics of white cabbage, red beet and leek in rotation with catch crops*. Artiklen skal skrives af Hanne Lakkenborg Kristensen i 2005. Resultaterne stammer fra forsøg med sædskiftesekvenser under delprojekt 8. En stor del af dataopgørelsen er gennemført, og en del af resultaterne er allerede anvendt i forbindelse med dansksproget publicering. Målingerne er mere detalierede end i de to ovennævnte artikler om rodvækst af grønsagsarter, og de indgår i en større sammenhæng dyrket med og uden efterafgrøder som forfrugt, som tillader en mere omfattende tolkning af rodvækstens betydning for

N udnyttelse og for optimal placering i et sædskifte. Materialet vurderes derfor at kunne bære en ”tungere” videnskabelig artikel end de to førnævnte, og artiklen planlægges sendt til *Plant and Soil*.

Delprojekt 3: International artikel om: *Organically grown carrot, cauliflower and onion varieties* udsat til 2005. Artiklen skal skrives færdig af Gitte Bjørn I 2005. Dele af materialet er tidligere publiceret i Forskningsnytt om økologisk landbruk i Norden og i en DJF-grøn viden. Lige nu arbejder en bachelorstuderende med det samlede materiale fra forsøget. En stor del af forarbejdet til den videnskabelige artikel er dermed gennemført. Artiklen forventes publiceret i *Biological Agriculture and Horticulture*

Delprojekt 4: International artikel om: *The effects of undersown catch crops on P bioavailability for subsequent crops.* Artiklen skal krives i 2005 af Lars Stouman Jensen. Resultaterne er opgjort, og viser desværre kun begrænsede effekter af efterafgrøderne. Resultaterne viser forskelle i efterafgrødearterne både i P optagelse, i C/P forhold og i deres respons på forskellige P niveauer i jorden. Så selvom der ikke kunne måles nogen P-eftervirkning, indeholder resultaterne interessant information om de forskellige arter. Materialet kan ikke bære en ”tung” videnskabelig publikation, men der satses indtil videre på en artikel i Acta Agriculturae Scandinavia eller f.eks. Comm. Soil Science and Plant Analysis.

Delprojekt 8: International artikel om: *The effects of crops with very different rooting depth in cropping sequences on N dynamics*. Artiklen skal skrives i 2005 af Kristian Thorup-Kristensen. Forsøget har givet meget spændende resultater. Der mangler lidt opgørelser af selve rodvæksten af afgrøderne, men langt de fleste data er opgjort, meget af beregningsarbejdet er gennemført, og skrivningen er påbegyndt. Dele af materialet er tidligere bearbejdet og anvendt i dansksprogede publikationer. Artiklen forventes p.t. at sendes til *Plant and Soil* senest i maj 2005.

Delprojekt 8: International artikel om: ***Rooting depth, soil depletion, N uptake and release of new species of undersown catch crops***. Artiklen skal skrives i 2005 af Kristian Thorup-Kristensen. Vi har valgt at fortsætte forsøgsarbejdet, så det sidste markforsøg gennemføres i løbet af 2004/2005. De allersidste data vil dermed først være tilgængelige efter høst 2005. De fleste data er dog allerede klar, og de sidste målinger af efterafgrødernes rodvækst, N optagelse og udtømning af jordprofilen er netop afsluttet, så vi nu blot venter på analyseresultater. Der er også gennemført en betydelig dataopgørelse, og dele af materialet er tidligere bearbejdet og anvendt i dansksprogede publikationer. Der er opnået meget spændende resultater hvor vi har kunnet identificere nye efterafgrøder med meget dyb og effektiv rodvækst, så der vurderes at være et godt grundlag for en international publikation. Publikationen færdiggøres i løbet af efteråret 2005, der er endnu ikke taget stilling til hvilket tidsskrift den skal sendes til.

Delprojekt 8: En international artikel om: ***A decision support system for choice and management of catch crops***. Artiklen skal skrives i 2005 af Anders Pedersen. Arbejdet er indgår i Anders SOAR støttede PhD projekt. Idegrundlaget for beslutningsstøtte systemet er på plads, men det meste af arbejdet mangler endnu at blive gjort, det vil være en vigtig opgave for Anders i løbet af 2005. Systemet skal baceres på en database med resultater fra DAISY simuleringer, gennemført med varierende jordforhold, nedbørsforhold og i forskellige sædskiftesituationer. Ved anvendelse skal brugerene altså ikke anvende DAISY modellen selv, men trække på indholdet i databasen ved hjælp af nogle få hovedparametre. Der er endnu ikke taget stilling til hvor arbejdet skal publiceres, dette indgår i den videre planlægning af Anders Pedersens PhD projekt.

Med venlig hilsen
Kristian Thorup-Kristensen