Status Report 2003 and Application for Continuation in 2004

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The Directorate for Food, Fisheries and Agro Business
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1. Research program

Research in organic farming 2000-2005 (DARCOF II)

2. Project title and number

Organic production of cucumber and tomato grown in composted plant material from field crops.
Number: I.1

3. Head of project

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5. Other project staff

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6. Project period (month, year)

Start of project:	2000
End of project:	2004

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

A. Project summary

The overall aim of the project is to develop production systems for organically grown glasshouse vegetables of good quality, utilising cheap, easily available growth substrates. The substrates should, first of all, release sufficient nutrients for the plants through the cropping period, but large excesses of nutrients should be avoided. Furthermore, the environment should not be contaminated with excesses of the supplied nutrients.

In greenhouse vegetable production, large amounts of plant nutrients are needed, and e.g. a tomato crop will need approximately 20 times as much nitrogen as most field crops. In organic production this leads to two main problems. Plant nutrients are a limited resource in organic crop production, and it can be difficult to acquire the large amounts needed from organic sources. In organic production where the crops are grown directly in the soil, addition of such large amounts of manure or compost to the soil can lead to serious risk of nitrogen leaching and other losses of plant nutrients to the environment.

It is generally assumed that organically produced vegetables are of better quality than conventional products, though such differences are not well documented. As plant nutrition cannot be controlled as precisely as in conventional production, temporal quality problems can occur due to excess, deficiency or imbalance between plant nutrients.

Thus, there are potential problems with nutrient losses and possibly quality, but we know little about how serious these problems are in the present organic vegetable production systems. Therefore the first goal of the project is to study the present systems used in organic greenhouse vegetable production, study nutrient balance, potential for nitrogen leaching loss and quality of the products.

The problems discussed, in combination with large investments for converting greenhouses from conventional to organic production and the risk for build up of soil diseases and pests in the greenhouse soil, has led to an interest in organic production where the plants are grown in compost in limited beds, i.e. without contact to the soil in the greenhouse. Using this method, the crops can be grown in organically produced composts, but it is possible to combine this with some of the advantages from the conventional production methods. Leaching losses can be prevented as drainage water can be collected, and problems with nematodes and soil borne diseases are prevented as the compost is changed for each crop. At the same time, conversion of conventional greenhouses to organic production will be cheaper, as much less changes will be needed in the greenhouse.

However, growing the crops in limited beds is seen by many as being in conflict with the basic ideas behind organic farming, and growing the plants directly in the soil also has advantages which will be lost by changing to growing the crops in limited beds. Soil is a very diverse growth medium, which will supply all nutrients and trace elements to the crop. Further, when the plants are grown in the soil, it will allow them to explore a large soil volume, and thus the reserves of water and many nutrients within the rooting zone of the crop will be bigger than in limited beds.

The conclusion is, that important problems and advantages are found with either of the systems, and a solution could be to develop a system, which combines the most important advantages of the two systems. In the project we want to compare these two systems with an intermediate system, where most of the compost is added to a limited bed, but where the plants are allowed to develop their root system both in the compost and in the surrounding soil. The amount of compost added directly to the soil can then be reduced to much lower levels and thereby the leaching risk will be strongly reduced, the drainage water from the compost can be collected, and the compost will be changed before each crop, so at least in this part of the root zone of the crop it will not encounter soil-borne pests and diseases due to previous crops.

The objectives of the project are to: 1) Study existing organic greenhouse vegetable production systems, e.g. nutrient balance, effects on soil organic matter and nitrogen leaching losses and on quality of the products, 2) Develop composts primarily based on clover-grass hay, straw and other plant materials which will be easy to obtain from organic farms, and 3) Develop and compare existing and alternative growing systems, study their effect on nutrient balance, leaching losses, crop production and quality. The results from the first part of the project will be used when deciding how much of the effort in the later part is to go into development of alternative systems, and how much is to be used for further development of the existing methods.

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

No.	Work package title	Participants*	Budget (1.000 DKr)	Start	End	Deliverable No:
1	The nutrient dynamics and nutrient use efficiency of the current production systems.	Kai Lønne Nielsen, Morten Nielsen	0.85	2000	2002	1-2
2	Development of plant based compost	Kristian Thorup-Kristensen, Dorte Bodin Dresbøll	1.0	2001	2004	3-6
3	Project co-ordination, development and comparison of production systems for tomatoes.	Kristian Thorup-Kristensen, Jørn Nygaard Sørensen	2.05	2001	2004	7-12
4	Quality evaluation of the greenhouse vegetables from contrasting cropping systems	Merete Edelenbos, Morten Nielsen	0.8	2002	2003	13-16

* Responsible participants are underlined

B. Objectives and expected achievements

The overall project aim is to promote organic production of greenhouse vegetables by developing a method where easily available growth substrates can be used for the production. We want to compose growing media, which can supply all or most of the necessary plant nutrients, and limit the need for supplementary fertilisation. On the other hand, large excesses of nutrients should be avoided as such excesses may depress plant growth and yield quality. And third, the environment should not be contaminated with excesses of the supplied nutrients. This will be done by the development of production systems and by identifying and analysing the main obstacles for the fertilisation both with respect to agronomic and ecological performance:

1. The proposal aims at the following main achievements: To describe the nutrient dynamics and nutrient use efficiency of the current production systems.
2. To develop a production system for selected greenhouse vegetables with optimised nutrient use efficiency and thereby reduce the risks of nutrient leaching. The production system will be based on the utilisation of cheap and locally available composted plant material from field crops.
3. To evaluate the quality of the greenhouse vegetables from contrasting cropping systems.

C. Midterm results and progress

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

Project in general

The results of the initial evaluation made in WP1 showed some of the problems of handling the very large quantities of nutrients that must be added to these very intensive production systems where crop rotation is not practicable. Composting experiments and initial tests of the tomato cropping systems started in 2001, and from 2002 the larger scale experiments with cropping systems for tomatoes have started.

During the early stages of the project we had a lot of changes in the project staff. During 2001 we included two further researchers into the project; Dorte Beck-Nielsen (now Dorte Bodin Dresbøll) who is employed as a PhD student to work with development of the plant based composts (WP2), and senior scientist Jørn Nygaard Sørensen to make the experiments on production systems (WP3). By the end of 2001 Kai Lønne Nielsen left DIAS, and thereby also the OrcTom project. During 2002 Morten Nielsen has been fired due to budget reductions within the Department of Horticulture, and from September 2002 Merete Edelenbos have taken over the responsibility for WP4. These changes have led to some delays, the contact to growers and the number of publications directed towards growers have

been less than it should have been, and the general cohesion within the project group have suffered somewhat.

During the project we have had meetings with a group of producers associated to the project. The group consists of two producers of organic greenhouse vegetables, one producer of conventional greenhouse vegetables and an advisor. During meetings with the group we have discussed the work and its results, and the plans for future work within the project.

In general, the results from WP1 showed that there may be some problems with excessive input of nutrients in the way organic greenhouse vegetables are currently being produced. Other conclusions from WP1 are that 1) We could not measure any clear effect of “organic age” (i.e. 4, 10 or 15 years as organic greenhouse soil) on the soil organic matter or nutrient content. 2) Grafting of tomatoes onto more vigorous and disease resistant root stocks may improve nutrient use efficiency considerably 3) Tomatoes were found to have deep rooting, in this experiment to c. 2.0 m, but it was probably limited from further depth development by a shallow ground water table. 4) We did not observe any difference in quality due to organic vs. conventional cropping systems, whereas choice of variety and maturity stage at harvest seemed to be important. These conclusions are our results of a number of measurements on existing organic tomato production systems, we find that they have given us some valuable information to work with, but they are not the results of experiments and they should not be seen as *firm scientific conclusions.*

Preliminary results from WP2 and WP3 show that plant based nutrients can be used as a valuable source of nutrients for organic greenhouse vegetables. We have obtained good results where plant based nutrients were used in combination with animal manure, even when the plant material were the main nutrient source. Our results do not yet show whether a system based solely on nutrients from plant material could be developed. It is also clear from the preliminary results of the cropping system experiment in WP3 that successful organic tomato production can be made in limited beds, though we encountered some problems as compared to growing the tomatoes directly in the soil. The *intermediate system*, where the tomatoes are planted into limited beds, but allowed then to spread their root system to the soil outside these beds have worked very well. The tomato root system have grown as well in the soil outside the limited beds as the roots of plants growing directly in the soil, and the crop growing in this intermediate system have shown the highest yields (though yield differences between the systems are small). The closed and the intermediate system may have several advantages as discussed in the project summary above. It is still discussed whether a system where the plants are grown in limited beds could be acceptable in organic production, or the plants has to grow in the soil. The *intermediate system* seems promising, it gives good yields and combine many of the advantages of the two other systems, and it can be used if the closed system is not acceptable as the plants are not grown in the soil.

WP1 **The nutrient dynamics and nutrient use efficiency of the current production systems**

This work package was finished almost two years ago. The main conclusions as mentioned above are that: 1) There may be some problems with excessive input of nutrients in the way organic greenhouse vegetables are currently being produced, 2) We could not measure any clear effect of “organic age” (i.e. 4, 10 or 15 years as organic greenhouse soil) on the soil organic matter or nutrient content. 2) Grafting of tomatoes onto more vigorous and disease resistant root stocks may improve nutrient use efficiency considerably 3) Tomatoes were found to have deep rooting, in this experiment to c. 2.0 m, but it was probably limited from further depth development by a shallow ground water table. 4) We did not observe any difference in quality due to organic vs. conventional cropping systems, whereas choice of variety and maturity stage at harvest seemed to be important. For more detail, se the status report from 2002.

We have used these conclusions in the planning of the of the rest of the experiment, but they are only publishable to a smaller extent, as they are not firm scientific conclusions from experiments but only the results of measurements at a few commercial greenhouses.

WP2 **Development of plant based compost**

When using composted plant residues as a growing medium for organic greenhouse production nutritional quality and physical structure of the compost are important parameters. We have primarily focused on how to control the quality of a compost by choice and combination of materials to be composted, and by management of the composting process. In order to obtain a compost which can supply the plants with the nutrients they need, an important part of the focus is on how compost quality is affected by the timing of addition of the different materials. By postponing the addition of most of the

nutrient rich material, it is the hypothesis that composting can take place with less decomposition of the structural material (straw) and less immobilisation of the nutrients from the nutrient rich material (clover grass hay) than if all the structural and nutrient rich materials are mixed together from the beginning.

In the fall 2001 a large scale composting experiment was set up to investigate this hypothesis. In contrast to an initial small-scale experiment, no significant effect was found on the CO2 release from the different treatments determined as weight loss. On the other hand, the postponing significantly affected the availability of mineralised N after composting. After 7½ weeks of composting twice as much nitrate was available in the treatment where addition of 75% of the clover grass was postponed until later during the composting process.

Finding that postponing addition of nutrient rich material has such an extended effect on mineralisation has brought interesting new insight on influencing compost processes. Instead of just changing the composition of plant material we have found another way to affect the compost processes using the same amount and type of material.

The compost was tested as a growing media in a small-scale growth experiment using lettuce (Lollo bionda) as test plant. The compost was suitable as a growing media, but the level of mineralised nitrogen was too high primarily in the treatments with postponed N addition, which led to delayed root growth. Further, the availability of K was found to be disproportionally high.

Due to these results a new composting experiment was set up, still following the same hypothesis, but with a higher initial C/N ratio. The results from this experiment showed that this time the initial nitrogen level was too low, thus no net mineralisation was observed. With low levels of nitrogen and high amounts of chloride the test plants grew poorly in a growth experiment with potted cucumber. A subsequent test with tomato plants showed clearly better growth.

Samples of compost was also placed in leaching tubes, where the release of nutrients and the weight loss was followed during half a year after the end of the composting process, to investigate whether the different treatments of the compost affects not only its quality at the end of the composting, but also its nutrient release and stability during the subsequent period where it will be used as a growing medium for plants. Results showed that postponing the addition of some of the nutrient rich material did not significantly affect the compost stability. Nutrient release results are still not ready.

Experience from the growth experiments with lettuce and cucumber showed that compost based solely on wheat straw and clover grass hay had some structural problems. Water retention capacity and stability of the medium was not satisfactory. This could also be a problem if the crops were grown in limited or intermediate systems and especially the instability was observed in the tomato experiments in WP3.

WP2 is a part of the Ph.D. project of Dorte Dresbøll where she also focuses on the structural aspects of decomposition of plant materials. Wheat straw has been used in the experiments up till now, as the high-C and structural component of the composts, as it is a cheap and very easily available material. However, as a part of the Ph.D. project of Dorte Dresbøll we also work in more detail with the structural aspects of other plant materials. Samples of hemp and *Mischanthus* straw and different qualities of wheat straw was placed in litterbags in the larger compost containers, and we investigated the actual decomposition of cellulose and lignin by the use of light and scanning electron microscopy (SEM). This might give insight in which types of material are best suited as structural elements in compost. Results from the SEM analyses showed how hemp and *Mischanthus* straw as expected are much more stabile than wheat straw. Additionally the results revealed that despite similar degradability (approximately 10% after 8 weeks) the anatomical structure and arrangement of the two species differed significantly. Based on the results we expect addition of hemp to have a better effect on the structure and water retention capacity of the compost than *Mischanthus*. While the *Mischanthus* material stay together in relatively large firm pieces in the compost, the different structure of hemp could allow it to disintegrate into fibres or threads in the compost. It is these qualities which have made hemp a fibre crop, and they have the possibility of adding improved water holding characteristics to the compost.

Due to the results obtained through the composting experiments we are able to make compost based on plant residues, which contains sufficient nutrients to function as a growing media. It is important to have the right nutrient input but assuming that the amounts of nutrients are sufficient; management of the composting process can partly control the release of nutrients. Work during the remaining project period will focus more on the structure and water retention capacity. New experiments are starting within a few weeks where we will test the effect of adding hemp or *Mischanthus* straw to the compost, how these materials may stabilise the compost and enhance the water retention capacity due to the low degradability and special fibre quality of hemp. During the mid term evaluation last year Urs Niggli suggested that Dorte Dresbøll contacted other groups working on compost. This summer

she visited Dr. Jacques Fuchs at the FiBL in Switzerland in order to exchange knowledge. There are also plans for her to visit a research group in Germany and one in Sweden.

Four papers for international scientific journals are currently planned from this work, which are also going to be part of the PhD thesis of Dorte Dresbøll:

- Delayed nutrient application affects mineralisation rate during composting of plant residues.
- Structural differences in wheat, hemp and mischanthus straw affects compost quality and stability.
- Long-term stability, structure and mineralisation rate of compost is influenced by timing of nutrient application.
- Microscopic studies of structural changes of plant residues during decomposition in a compost environment.

***WP3* Project co-ordination, development and comparison of production systems for tomatoes**

The experiments on growing systems for tomatoes started with two small-scale experiments in the late summer of 2001. The results of the small-scale experiments showed that the deep-litter compost used alone led to a strong immobilisation of nutrients in the beginning, and on its own it was totally unsuited to deliver nutrients for the tomatoes. Use of clover grass hay as a growing medium showed high release of nutrients during the early phase. Both of the media showed severe problems with physical structure. Addition of a material, which could improve the structure and give a more uniform and well-aerated medium was necessary. Based on this, a growing medium made of clover grass, deep-litter compost manure and peat was chosen for the larger scale experiments for 2002 and 2003. The ratio between clover grass and deep-litter compost manure was 1:1 by volume in 2002, but 3:1 in 2003.

Transplants of 'Aromata' grafted on 'Beaufort' rootstocks were established either in 1) an open, 2) a closed or 3) an intermediate growing system. All treatments were applied equal amounts of the growing medium. Compared with 2002, the applied amount of total N in the growing medium was slightly higher in 2003. In the open system, the compost was slightly incorporated into the soil. In the closed and intermediate systems, the medium was placed on a layer of wheat straw in boxes. In the intermediate system, holes were made in the vertical side of the boxes, to allow the roots to grow also in the soil outside boxes. All plants were irrigated with water applied through drippers and micro sprinklers. Drainage water was re-circulated in both the closed and intermediate system. During the summer period, half of each plot was applied supplemental fertilizer in the form of dried lucerne pellets. Compared with 2002, the amount of supplemental fertilizer was lower and applied earlier in 2003. Biological control was used with success against insect pests. During the growing period, samples of leaves, growing media, and drainage water were analysed repeatedly to evaluate the nutritional status of the plants.

The plants have grown very well, and the plants from all the three growing systems appeared to be well supplied with nutrients. In the closed system some blossom-end rot was found in the early fruits, indicating a possible lack of calcium or excessive K supply, and some symptoms indicating a lack of magnesium have also been observed. In total, the results show that the mixture of clover grass and deep litter compost is a satisfying growing medium for tomatoes. During the first part of the growing period nutrients from clover grass are easily available both for plants and for microorganisms. Immobilized nitrogen is believed to be re-mineralised later during the growing season.

Nutrient concentrations in the plants have been followed during growth, to observe possible deficiencies or imbalances. The nutrient concentrations have not been very different among the cropping systems. During the summer 2002 the levels fell slowly, and at the time when it was planned to add supplemental fertilizer to half of each plot, the levels of N and K was found to be the most critical. N rich plant material is a good source of both of these nutrients, and it was decided to use dried lucerne pellets for supplemental fertilization. Measurements of plant nutrient concentrations two weeks later already showed increased concentrations of most plant nutrients where lucerne pellets had been added.

Measurements of rooting depth and intensity have been made in order to evaluate the capability of the plants from the intermediate system to exploit the soil for plant nutrients. In 2002, minirhizotron measurements showed a rooting depth of 60 and 110 cm three and five weeks after transplanting, respectively. No differences between the open and the intermediate system were observed. In 2003, minirhizotron measurements have been made less intensively.

During the first two weeks of the harvesting period, plants from the open system produced less

yield compared with plants grown in closed or intermediate systems, i.e. in open boxes. This effect could be due to differences in soil temperature. During the first two month of growth, the root-media temperature in the open boxes was approximately 5°C higher than the open growing system. The yield from plants grown in the closed system dropped below that of the intermediate and open systems after a few weeks (Figure 3.1).

After seven month of growth, in both years, we attained a yield of 34-36 kg per m^2 in the open system and around 1 kg per m^2 more in the combined system (Figure 3.1). This increase may be ascribed to the higher root-media temperature during the first month or two. The yields obtained were of the same size as at commercial growers. Application of supplemental fertilizer tended to increase the yield in 2002, but not in 2003. In both years, the yield of plants from the closed system was significantly lower than the two other systems. This decrease was probably due to deficiency in some plant nutrients and to some extent to imbalances between nutrients. Further, differences in nutrient availability are likely to occur due to differences in water and air content of the growing media. This deficiency or imbalance caused the development of some blossom-end rot in fruits from the closed system. Apart from this disorder, the three growing systems did not influence the marketable fruit quality.

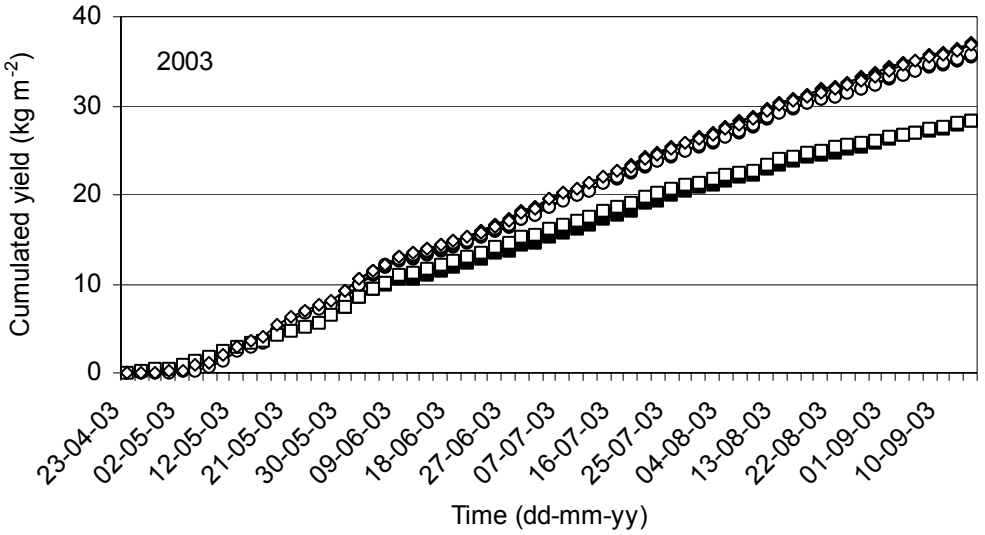

Figure 3.1. Cumulated yield of tomato produced in open (dot), closed (square), and intermediate (diamond) growing system with (solid symbols) and without (open symbols) supplemental fertilizer.

Tomatoes from the three production systems have been delivered to quality analysis in WP4 in June, July, and late September. In 2003, fruits were harvested slightly more mature compared with 2002.

The very good results we attained both years show that we can base most of the nutrient supply for tomatoes on plant material. Though the goal was a 100% plant-based growing medium, this is still a clearly promising result, as it will help making the producers less dependent on import of animal manure.

In the closed and intermediate systems, the growing media in the open boxes can be replaced before each new planting. Thereby, problems with soil borne pest and diseases can be avoided or at least reduced. In the combined growing system, plant roots may be injured by soil borne pest or diseases. However, we believe such problems will be less significant compared with common soil growing.

The results with the intermediate system show that this system is very promising, and it could probably be implemented with the level of knowledge we have already. It seems to combine many of the advantages of each of the two other systems, though we cannot be sure that it will be as effective against soil borne pests and diseases as the closed system. If the closed system is to be used in practice, more research work will be needed first, due to the observed problems with nutrient deficiency and imbalances, causing blossom-end rot and reduced yield in this system.

In the closed and intermediate systems the drainage water was recycled. Thereby loss of N by leaching could be avoided. At the final harvest the content of soil mineral nitrogen was acceptable low

in the intermediate system, whereas in the open system the content was 2 to 5 fold higher.

WP4 **Quality evaluation of the greenhouse vegetables from contrasting cropping systems**
The influence of different cropping systems on chemical composition and sensory quality of tomatoes from the three growing systems was determined for three harvest times in 2002 (June, July, October) and for two harvest times in 2003 (June and October). All results, except for the results from the harvest in October 2003, have been analysed by statistics. For both years it is very obvious that only minor effects of the cropping system on sensory quality is obtained, and where significant differences were found these differences in quality were very small. The minor differences in sensory quality are a reflection of very little effects of the cropping systems on the chemical composition in the tomatoes, which includes dry matter -, acid- and sugar content, pH and content and composition of aroma components. The very small effects on these chemical compounds in the tomatoes were found even though a clear effect of growing system was observed on both leaf and fruit content of plant nutrients. As very few differences in sugar- and acid content was observed between the cropping systems in 2002 and 2003 for the various harvest times, very few differences in sensory sweetness and sourness was obtained. However a small effect of the cropping system on the sensory determined tomato aroma was seen for the first harvest for both years. Tomatoes from the “closed” growing system had significantly more intense tomato aroma compared to the “open” growing system.

In 2003 the cropping system had a significant effect on many of the sensory quality attributes, which could be due to the fact that the tomatoes were harvest at a more mature stage in 2003 than in 2002. The maturity stage of the tomatoes in 2003 was more comparable with the maturity stage of tomatoes preferred by consumers. Tomatoes from the “closed” growing system seemed to be firmer and crispier and with slightly higher tomato aroma, sweetness and less sourness compared to tomatoes from the “open” growing system. In conclusion the results show that the contrasting cropping systems did only have a minor affect on the eating quality of tomatoes, but a slight increase in quality could be obtained by growing tomatoes in a “closed” cropping system.

C.2 Fulfilment of deliverables and milestones

(To be completed for each work package)

WP1 The nutrient dynamics and nutrient use efficiency of the current production systems.	**Time schedule according to application**	**Deviations, if any***
Task		
1 Monitor current organic cropping systems for their effects on the soil and nutrients		
2 Monitor current organic cropping systems for their effects on product quality.		
Deliverables		
1 Two popular paper in growers journals	2001	Only one
2 Presentation at growers and advisors meetings		
Milestones		
1 Evaluation of nutrient availability with soil depth at the end of the growing season	2000	
2 Evaluation of the effect of organic cropping practice on soil organic matter	2001	
3 Evaluation of effect of existing cultivation conditions on tomato fruit quality	2000	
4 Evaluation of rooting density and depth potential for the tomato and cucumber crops, ultimo 2001	2001	Only tomato
5 Evaluation of potential for nutrient leaching with current cropping systems	2001	

WP2 Development of plant based compost	**Time schedule according to application**	**Deviations, if any***

Task		
1 To develop plant based composts for organic production of greenhouse vegetables	2001/2002	
2 To test the compost as a nutrient source for cucumber crops	2002	2003
Deliverables		
1 At least 2 popular papers in growers journals	2002/2003	
2 Paper on the effect of the effect of different compost compositions cucumber	2003	
3 Paper on the significance of compost mixture and supplemental fertilisation for growth and temporal nutrient uptake of cucumber	2003	
4 Presentation at growers and advisors meetings		
Milestones		
1 Selection of the most suitable composition of field crop plant material for further work	Summer 2002	
2 Determining composts to be used in WP3	2001	

WP3 Project co-ordination, development and comparison of production systems for tomatoes	**Time schedule according to application**	**Deviations, if any***
Task		
1 To co-ordinate the project		
2 To develop an “intermediate” growing system		
3 To compare the intermediate growing system with growing in limited beds and directly in the soil		
Deliverables		
1 Project homepage	2001	Cancelled
2 Two popular papers on the testing and comparison of cropping systems	2003/2004	
3 Paper on the comparison of tomato growth in soil, limited beds, and the intermediate system	2003	
4 Paper on root growth and soil nutrient depletion of tomatoes	2004	
5 Presentation at scientific meetings	2003/2004	
6 Presentation at growers and advisors meetings		
Milestones		
1 Determining treatments to be used for the tomato experiment in 2002	2001	
2 Determining whether growing directly in the soil or growing in the intermediate system should have first priority in optimisation of the growing methods	2002	

WP4 Quality evaluation of the greenhouse vegetables from contrasting cropping systems.	**Time schedule according to application**	**Deviations, if any***
Task		
1 To determine which of the compared cropping systems optimise sensory and nutritional quality of tomatoes		
2 To determine how relevant nutrient imbalances influence taste and other quality aspects		

3 To determine relevant objective quality characteristics of tomatoes		
Deliverables		
1 At least 2 popular papers in growers or food trade journals	2002/2003	
2 Paper on the significance of cropping system for the aroma composition of tomato	2003	2 and 3 merged to one paper, will be submitted early 2004
3 Paper on the significance of compost mixture and supplemental fertilisation for quality of tomato	2003	
4 Presentation at meetings for growers, advisors and others		
Milestones		
1 Aroma analyses for tomato are established and validated	2001	
2 Determining whether differences in cropping systems cause significantly different aroma compositions in tomato	2002	
3 Determining whether the cropping system being tested produce tomatoes of a quality which is similar or superior to the standards generally found with the cultivar(s) in question	2002	
4 Contribution to recommendation for cultivation programme for tomatoes and cucumber	2003	

** Deviations are to be further discussed in D*

D. Description of deviations and subsequent adjustments of plans

Basically, the project is running according to the original plan. However, the many changes of staff, and the fact that the start of WP2 had to await the employment of a PhD student, have led to a few delays and other changes in the plans as can be seen in the list above. The delay in WP2 has led to the most pronounced changes, in that the tomatoes in 2002 is not grown in the compost developed in WP2 as planned. Still, we have been able to test the three cropping systems, and tested them with a fertilisation primarily based on plant material. With the changes in staff, we have had to concentrate the effort, and e.g. the measurements on root growth of cucumbers will not be made, we only measure root growth of tomatoes, as this is the crop we are mainly using in the experiments. Also the production of the homepage has been cancelled. As there have been many other tasks in co-ordinating the project the homepage was not considered top priority. A short description of the project can be found at the DARCOF homepage, and using a lot of time to keep a continuously updated and informative homepage for a relatively small group of growers and advisors was not considered the optimal way to inform them about the project.

With these adjustments of the project, we believe that we can achieve all the main objectives of the project in spite of the problems encountered.

E. Project publications and other products

1. Articles in international, scientific journals with review procedures

None yet.

2. Papers presented at congresses, symposiums, etc.

***Nielsen, K.L. & Thorup-Kristensen, K.**, 2001. Growing media for organic tomato production. In: International Symposium on Growing Media & Hydroponics, eds. B. Alsanius, P. Jensén & H. Asp. SLU, Alnarp, 14.

3. Reports, articles in agricultural journals, etc.

Beck-Nielsen, D. 2003. Plantebaseret compost – en erstatning for sphagnum og husdyrgødning? Forskningsnytt om økologisk landbruk i Norden 2: 10-11.

Nielsen M., 2001. Quality of Danish tomatoes (Kvalitet af danske tomater). Gartner Tidende 9, 4-5.

Edelenbos, M.; Thybo A. & Nielsen, M. 2003. Nyt økologisk dyrkningssystem påvirker ikke tomaters kvalitet. Gartner Tidende 119 (11), 14-15.

Sørensen JN & Thorup-Kristensen K 2003. Økologisk dyrkningssystem til tomat. GartnerTidende 119(9):34-35.

Sørensen JN 2003. Dyrkningssystem til økologiske tomater. Økologisk Jordbrug 23(286):6.

Sørensen JN 2003. Miljøvenligt dyrkningssystem til økologiske tomater. JordbrugsForskning 2:1-2.

Sørensen JN 2003. Miljøvenligt dyrkningssystem til økologiske tomater. ExterntFORUM 22.

Sørensen JN 2003. Et økologisk og miljøvenligt dyrkningssystem til tomat.

Sørensen JN 2003. Miljøvenligt dyrkningssystem til økologiske tomater.

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

Morten Nielsen participated at the open house arrangement “taste tomatoes” (”Smag på tomater”) 28 August 2001 at Lene Tvedegaard, Gartneriet Toftegaard with a presentation on “Quality of Danish tomatoes” (”Kvalitet af danske tomater”).

Morten Nielsen participated 3 October 2001 in the annual general meeting of the Danish tomato growers wth a presentation on “Quality of Danish tomatoes” (”Kvalitet af danske tomater”).

Kai Lønne Nielsen participated in a “field day” 2nd May 2002 arranged by the Danish Horticultural Growers organisation at a commercial organic cucumber producer, where he presented the project, mainly the results from WP1.

Kristian Thorup-Kristensen participated in the “Tomato Conference” held by the British Tomato Growers Organisation in Coventry in October 2003, with the presentation “Nutrition of organic tomatoes” presenting the ideas and results of the project.

The project and its results have been presented at a number of occasions at open house days for both Danish and other visitors at the Department of Horticulture.

F. Scientific education

Dorte Bodin Dresbøll is doing her PhD on development of composts for organic greenhouse production. Her study is based on a combination of the OrcTom project and a project on organic production of potted flowers.

G. National and international cooperation

There is collaboration with the DARCOF2 project I.10, dealing with catch crops, green manures and field vegetable production. The understanding gained in this project on N dynamics, root growth and the nutrient value of various catch crops and green manures is included in the planning of the activities in the OrcTom project.

There is collaboration with the project **Development of organic production of potted plants in Denmark** which is also running at the department. Both projects deal with various aspects of growing media for organic production.

Kristian Thorup-Kristensen will participate in the project EUROTATE_N, Development of a model based decision support system to optimise nitrogen use in horticultural crop rotations across Europe. Within this project growth and N relations of vegetable crops will be modelled for use in fertilizer desi-

cion support systems. The project will work on outdoor vegetables, but tomatoes, cucumbers and other species relevant for Danish greenhouse production will also be included as the model should be usefull also in southern Europe. This project will start in the beginning of 2003.

Merete Edelenbos is collaborating with Dr. Angelika Krumbein, Institut für Gemüse- & Zierpflanzenbau, Grossbeeren/Erfurt on aroma and sensory quality of tomatoes.

Kristian Thorup-Kristensen is a member of the management comity of Cost-631, Understanding and Modelling Plant-Soil Interactions In the Rhizosphere Environment

H. Critical reflection on the project

This project has from the beginning had some clear ideas and goals, but there have also been a lot of uncertainties. We had some ideas about how the existing organic greenhouse vegetable production systems worked, and the improvements, which could be needed. But generally too little was known about how they worked, and in the project we have used the first two years mainly to gather information about the systems, and doing some initial investigations, before we started the really experimental work. We still find that this was the right approach, even though we could have done more experimental work if we had started right from the beginning.

I find it hard to give any general comments on the methods and approaches of the project. Even though the different parts of the project are closely connected and work towards a common goal, the methods used within them are very different. One common feature is, that we have tried not just to work on adjustments and optimisation of the existing systems, but chosen to work on alternatives to the present systems (plant based compost, and production in limited beds), which we believed could offer possibilities to develop the production methods. This does make an immediately useful result of the project less certain, but if we succeed, it could be of greater value. Luckily, the results show that we will succeed at least with some of these ideas. The intermediate growing system seems very promising, and though we have not shown that we can base fertilization solely on plant matter, the results clearly show that most of the nutrient supply can be based on plant matter. Whether it would have been better to work more on improving the existing systems we will never know, but this could also have given valuable results. However, I think that it is more obvious to do this in development projects, which we could apply for together with specific growers, and to pursue some of the new ideas in a research project as this.

We have included a “users group” which is following the project, where we have discuss the ideas, progress, and results. This is a good way of involving the end users in the research, and we have had many good discussions, but it is not without problems. This is especially true within an area as organic greenhouse vegetable production where quite few people are active. The discussions could be more open if more people were active within the area.

8. Budget

A. Account for any change in budgets

B. Budget for the whole project (1.000 DKK)

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

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

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	1082	577	212		1871
Technical personnel	688	445	25		1158
Other operational costs	474	200	20		694
Equipment					
Others (please specify)	99	85	10		194
Direct costs	2343	1317	267		3917
Indirect costs (20% of direct costs)	469	261	53		783
Total	2812	1568	320		4700

Comments: Activities in WP2 has been somewhat delayed compared to the original plans, meaning that at the end of 2002 we had used a smaller sum (72.000 less) than in the original budget. As the final experiment in this WP is just being started now, there will still be a few experimental activities in early 2004. We therefore want to transfer the kr. 72.000 to the 2004 budget to finish these activities as shown in the budget above.

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	Expected consumption 2003	2004	2005	Total
Man-months					
Scientific personnel					
Technical personnel					

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries					
Scientific personnel	1082	577	212		1871
Technical personnel	688	445	25		1158
Other operational costs	474	200	20		694
Equipment					
Others (please specify)	99	85	10		194
Direct costs	2343	1317	267		3917
Indirect costs (20% of direct costs)	469	261	53		783
Total	2812	1568	320		4700

Comments:

B. Budget for each participating department (1.000 DKK)

Danish Institute of Agricultural Science, Department of Horticulture

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

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries Scientific personnel	1082	577	212		1871
Technical personnel	688	445	25		1158
Other operational costs	474	200	20		694
Equipment					
Others (please specify)	99	85	10		194
Direct costs	2343	1317	267		3917
Indirect costs (20% of direct costs)	469	261	53		783
Total	2812	1568	320		4700

Comments:

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

Name of Institute:

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

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

Comments:

Dansk resume

Del 1: Undersøgelser af eksisterende systemer

Undersøgelserne har vist et betydeligt overskud af næringsstoffer, og vist at det i praksis er vanskeligt at håndtere så store mængder af organisk gødning uden at det giver en betydelig risiko for tab. Resultaterne peger dog også klart på at der kan skabes forbedringer, både ved udvikling af gødnings- og dyrkningsstrategier og f.eks. ved podning af tomaterne på mere effektive rodsystemer som vi fik lejlighed til at undersøge. Undersøgelser af jord der havde været dyrket med økologiske tomater i 4, 10 eller 15 år viset ingen klare effekter af "økologisk alder". Muligvis opvejes den store tilførsel af organisk materiale af at temperatur og fugtighedsforhold giver anledning til en langt hurtigere omsætning end under udendørs forhold. Dette kan have stor betydning for værdien af tungtomsættelige organiske gødninger.

Undersøgelse af kvalitet viste ikke nogen klar effekt af om tomaterne blev dyrket økologisk eller konventionelt, men en tydelig effekt af sortsvalg og af hvor modne tomaterne var ved høst. Det ser altså ikke ud til at økologisk dyrkning i sig selv er garanti for en god smag og kvalitet, man at der skal arbejdes målrettet på at opnå dette.

Del 2: Fremstilling af plantebaceret kompost

Storskala komposteringsforsøg blev igangsat i efteråret 2001 med hvedehalm og kløvergræshø som materiale. I forsøgene testede vi hypotesen, at forskudt tilsætning af en del af det næringsrige materiale ville forhindre en betydelig immobilisering under nedbrydningen af det kulstofrige hvedehalm. Resultaterne bekræftede hypotesen og viste, at efter 7½ uges kompostering var der dobbelt så meget tilgængeligt kvælstof i de behandlinger, der kun havde fået tilført en del af det kvælstofrige materiale fra starten. De interessante resultater der viste, at komposteringsprocessen kan påvirkes blot ved at forskyde tidspunktet for tilsætning af N-rigt materiale giver grund til at tro, at vi på baggrund af planterester kan danne en næringsrig kompost der er anvendelig som dyrkningsmedium. Resultater fra de indledende undersøgelser i projektets *del 3* samt resultater fra et forsøg med dyrkning af økologiske potteplanter har vist at kompostens struktur og vandfysiske egenskaber er meget vigtig. Vi har derfor fokuceret undersøgelserne mere på kompostens struktur, og brug af andre plantematerialer til at skabe struktur i komposten, især hamp og elefantgræs. Mikroskopistudier har vist at hamp, udover at være meget stabilt også indeholder mange fibre der forventes at kunne give en bedre vandholdende evne og overordnet struktur til komposten.

Del 3: Udvikling af dyrkningssystemer for tomater

Der blev i 2001 lavet et indledende forsøg med substrat til dyrkning af tomater i afgrænset bed. Forsøget viste bl.a. at den anvendte dybstrøelseskompost fra starten immobiliserede næringsstoffer så der ikke var noget tilgængeligt til tomaterne, mens kløvergræshø som dyrkningssubstrat frigav mange næringsstoffer helt fra starten. Begge medier havde problemer med dårlig fysisk struktur. På baggrund af disse resultater har vi fremstillet et dyrkningssubstrat der består af en blanding af dybstrøelse, kløvergræs og sphagnum.

Med dette dyrkningssubstrat er der i 2 år gennemført forsøg med dyrkning af tomater i afgrænsede bede, direkte i jorden og i et "blandet" system hvor tomaterne startes i dyrkningsmediet i de afgrænsede bede, men hvor de får mulighed for også at sprede deres rodsystem til jorden uden for bedene. Alle behandlingerne blev tildelt samme mængde dyrkninssubstrat. Planterne blev etableret tidligt forår og afsluttet efter syv måneders vækst. Afgrøden lykkedes rigtigt godt i alle tre behandlinger. Det "blandede" system har givet de bedste resultater, men forskellene i udbytte, tilvækst og næringsstofkoncentrationer er ikke stor. I 2003 var udbyttet i afgrænsede bede dog betydeligt lavere end i de øvrige behandlinger. Midt på sæsonen har vi opdelt parcellerne og eftergødet halvdelen af hver parcel. Til eftergødskningen har vi brugt lucernepiller, og resultater fra målinger af næringsstofindhold i planterne tyder på at eftergødskningen har virket godt. Udbyttet var dog ikke påvirket i større omfang.

Resultaterne tyder altså på at vi kan dyrke tomater med godt resultat i bede hvor recirkulering af overskudsvand er muligt, også i en længere sæson, og at vi kan forsyne tomaterne med en stor del af de næringsstoffer der har behov for ved hjælp af plantemateriale. Plantemateriale kan bruges både som en vigtig del af det dyrkningssubstrat planterne etableres i og til eftergødskning.

Ved dyrkning i det "blandede" system er det ikke alene muligt at forhindre tab og nedvaskning af kvælstof, men også muligt at sikre optimal næringsstofforsyning. Endvidere er det muligt at mindske risikoen for rodsygdomme idet planterne etableres i friskt dyrkningssubstrat.

Del 4: Effekt af dyrkningssystem på kvalitet af tomater

Effekten af dyrkningssystemerne på indholdsstoffer og sensorisk kvalitet blev undersøgt ved 3 høsttider i 2002 (juni, juli og oktober) og ved 2 høsttider i 2003 (juni og oktober). Resultaterne (uden data fra oktober 2003) viser, at dyrkningssystemerne generelt har haft lille effekt på såvel pH, indholdsstoffer som tørstof, syre, sukker og aromastoffer, hvilket resulterer i, at der kun er observeret en lille effekt af dyrkningssystemer på den sensorisk kvalitet (tekstur, smag, aroma egenskaber) af tomaterne. I 2003 blev tomaterne høstet ved et modenhedstrin højere end i 2002, hvilket bevirkede, at lidt større forskelle i sensorisk kvalitet blev registreret. Tomaterne fra det lukkede system i juni 2003 blev bedømt mere sprøde, faste, søde og havde svagt højere intensitet af tomat aroma i forhold til tomater dyrket i det åbne system.