Danish Research Centre for Organic Farming

Midterm Status Report 2002 and Application for Continuation in 2003

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1. Research program

Research in organic farming 2000-2005 (DARCOF II)

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2. Project title and number

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

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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 Beck Nielsen	1.0	2001	2003	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	2004	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 project is now through the initial phase of evaluation of current practices of organic greenhouse vegetable production. The results of the initial evaluation show 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 last year, but from the beginning of 2002 the larger scale experiments with cropping systems for tomatoes have started.

During the project until now, we have had a lot of changes in the project staff. During 2001 we included two further researchers into the project; Dorte Beck-Nielsen 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. Though some changes in staff are normally unavoidable within such a project, and do not have to become a problem, there have been too many changes in staff within the OrcTom project. We still believe that we can fulfil most of our plans, and as it can be seen from the discussion of the single work packages below, we have obtained a number of promising results. However, it has led to some delays, the contact to growers and the number of publications directed towards growers have 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. The meetings with this group will continue until the end of the project.

In general, the results from WP1 showed that there may be some problems with the way organic greenhouse vegetables are currently being produced. The input of nutrients is very high, and even though these crops require high input, the results indicate that it may be higher than needed by the crops and so high that it may cause environmental problems. A few other conclusions from WP1 is 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. Also 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 root 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. If limited beds are not acceptable, the intermediate system could then be used.

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

The starting point of this project has been to describe the nutrient dynamics and nutrient use efficiency of the current production systems and to evaluate the quality of the greenhouse vegetables from contrasting cropping systems. By the end of the growing season 2000 the first measurements of the nutrient status of two organic greenhouse operations took place as described below.

Two greenhouse nurseries were selected for the first samplings in the project: ”Gartneriet Markhaven” growing organic tomatoes and ”Narayana” where they grow organic cucumbers.

Soil were sampled to 250 cm depth and into layers of 50 cm for analysis and analysed for content of inorganic N (N_{min}) and dry matter percentage, Mg, P, K, pH, total-C, and total-N (tab. 1.1). The amounts of nitrate found in the soil at the end of the growing season can be seen in fig. 1.1.

Table 1.1. *The concentration of plant available ammonium-N (NH_4-N), phosphorus (Pt) and potassium (Kt) and the amount of plant available NH4-N, P and K expressed as kg per ha., measured in an organic nursery (Gartneriet Markhaven) in a “4 year old organic soil” under ungrafted tomato plants.*

Depth (cm)	NH4-N (mg/kg)	Pt (mg/100g)	Kt (mg/100g)
0-50	2.93	10.20	74.50
50-100	0.57	2.30	9.00
100-150	0.13	0.70	7.90
150-200	0.20	0.60	7.20
200-250	0.23	0.50	7.60
kg/ha	28	996	7406

At ”Gartneriet Markhaven” we took soil samples in three greenhouses which had been changed to organic production at different times, 15 years ago, 10 years ago and 4 years ago, to test whether the large amounts of organic matter added for years led to an accumulation of organic N and thus lead to soils with very high mineralisation potential. Further, samples were taken within a subplot where the tomato plants had been grafted onto a supposedly healthier root system rather than growing on their own root system (Fig. 1.1.).

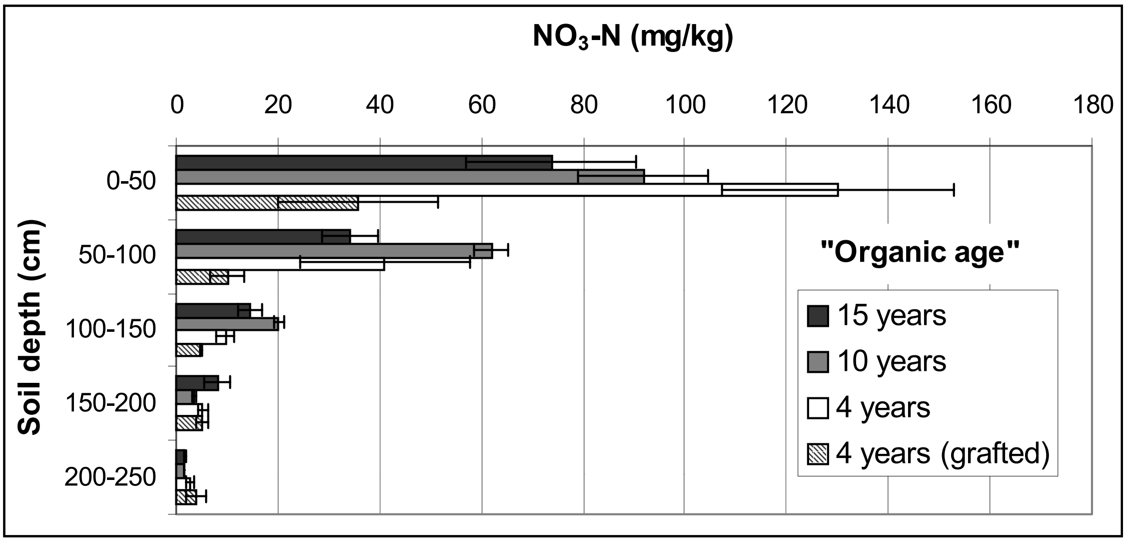

Figure 1.1. *The concentration of nitrate in organic greenhouse soils (Gartneriet Markhaven) of differing organic age. The climatic conditions were similar in the different greenhouses and identical amounts of compost had been added to the soil prior to tomato planting in 2001.*

There was no significant effect of “organic age” on nitrate concentration, but there was a highly significant difference in nitrate concentration between plants that were grafted on ‘Beaufort’ root-stock, compared to plants grown on their natural root. The total amount of nitrate from 0 to 250 cm was 421 kg NO3-N/ha under grafted plants and 1319 kg NO3-N/ha under ungrafted plants. In addition to this the soil contained 21 kg NH4-N/ha under grafted plants and 28 kg NH4-N/ha under ungrafted plants. The pH, concentration of P, K and Mg was not significantly affected by “organic age”, but nutrient availability at the end of the growing season was generally very high, but reduced slightly when the plants were grafted.

The topsoil (0-50 cm) contained more than 10,000 kg N/ha (total-N) under both grafted and ungrafted plants, but the level was not affected by “organic age”. This is surprising, as very large amounts of organic matter is added to the soil in this system, and a build-up of organic matter would have been expected. On the other hand, the conditions are also very favourable for organic matter decomposition. The temperature is very high for most of the year; the average yearly temperature must be around 20 °C compared to the approximately 8 °C which is the average yearly temperature in Denmark. At the same time the soil is kept humid and nutrient rich during the whole period, which will further promote organic matter decomposition. Such fast decomposition of organic matter will affect the value of various organic manures, and especially manures that show a slow nutrient release in the field, must be expected to have a much higher first year effect when used for greenhouse vegetables.

Measurements of rooting depth and intensity has been made during the 2001 growing season in order to determine the capability of the crop to deplete the available resources in the soil, and to evaluate how much of the remaining nutrients can potentially be lost by leaching. Minirhizotron tubes were inserted in one of the greenhouses and rooting depth and intensity was monitored over the growing season.

The rooting depth of tomatoes increased relatively fast during early growth stages with a rate of c. 16 mm per day. However, when calculated relative to temperature sum the rate was c. 0.7 mm day^{-1} $degree^{-1}$, which is low compared to most crops. Due to the high temperature in the greenhouse and the very long growing season, the tomato crop has the potential for very deep rooting anyhow. Later during the growing season the depth development slowed down and finally stopped. Apparently, the ground water level was between 100 and 150 cm for a long part of the season, but whether this, or other factors such as an increasing fruit load made the root growth slow down is unknown. No roots were found between the rows until the end of September, and the root intensity between the rows remained low.

Generally it can be concluded that high amounts of especially nitrate and potassium were found in the soil at the end of the growing season. There were no effects of organic age, suggesting that little or no build up of organic matter and N occurs in these systems, even though very high amounts of organic matter is added. The results suggest possibilities for improved nutrient strategies with reduced nutrient surpluses, but also that improved nutrient utilisation may be achieved by improving the plant material as indicated by the drastic effects of grafting. The results confirm the need for evaluation of cropping systems in order to reduce the risk of environmental contamination with excesses of the supplied nutrients.

The results of the quality evaluation have been published as a popular paper and presented orally at two occasions. The results showed that the variation in the different tomato samples was first of all influenced by difference in maturity and difference between varieties. In this sample, the difference between growers as well as the difference between organic and conventional production systems was of minor importance.

The general impression of taste was determined by, sweetness, aroma and intensity of red colour. These taste characteristics was not fully described by analyses of soluble solids (sugar) and acids. The impression of firmness and crispness of the tomatoes were related to analyses of maximum force during penetration. It is expected that a better description can be obtained by including additional texture parameters.

WP2 **Development of plant based compost**

Dorte Beck Nielsen is doing her PhD on this topic, and as a part of the Research School for Agriculture and Food Systems (SOAR). Within the PhD she focus 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 retains good structure from the composted materials such straw, and which at the same time 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 affected the availability of mineralised N after composting significantly. 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 simple 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.

Due to these results a new composting experiment was set up, still following the same hypothesis, but with a higher initial C/N ratio. Analyses of this compost are still being conducted, and a preliminary growth experiment with cucumber has started recently. Samples of this compost has also been placed in leaching tubes, where the release of nutrients and the weight loss will be followed during several months after the end of the composting process, to find out 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.

Experience from the growth experiment with lettuce and the recently started experiment with potted cucumbers showed that compost based solely on wheat straw and clover grass hay have some problems concerning water retention. This could also be a problem if the crops were grown in limited or intermediate systems.

Wheat straw has been used in the experiments 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 Beck-Nielsen we also work in more detail with the structural aspects. Samples of hemp and *miscanthus* straw and different qualities of wheat straw have been placed in litterbags in the larger compost containers, and we are investigating the actual decomposition of cellulose and lignin by the use of light and scanning electron microscopy. This might give insight in which types of material are best suited as structural elements in 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. Future work will focus more on the structure and water retention capabilities. This can be influenced by the degree of cutting the material, or it can be influenced by the use of other plant materials. It is the plan to test the effect of adding hemp to the compost, which may stabilise the compost and enhance the water retention capacity due to the special fibre quality of this plant.

It was the original plan that plant based compost developed within WP2 should be used for the tomato experiments in WP3. As the start of WP2 was delayed until Dorte Beck Nielsen was employed, this has not been possible. For 2003 it is still the plan to base the tomato production at least partly on the compost developed within WP2.

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

The work on project co-ordination has been strongly affected by the changes in staff as mentioned above. A lot of communication and follow up is needed to make sure that the project is continuing towards its main goals when scientists who were not included in the formulation and the early stages of the project take over. By now, the project leader is the only scientist in the project who have been involved from the start, and though I believe that the project is now running quite well, and will obtain most of its goals, the changes have led to delays and less contact and publications directed at the growers. It has also led to less cohesion and interchange between the active scientists in the project, as they have had to use much of their time and energy on getting started in their own part of the project. We hope that no further changes in staff will occur, so the co-ordination during the rest of the project period can focus on improving communication both within the project and with the growers and advisors.

Due to the delay of WP2, we have not produced the purely plant based compost which should have been used for the tomato experiment of 2002. Still, we have based most of the nutrient supply for the tomatoes on plant material, as described below.

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, and 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 experiment for 2002.

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. In the open system, the compost was 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, wholes were made in the side of the boxes, to allow the roots to grow also in the soil outside boxes. All plants are irrigated with water applied through drippers and micro sprinklers. Drainage water is re-circulated in both the closed and intermediate system. In the middle of August, half of each plot was applied supplemental fertilizer in the form of dried lucerne pellets. 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 appear 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, and some symptoms indicating a lack of magnesium have also been observed. The mixture of clover grass and deep litter compost is therefore believed to be 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 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, and the yield during the subsequent period have been higher with than without supplemental fertilizer (figure 3.1).

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. 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.

During the first two weeks of the harvesting period, plants from the open system produced less yield compared to plants grown in open boxes. This effect could be due to differences in soil temperature. The yield from plants grown in the closed system dropped below that of the intermediate system after two weeks and below that of the open system after three weeks (Figure 3.1). From then on the three systems produced equal amounts of fruits. Application of supplemental fertilizer tended to increase the yield. Apart from some blossom-end rot in fruits from the closed system, the three growing systems did not influence the marketable fruit quality.

Tomatoes from the three production systems have been delivered to quality analysis in WP4 in June and July, and a third sample will be delivered in early October.

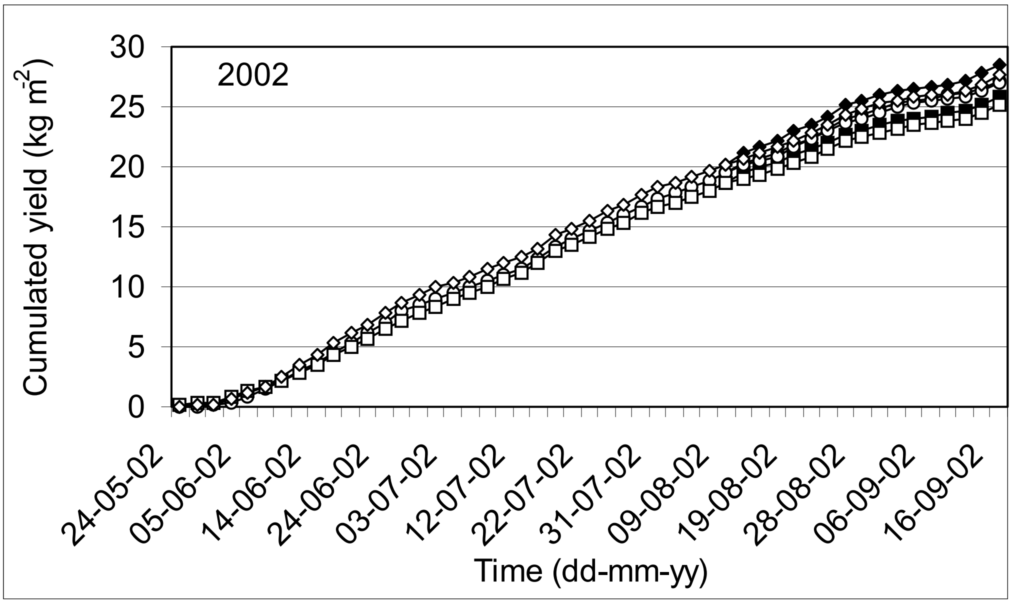

Figure 3.1. Cumulated yield of tomato produced in open (dot), closed (square), and intermediate (diamond) growing system with (solid symbols) and without (open symbols) supplemental fertilizer.

The tomato experiment will continue until late October. The very good results we seem to get this year show that we can base most of the nutrient supply for the 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. The choice of strategies to be tested in 2003 will be based on the results of the 2002 experiment and of the results from WP2, but we expect to supply a larger fraction of the nutrients from plant material than we have done in 2002.

***WP4* Quality evaluation of the greenhouse vegetables from contrasting cropping systems**

A method for collection and quantification of volatile compounds in tomatoes has been developed and validated. Aroma volatiles were collected from 250 blended tomatoes using dynamic headspace analysis at 25 ºC. The enzymes in the tomatoes were inactivated after 180 seconds to resemble a typical eating situation. The aroma extracts were quantified on a GC coupled to a FID for routine analysis and to a MS for analytical purposes. A total of 31volatiles were identified by GC-MS and quantified by GC-FID in cv. Aromata. Of these, most of the compounds have been identified previously in tomatoes.

The aroma analysis and other important physical and chemical quality methods were applied on tomatoes harvested in WP3 in June (10th) and July (22nd) 2002. These methods will also be applied on tomatoes harvested in October (7th) 2002. The measures include colour determined by HunterLab colourimetry, texture determined on a Texture analyzer, titratable acid determined by potentiometric titration, soluble solids determined on a refractometer, pH using an electrode and, dry matter content determined by forced air convection, vitamin C using dichlor-indophenol titration and minerals determined by atomic absorption.

Sensory quality of tomatoes at each harvest time is also evaluated using descriptive analysis with 10 trained panellists. The panellists developed a sensory profile with 9 attributes: “surface redness colour”, “flesh redness colour”, “general impression”, “tomato aroma”, “sweetness”, “sourness”, “mealiness”, “crispness” and “firmness”. The sensory analysis of the tomatoes from harvest 1 showed difference in surface and flesh redness colour and firmness, however, the was no differences between the cropping systems in the intensity of the flavour attributes. Though the measurements made so far have indicated little difference in quality between the cropping systems, this may change with the last samples, which will be harvested October 7th. During the earlier part of the growing period all the tomatoes were well supplied with nutrients and there were little difference between the treatments, but the results from WP3 show much larger differences now, differences that may affect quality more strongly.

All data from the 2002 experiment has to be analysed in order to make final plans for year 2003.

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	Delayed
2 To test the compost as a nutrient source for cucumber crops	2002	
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	Delayed
2 Determining composts to be used in WP3	2001	Delayed

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	
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.

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

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.

F. Scientific education

Dorte Beck-Nielsen 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 desicion 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 preliminary results indicate that we will succeed at least with some of the ideas. 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 projects 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, and where we 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:	Consump-tion before 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months						
Scientific personnel	13	13.5	13.5	5		45
Technical personnel	8.4	18.5	16.5	1		44.4

Year:	Consump-tion before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries						
Scientific personnel	527	542	577	214		1860
Technical personnel	203	475	445	28		1151
Other operational costs	132	254	203	12		601
Equipment						
Others (please specify)	99	110	86	10		305
Direct costs	961	1381	1311	264		3917
Indirect costs (20% of direct costs)	192	276	262	53		783
Total	1153	1657	1573	317		4700

Comments:

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:	Consump-tion before 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months						
Scientific personnel	13	13.5	13.5	5		45
Technical personnel	8.4	18.5	16.5	1		44.4

Year:	Consump-tion before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries						
Scientific personnel	527	542	577	214		1860
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Equipment						
Others (please specify)	99	110	86	10		305
Direct costs	961	1381	1311	264		3917
Indirect costs (20% of direct costs)	192	276	262	53		783
Total	1153	1657	1573	317		4700

Comments:

B. Budget for each participating department (1.000 DKK)

Danish Institute of Agricultural Science, Department of Horticulture

Year:	Consump-tion before 2002	Expected consumption 2002	2003	2004	2005	Total
Man-months						
Scientific personnel	13	13.5	13.5	5		45
Technical personnel	8.4	18.5	16.5	1		44.4

Year:	Consump-tion before 2002	Expected consumption 2002	2003	2004	2005	Total
Salaries						
Scientific personnel	527	542	577	214		1860
Technical personnel	203	475	445	28		1151
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Comments: