Final Report

For DARCOF II research projects financed by grants from
The Directorate for Food, Fisheries and Agro Business
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1. Research program

Research in organic farming 2000-2005 (DARCOF II)

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2. Project title and number

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

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Slutrapporten sendes elektronisk til Forskningscenter for Økologisk Jordbrug *foejo@agrsci.dk* senest 3 måneder efter projektets afslutning.

Slutrapporten vedlægges et dansk resumé.

6. Project period (month, year)

Start of project: 2000
End of project: 2004

7. Final report

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. Progress and results

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

[Her anføres resultater og konklusioner, samt resultaternes aktuelle anvendelighed og fremtidige perspektiver, herunder beskrives resultaternes eventuelle markedsmæssige potentiale og samfundsøkonomiske bidrag. Endvidere skal det anføres i hvilket omfang resultaterne har ført til nye kompetencer, fastholdelse af projektmedarbejdere, givet grundlag for nye projekter o.lign.]

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 were made in 2001, and during 2002 and 2003 the larger scale experiments with cropping systems for tomatoes were made.

In general, the results from WP1 showed the problems involved with the high 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.*

The 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 not shown that all of the plant nutrients for a tomato crop can be supplied by plant based fertilizers, but we have shown that most of it can, and that the plant based fertilizers can be used for production of the basic growing medium as well as for supplemental fertilization during the crop growth. We have also shown that high yielding tomato crops may be grown with substantially lower nutrient supply than was assumed. By these results we have reached one of our main goals, by making organic greenhouse vegetable production much less dependent on nearby organic dairy farms with a substantial manure surplus.

It is also clear from the 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 both years (though yield differences between the open and the intermediate systems were small). The closed and the intermediate system may have several advantages as discussed in the project summary above. By this result we have met another main goal of the project, by showing that alternative production methods can be used, which solve some of the problems encountered by the intensive monoculture cropping systems used for organic greenhouse vegetable production. The closed system will need more studies before it is ready for practical use. The intermediate system on the other hand, can be employed in tomato production as it is.

Many measurements of tomato quality from the different systems showed very few differences. A very small tendency towards better taste in tomatoes from the closed system and the intermediate system compared to tomatoes grown directly in the soil was found. This difference was too small to conclude that these systems give better tomatoes, also because the many chemical measures of quality (contents of sugars, acids and many other compounds of importance for quality) showed practically no differences between tomatoes from the different systems. The very small differences are surprising, as quite significant differences were found in plant nutrient uptake and also in nutrient content in the fruits. It indicates that tomato quality is quite robust towards this sort of changes in cropping systems and nutrient supply.

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 combines 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. The quality measures show that either of the systems can be used, without significant effects on tomato quality.

Though the results from the experiments are at the moment only used to a limited extent in organic greenhouse production, methods are now available which can be used to solve problems in existing or new organic greenhouse production systems. We have met considerable interest in the use of plant based fertilizers from organic vegetable producers, for various reasons. The interest has come from both greenhouse and outdoor producers. This interest is likely to increase as regulations on nutrient import e.g. through feed import to organic animal production become more strict. The results from the project have given important knowledge on how to use the plant materials as fertilizers, and have given us research expertise to develop this aspect further.

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

This work package was finished at the end of 2001. 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.

The results and conclusions from WP1 have been very valuable for the planning and development of the of the rest of the project. However, 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 compost by choice and combination of materials to be composted, and by management of the composting process. In order to obtain 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 the starting materials 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 disproportionably 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. However, during the leaching tube incubation a significantly higher nitrogen release was observed when the addition of part of the nutrient rich material had been postponed for three weeks during composting. These finding corresponds to the findings in the first composting experiment. As no net mineralisation was observed during the previous composting period it was concluded that the mineralisation had been delayed due to the low initial nutrient content.

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 formed a part of the Ph.D. project of Dorte Dresbøll where she also focused on the structural aspects of decomposition of plant materials. Wheat straw was used in the initial 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 Dresbøll we also worked in more detail with the structural aspects of other plant materials. Samples of hemp and *Miscanthus* 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 into which types of material are best suited as structural elements in compost. Results from the SEM analyses showed how hemp and *Miscanthus* straw as expected are much more stable 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 *Miscanthus*. While the *Miscanthus* 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 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. Thus, during the final work of the PhD of Dorte Dresbøll we focused more on the structure and water retention capacity. The effect of adding hemp or *Mischanthus* straw to the compost was tested, comparing the particle size distribution and water retention capacity of the different compost types. No significant differences was found in particle size distribution, however particle geometry was observed to be very different in the hemp compost where the particles had a 'fluffy' appearance compared to the more defined pieces of straw in the *Miscanthus* and wheat compost. As expected this 'fluffy' surface improved the capillarity in the medium and enhanced the water retention capacity of the hemp compost. Thus, it was concluded that hemp would be a suitable structural element in plant based compost used as growing medium.

Though hemp straw is not a crop residue such as wheat straw, it can still be produced at a relatively low price under Danish field conditions, and it is therefore a realistic material to use for improving the structure of growing media for organic production. The most obvious alternatives are peat or fibre from coconut production. Both of these products are problematic in terms of either environment or long distance transport.

***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 tomatoes. Use of clover grass hay as a growing medium showed high release of nutrients during the early growth 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 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. In the open system, the compost was incorporated into the topsoil. 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 the 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. Based on the results from 2002, this additional fertilization was reduced but applied earlier in the 2003 experiment. 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. It is interesting the tomatoes from the intermediate system behaved differently, and did not show symptoms of blossom end rot. Thus, already very early during growth, the plants in the intermediate system were able to benefit from the access to the soil outside the boxes, and thereby to obtain a more balanced nutrition. 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.

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 already three and five weeks after transplanting, respectively, later during the season they reached more than 200 cm depth. No differences between the open and the intermediate system were observed, showing that tomatoes in the intermediate system were able to develop their root system in the soil outside the boxes to the same level as the tomatoes grown directly in the soil.

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-medium temperature in the boxes was approximately 5°C higher than in the soil. However, 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. Both years the yield in the intermediate system was around 1 kg per m^2 higher than when tomatoes were grown directly in the soil (Figure 3.1). This increase may be ascribed to the higher root-media temperature during the first month or two. The yields obtained ($kg/m^2/week$) were of the same size as at commercial growers. 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. Application of supplemental fertilizer tended to increase the yield slightly in 2002, but not in 2003. 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. Quite large differences in nutrient supply and plant nutrient concentrations were obtained between the systems, especially when comparing the closed system to the open and the intermediate system. However, apart from the problems with blossom end rot in 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, July, and late September.

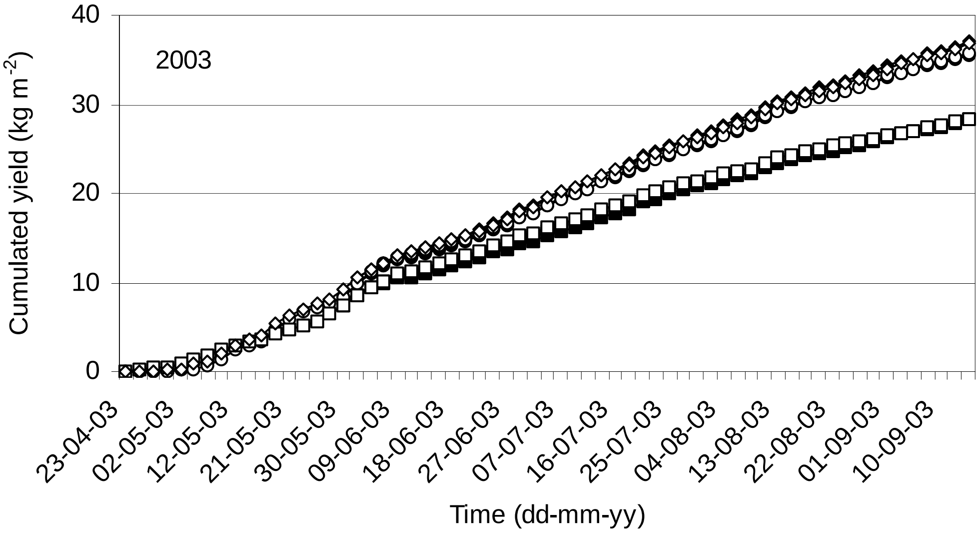

Figure 3.1. Cumulated yield of tomato produced in open (dot), closed (square), and intermediate (diamond) growing system with (solid symbols) and without (open symbols) supplemental fertilizer.

The nutritional status, expressed by the chemical composition of the youngest fully developed leaf (YFDL), differed between the treatments. On average of years, the N concentration in YFDL from closed system was 3.3% of the dry matter compared with 3.6% in the open and intermediate systems. These values are considerably lower compared with the recommended value of 4-5% N in YFDL. Both years, Mg accumulated in the YFDL from plants grown in closed beds. Plants grown in closed beds showed a significant reduced Ca concentration of the YFDL compared with plants grown in the open system and the intermediate system. Application of supplemental fertilizer significantly increased the concentration of N and in one year also the concentration of K of the YFDL.

The concentration of N, Ca, and Cd in fruits from plants grown in closed beds was significantly lower compared with those grown in the open system. In 2002, this was also the result for the P concentration. The concentration of K and Mg was not influenced by the treatments.

Estimates on the total nutrient acquisition have been calculated. These calculations were based on the cumulated fruit production, cumulated leaf production and chemical analyses of fruits and mature leaves at several sampling dates during the growing period and on production and chemical composition of stems, leaves and green fruits at the final harvest date. Calculations showed that the total acquisition of N, P, K, and Mg by plants grown in the closed beds was lower compared with plants grown in the soil or in the intermediate system. In 2002, the total acquisition of N from the open, closed, and intermediate systems was 77, 67, 74 g m-2, respectively, and 63, 48, 65 g m-2 in 2003. Of the total N acquisition, approximately 55% and 30% was removed by the fruits and the mature leaves, respectively. The results thereby show, that high yields can be achieved with more moderate N supply than generally assumed for greenhouse grown tomatoes.

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 intermediate 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 cropping systems was determined for three harvest times in 2002 (June, July, September) and for two harvest times in 2003 (June and October). For both years it is obvious that only minor effects of the cropping system on sensory quality is obtained, and where statistical significant differences were actually found, the differences were very small.

The minor differences in sensory quality were obtained even though the different cropping systems had clearly affected the nutrient supply for the plants, and the concentration of major plant nutrients in the harvested tomatoes. Still, the effects on the organic compounds in the tomatoes were very limited. This was true both for the concentration of dry matter, acid- and sugar content, pH and content and composition of aroma components.

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 small differences in sensory sweetness and sourness was obtained. However a small effect of the cropping system on the sensory determined tomato flavour was seen for the first harvest for both years. Tomatoes from the “closed” growing system had significantly more intense tomato flavour 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” and “intermediate” 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 followed by an “intermediate” 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*	Full filled
Deliverables			
1 Two popular paper in growers journals	2001	Only one	
2 Presentation at growers and advisors meetings			OK
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*	Full filled
Deliverables			
1 At least 2 popular papers in growers journals	2002/2003	2003/2004	OK
2 Paper on the effect of the effect of different compost compositions cucumber	2003	Due to results and a PhD study, the subjects have been changed and more papers published	OK Four scientific papers plus a PhD thesis written
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			OK
Milestones			
1 Selection of the most suitable composition of field crop plant material for further work	Summer 2002		OK
2 Determining composts to be used in WP3	2001		OK

WP3 Project co-ordination, development and comparison of production systems for tomatoes	Time schedule according to application	Deviations, if any*	Full filled
Deliverables			
1 Project homepage	2001	Part of DARCOF homepage	(OK)
2 Two popular papers on the testing and comparison of cropping systems	2003/2004		Several popular papers
3 Paper on the comparison of tomato growth in soil, limited beds, and the intermediate system	2003	Delayed	Draft paper available. To be submitted May 2005
4 Paper on root growth and soil nutrient depletion of tomatoes	2004	Merged into paper 3	See 3
5 Presentation at scientific meetings	2003/2004		OK
6 Presentation at growers and advisors meetings			OK
Milestones			
1 Determining treatments to be used for the tomato experiment in 2002	2001		OK
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		OK

WP4 Quality evaluation of the greenhouse vegetables from contrasting cropping systems.	Time schedule according to application	Deviations, if any*	Full filled
Deliverables			
1 At least 2 popular papers in growers or food trade journals	2002/2003	1 paper is published	(OK)
2 Paper on the significance of cropping system for the aroma composition of tomato	2003	Delayed	Draft paper available. To be submitted before 15 April 2005
3 Paper on the significance of compost mixture and supplemental fertilisation for quality of tomato	2003	Delayed	Draft paper available. To be submitted during April 2005
4 Presentation at meetings for growers, advisors and others			OK

Milestones			
1 Aroma analyses for tomato are established and validated	2001	2002	OK
2 Determining whether differences in cropping systems cause significantly different aroma compositions in tomato	2002	2002-2003	OK
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	2002-2003	OK
4 Contribution to recommendation for cultivation programme for tomatoes and cucumber		2003	OK

[Deliverables er forskellige former for offentligt tilgængelige produkter (artikler, rapporter, informationsmøder etc.) og det skal angives, hvilken form for produkt der er tale om. Milestones er væsentlige trin i forskningsprocessen. Der skal angives et tidspunkt for både deliverables og milestones (milestones ligger typisk tidligere end deliverables). Ændringer i deliverables og milestones forsyne med en notits om, at de er ændret i forhold til ansøgningen, og hvorfor de er ændret. Alle deliverables og milestones skal stå i rapporten, og de, der er passeret, mærkes af som udførte, eller der angives en ny dato. Større afvigelser kommenteres i D.]

D. Description of deviations and subsequent adjustments of plans

[Her skal der kun stå en kort forklaring på de afvigelser der er anført i C.2, og en beskrivelse af de ændringer i planerne det har givet anledning til. Der skal ikke gives resultater eller konklusioner]

Basically, the project has worked according to the original plan. However, there have been some problems with changes of staff.

During 2001 we included two new researchers into the project; Dorte Beck-Nielsen (now Dorte Bodin Dresbøll) who was 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 left DIAS due to budget reductions within the Department of Horticulture, and from September 2002 Merete Edelenbos have taken over the responsibility for WP4. In 2003 Anette Thybo took over the responsibility for WP4, but she has then been on maternity leave during the later half of 2004 and until March 2005. These changes have led to some delays, as can be seen from the list of C2 above. Also 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.

The delay in WP2 has led to the most pronounced changes in the project, in that the tomatoes in the cropping system experiment has not been grown in the compost developed in WP2 as planned. Still, we have been able to test the three cropping systems, and done so using growing media based primarily on plant material, thereby reaching the main goals of the project. With the changes in staff, we have had to concentrate the effort, and e.g. the measurements on root growth of cucumbers has not be made, we have only measured root growth of tomatoes, as this is the crop we have mainly used in the experiments. Also the production of the homepage has been cancelled, but the purpose of the homepage is now at least partly covered by the DARCOF homepage.

These changes and the inclusion of a PhD study in WP2 have obviously changed the publication plans of WP2 as well. The total amount of publications from WP2 has been much higher than planned, with four scientific papers and a PhD thesis rather than the two scientific papers originally planned. The focus of the papers differ somewhat from what was planned, with more focus on the composts and their quality, and less focus on actual plant growth in these composts.

Most of the publications has been finished, but a few important ones from WP3 and WP4 are left to be submitted within the next two months. This is unfortunate, but most of the work of these publications has been done and drafts have been deposited at Organic E-prints. The scientific paper in WP4 (deliverable 4.2) is almost ready, and will be submitted within the first half of April, and also deliverable 4.3 will be submitted during April. The delayed scientific paper of WP3 needs more work to be ready, but it will be submitted before the end of May.

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

E. Project publications and other products

[Produkter under 1 skal kopieres fra Organic Eprints. Dette gælder også for produkter, som kun delvist er finansieret af FØJO. Listen fra Organic Eprints kan findes på hjemmesiden http://www.okoforsk.dk/projekt/index.html under "Project publications" på de enkelte projekter.]

[Produkter under 2 er mundtlige præsentationer og andet, som ikke skal kunne findes i Organic Eprints]

1. Products from Organic Eprints archive

Peer-reviewed and accepted

English

Dresbøll, Dorte Bodin and Thorup-Kristensen, Kristian (2005) Delayed nutrient application affects mineralisation rate during composting of plant residues. *Bioresource Technology* 96:pp. 1093-1101.*

Nielsen, Dr. Kai Lønne and Thorup-Kristensen, Dr. Kristian (2001) GROWING MEDIA FOR ORGANIC TOMATO PLANTLET PRODUCTION. Paper presented at Symposium on Growing Media & Hydroponics, Alnarp, September 2001. Acta Horticulturae.

Submitted for peer-review but not yet accepted

English

Dresbøll, Dorte Bodin and Magid, Jakob (2004) Structural changes of plant residues during decomposition in a compost environment. [preprint]*

Dresbøll, Dorte Bodin; Magid, Jakob and Thorup-Kristensen, Kristian (2004) Long-term stability and mineralisation rate of compost is influenced by timing of nutrient application during composting of plant residues. [preprint]*

Dresbøll, Dorte Bodin and Thorup-Kristensen, Kristian (2004) Structural differences in wheat (Triticum aestivum), hemp (Cannabis sativa) and Mischanthus (Mischanthus ogiformis) affect the quality and stability of compost as growing medium. [preprint]*

Not peer-reviewed

English

Dresbøll, Dorte Bodin (2004) *Optimisation of growing media for organic greenhouse production*. Ph.D. thesis, Department of Horticulture, Danish Institute of Agricultural Sciences.*

Edelenbos, Merete; Thybo, Anette and Christensen, Lars P. (2005) Flavour quality of early and late harvested tomatoes from different organic growing systems. Paper presented at Weurman Flavour Research Symposium.*

Sørensen, Jørn Nygaard and Thorup-Kristensen, Kristian (2005) An organic and environmentally friendly growing system for greenhouse tomatoes. [preprint]

Thorup-Kristensen, Kristian (2003) Optimising nutrition in organic tomato production [Gødningsoptimering i økologisk tomatproduktion]. Paper presented at HDC/HRIA/TGA Tomato Conference, Coventry, UK, 2nd October 2003; Published in *Book of abstracts, HDC/HRIA/TGA Tomato Conference*, page pp. 14-15.

Thybo, Anette K.; Edelenbos, Merete; Christensen, Lars P.; Sørensen, Jørn Nygaard and Thorup-Kristensen, Kristian (2005) Effect of organic growing systems on sensory quality and chemical composition of tomatoes. Working Paper, Department of Food Science, Danish Institute of Agricultural Sciences.

Dansk - Danish

Beck-Nielsen, Dorte (2003) Plantebaseret kompost - en erstatning for sphagnum og husdyrgødning? [Plant based compost - can it replace peat and animal manure?]. In *Forskningsnytt om økologisk landbruk i Norden*, July, Volume 2, page pp. 10-11.*

Dresbøll, Dorte Bodin (2003) Kompost til økologiske væksthuse. In *Økologisk Jordbrug*, 12. December, Volume 23. årgang, No 302, page 6.*

Edelenbos, Senior Scientist Merete; Thybo, Senior Scientist Anette and Nielsen, Scientist Morten (2003) Nyt økologisk dyrkningssystem påvirker ikke tomaters kvalitet [A new ecological growing system do not affect the quality of tomatoes]. In *Gartner Tidende*, Volume 11, page pp. 14-15.

Nielsen, Dr. Morten (2001) Kvalitet af danske tomater [Quality of Danish tomatoes]. In *Gartner Tidende*, No 9, page pp. 4-5.

Sørensen, Dr. Jørn Nygaard (2003) Dyrkningssystem til økologiske tomater. *Økologisk Jordbrug* 23(286):pp. 6-6.**

Sørensen, Dr. Jørn Nygaard and Thorup-Kristensen, Dr. Kristian (2003) Miljøvenligt dyrkningssystem til økologiske tomater. *Nyhedsbrevet JordbrugsForskning* 2.

Sørensen, Seniorforsker Jørn Nygaard and Thorup-Kristensen, Forskningsleder Kristian (2003) Økologisk dyrkningssystem til tomat. *Gartner Tidende* 119(9):pp. 34-35.

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

The experiments showed to be very popular. The experimental design and results have been presented at a number of occasions for national and international visitors, especially, scientists, advisers and advanced growers from Sweden, Norway and Finland.
The results are going to be presented at a course entitled 'Ekologisk odling av tomat' arranged by Jordbrugsverket in Sweden, 19-20 April 2005.

F. Scientific education

Dorte Bodin Dresbøll was doing her PhD on development of composts for organic greenhouse production. Her study was based on a combination of the OrcTom project and a project on organic production of potted flowers. December 13th 2004 she obtained the PhD degree from the Royal Veterinary and Agricultural University.

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 EU-Rotate_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 decision support systems. The project will work on outdoor vegetables, but tomatoes and other species relevant for Danish greenhouse production will also be included as the model covers also southern Europe.

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

[Her gives der en kritisk refleksion over projektets planer, forløb og resultater. Det kan rumme refleksioner over det videnskabelige håndværk med hensyn til fx metodevalg, prøvbarhed og udførelse; over eventuelle ændringer i relevans som følge af ændringer i omverdenen eller som følge af den læring der er sket i projektet; samt over aspekter af forskningsudvikling, især i relation til FØJOs mål om at udvikle tværgående og relevant forskning (og hvad der evt. kunne gøres bedre). Her diskuteres endvidere væsentlige justeringer af projektet som følge af afvigelser fra planen (fra C.2 og D) og andre væsentlige ændringer.]

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 would 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 existing 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 have shown success on at least with some of these ideas. The intermediate growing system seems very promising. 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 and less certain ideas in a research project as this.

We have included a “users group” which is following the project, where we have discussed the ideas, progress, and results. This has been 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. Another problem is that it is not easy to keep the growers interested in the project during a five year period, the time span for a research project as this is much longer than the time span the growers are used to when they develop their own production methods!

8. Budget

A. Account for any change in budgets

B. Budget for the whole project (1.000 DKK)

Year:	**Original budget**	**Consumption before 2003**	**Consumption 2003**	**Consumption 2004**	**Total**
Man-months					
Scientific personnel	44.5	26	9	12	47
Technical personnel	43.5	26.67	21.67	0.33	48.67

Year:	**Original budget**	**Consumption before 2003**	**Consumption 2003**	**Consumption 2004**	**Total**
Salaries					
Scientific personnel	1871	1076	393	240	1709
Technical personnel	1158	688	559	9	1256
Other operational costs	694	467	353	20	840
Equipment					
Others (please specify)	194	114			114
Direct costs	3917	2345	1305	269	3919
Indirect costs (20% of direct costs)	783	469	261	50	780
Total	4700	2814	1566	319	4699

Comments: Others: travels, analyses and extension service

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project Kristian Thorup-Kristensen	 Danish Institute of Agricultural Sciences, Department of Horticulture	 30 March, 2005	

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

Name of Institute: Danish Institute of Agricultural Sciences

Year:	Original budget	Consumption before 2003	Consumption 2003	Consumption 2004	Total
Man-months					
Scientific personnel	44.5	26	9	12	47
Technical personnel	43.5	26.67	21.67	0.33	48.67

Year:	Original budget	Consumption before 2003	Consumption 2003	Consumption 2004	Total
Salaries					
Scientific personnel	1871	1076	393	240	1709
Technical personnel	1158	688	559	9	1256
Other operational costs	694	467	353	20	840
Equipment					
Others (please specify)	194	114			114
Direct costs	3917	2345	1305	269	3919
Indirect costs (20% of direct costs)	783	469	261	50	780
Total	4700	2814	1566	319	4699

Comments: Others: travels, analyses and advisors

B. Budget for each participating department (1.000 DKK)

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

Year:	Original budget	Consumption before 2003	Consumption 2003	Consumption 2004	Total
Man-months					
Scientific personnel		18.5	5.75	11.75	36
Technical personnel		22.75	19.67	0.33	42.75

Year:	Original budget	Consumption before 2003	Consumption 2003	Consumption 2004	Total
Salaries					
Scientific personnel		767	240	240	1247
Technical personnel		588	507	9	1104
Other operational costs		393	308	20	721
Equipment					
Others (please specify)		114			114
Direct costs		1862	1055	269	3186
Indirect costs (20% of direct costs)		372	211	50	633
Total		2234	1266	319	3819

Comments:
The original budget was not divided on departments as only one department participated initially. In 2003 Department of Horticulture was divided and part of the project was then located in Department of Food Science.

B. Budget for each participating department (1.000 DKK)

Name of Institute and department: Danish Institute of Agricultural Sciences, Department of Food Science

Year:	**Original budget**	**Consumption before 2003**	**Consumption 2003**	**Consumption 2004**	**Total**
Man-months					
Scientific personnel		7.5	3.5	0	11
Technical personnel		4	2	0	6

Year:	**Original budget**	**Consumption before 2003**	**Consumption 2003**	**Consumption 2004**	**Total**
Salaries					
Scientific personnel		309	153	0	462
Technical personnel		100	52	0	152
Other operational costs		74	45	0	119
Equipment					
Others (please specify)		0	0	0	0
Direct costs		483	250	0	733
Indirect costs (20% of direct costs)		97	50	0	147
Total		580	300	0	880

Comments:

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

Name of Institute: Danish Institute of Agricultural Sciences

Year:	Original budget	Consumption before 2003	Consumption 2003	Consumption 2004	Total
Man-months					
Scientific personnel					2
Technical personnel					3.75

Year:	Original budget	Consumption before 2003	Consumption 2003	Consumption 2004	Total
Salaries					
Scientific personnel					85
Technical personnel					98
Other operational costs					84
Equipment					
Others (please specify)					53
Direct costs					320
Indirect costs (20% of direct costs)					-2
Total	0				318

Comments:

Dansk resume

I projektet har vi forsket i metoder, som kan bidrage til at udbrede produktionen af økologiske væksthusgrønsager. Vi har konkret arbejdet med tomater og fokuseret på to hovedproblemer. Det ene er, at økologisk væksthusproduktion af grønsager gennemføres i en intensiv monokultur, som gødes meget kraftigt. Det kan give problemer med sædskiftesygdomme og skadedyr, og med næringsstofudnyttelse og tab. Det andet hovedproblem er, at det kan være svært at skaffe de nødvendige næringsstoffer til de meget næringsskrævende afgrøder. Udbuddet af økologisk husdyrgødning er begrænset, og kan forventes at blive endnu mere begrænset efterhånden som regler for f.eks. import af foder i økologisk husdyrproduktion strammes. Samtidig findes væksthusproduktionen ofte i andre områder af landet end den økologiske husdyrproduktion, og det kan betyde at gødning skal transporteres over lange afstande. Når dyrkningssystemerne ændres for at tage højde for disse problemer, kan man risikere at det går ud over kvaliteten af produkterne. Konkret har der været stor betænkelighed ved, om tomater dyrket i beholdere med kompost, frem for dyrkning direkte i jorden, ville få forringet kvalitet. I projektet har vi undersøgt effekten af forskellige dyrkningssystemer på en lang række kvalitetsparametre for tomater.

Resultaterne har vist, at vi med godt resultat kan ændre dyrkningssystemet, så man kan afhjælpe nogle af problemerne med manglende sædskifte. Dyrkning i afgrænsede bede (beholdere) med kompost har givet gode resultater, og de muliggør udskiftning af dyrkningsmedium imellem kulturerne, og at drænvand kan opsamles og recirkuleres. Gode resultater blev især opnået med det kombinerede system, hvor tomaterne blev plantet i beholderne med kompost, men hvor de samtidig havde mulighed for at sprede rødderne i jorden omkring.

Resultaterne viste også, at tomaterne kunne forsynes med en meget stor del af deres næringsstofbehov ved at bruge plantemateriale (især kløvergræs og lucernepiller) som gødning. Det kunne bruges både som en del af det grundlæggende dyrkningsmedium, og til eftergødskning. Ved brug af kompost som dyrkningsmedium kan der opstå problemer med strukturen, men forsøgene med kompostering viste muligheder for at forbedre dette ved at anvende andre plantematerialer. Dyrkningsforsøgene med tomater viste også, at den anvendte vandingsteknik var vigtig for at håndtere disse problemer.

Resultaterne af kvalitetsundersøgelserne viste kun få og små forskelle imellem tomater fra de forskellige dyrkningssystemer, hvilket viser, at de afprøvede dyrkningssystemer alle kan anvendes i praksis uden at man risikerer at kvaliteten af tomaterne forringes.

Alt i alt har projektet udviklet og dokumenteret metoder, som kan danne grundlag for en udvidet produktion af økologiske væksthusgrønsager. Resultaterne omkring plantemateriale som gødning, kan bruges her og nu til at sikre næringsstofforsyningen. Det kan gøres uafhængigt af de dyrkningssystemer vi har arbejdet med i projektet, og vi har også mødt betydelig interesse fra erhvervet for dette. Resultaterne omkring dyrkning i afgrænsede bede kan også anvendes her og nu, i hvert fald hvis det gøres i det kombinerede system, hvor planterne får mulighed for at udvikle rødderne også i jorden uden for bedene. Systemer hvor tomaterne dyrkes i helt lukkede bede kan også udvikles hvis der er interesse for det, men de er mere komplicerede at styre, og vil kræve yderligere udviklingsarbejde.

Herunder er der en mere detaljeret omtale af resultater og konklusioner fra de enkelte delprojekter.

Del 1: Undersøgelser af eksisterende systemer

Undersøgelserne viste et betydeligt overskud af næringsstoffer, og viste at det i praksis er vanskeligt at håndtere de store mængder af organisk gødning uden at det giver en betydelig risiko for tab. Resultaterne pegede 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 viste 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 plantebaseret 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 der efter 7½ uges kompostering var 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 projektets *del 3* samt resultater fra et forsøg med dyrkning af økologiske potteplanter viste at kompostens struktur og vandfysiske egenskaber er meget vigtige. Vi fokuserede derfor undersøgelserne mere på kompostens struktur, og brug af andre plantematerialer til at skabe struktur i komposten, især hamp og elefantgræs. Mikroskopistudier viste at hamp, udover at være meget stabilt også indeholder mange fibre der kan 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 fremstillede vi et dyrkningssubstrat der består af en blanding af dybstrøelse, kløvergræs og sphagnum.

Med dette dyrkningssubstrat blev der i 2 år gennemført forsøg med dyrkning af tomater i afgrænsede bede, direkte i jorden og i et ”kombineret” 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 dyrkningssubstrat. Planterne blev etableret tidligt forår og forsøget afsluttet efter syv måneders vækst. Afgrøden lykkedes rigtigt godt i alle tre behandlinger. Det ”kombinerede” system gav de bedste resultater, men forskellene i udbytte, tilvækst og næringsstofkoncentrationer var ikke stor. I 2003 var udbyttet i afgrænsede bede dog betydeligt lavere end i de øvrige behandlinger. Midt på sæsonen opdelte vi parcellerne og eftergødede halvdelen af hver parcel. Til eftergødskningen brugte vi lucernepiller, og resultater fra målinger af næringsstofindhold i planterne viste at eftergødskningen virkede 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 ”kombinerede” 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 viste, at dyrkningssystemerne generelt har haft lille effekt på såvel pH, indholdsstoffer som tør-stof, syre, sukker og aromastoffer, hvilket resulterer i, at der kun blev observeret en lille effekt af dyrkningssystemer på den sensoriske 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 som de bedste (mere sprøde, faste og søde og havde svagt højere intensitet af tomat aroma) og tomaterne dyrket direkte i jorden som de ringeste, men forskellene var små.