

# Organic research and development 1996-2010

– effects on industry and society



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## Preface

Since 1996 Denmark has had four research programmes in organic farming and foods financed via special government grants. A so-called 'centre without walls' was established (the current ICROFS) to coordinate these programmes so that the research could be undertaken within the existing research environments. The centre has had close contact to the industry and other stakeholders via user groups and programme committees and an extensive meeting and dissemination activity in order to ensure the continued relevance of the research effort and applicability of the results.

In the same period the organic sector has undergone a strong development from its beginnings as a niche market and has become an important part of the Danish food sector. Nearly all supermarket chains currently have a large assortment of organic products and for some product groups, such as eggs and milk, the organic market share is 20-30% of retail sales. This requires a stable supply and good quality of products and an effective organisation of the entire chain. This is supported by a dynamic community of farmers and businesses which stimulates a continuous product development. Much indicates that the highly applied research has had a very important part to play in the development of the sector.

You would think that it would be quite a simple task to assess the effect of 15 years of research and development in organic farming and food production. But rarely have research programmes been analysed and evaluated on their effect on a sector of society and this is generally thought to be quite difficult, among other things because it can be difficult to distinguish the contribution from research from those of other development forces. Here we have, however, made an attempt.

There are of course many important factors and causes of the positive development of the organic sector in Denmark, including support for marketing and the regulatory framework from public and private sectors and the establishment of strong institutions in organic farming. A large group of very clever entrepreneurs and pioneers in the organic farming, processing and retailing sectors have also shouldered a good deal of the burden. The results of research obviously

need to be channelled through these agents to be able to penetrate the market. Farmers need new knowledge about nutrient balancing, weed control and animal husbandry to ensure an effective and economically viable production that is also robust and resistant to pests and diseases and adheres to the organic principles and regulations. Farmers do not really care, however, whether new methods are or are not the result of a research and development project, as long as they work. And many learn new stuff from colleagues or consultants. The generally good connection in Denmark between research and development, the advisory service and farmers means that the people delivering the new knowledge to farmers tend to be the consultants, often as a result of discussions with scientists, who in turn are affected and inspired in their design of solutions to problems via this process. This linking has been documented in this analysis.

Results of research and development do not always have farming as the primary target. Other users of the research results are businesses, organisations and the political system where knowledge of the effects of organic farming on, for example, animal welfare, climate and biodiversity form part of decision-making and political processes.

In our analysis of the effect of research and development programmes we have therefore chosen to include testimonies from a wide range of potential users in combination with documentation of dissemination of results from research and development projects. As described in the report we have in many cases been able to link accounts of changes made to practices or advice given to projects that have addressed and generated new knowledge for this particular theme.

This analysis also contains an evaluation of the research results based on the general point scoring method used to evaluate other research programmes under the Ministry of Food, Agriculture and Fisheries. In an internal evaluation of DARCOF II, a different method was used to count the articles and compare with funding. Measured on the number of research publications, the output of the earlier programmes was deemed to be satisfactory. In an evaluation

by an international panel, the activities under the former DARCOF were likewise found to be of a high research quality. The experience was nevertheless that this method does not give a satisfactory picture of the effect of the research in terms of the practical application of project results. This is because the point scoring method principally analyses research results (output) and only to a lesser degree research application (outcome).

This criticism we have attempted to address in the current analysis, which is an attempt to get closer to the users of the research and development results. The method used is described in Chapter 2 and builds on a triangulation of three viewpoints: the research projects themselves and their themes and results, interviews with end-users about how they perceive the role of research in relation to the development of the sector, and an identification of the results that have been conveyed from research to users and the channels used. Chapter 3 shows the results of this triangulation in different areas within primary production and in other areas. Chapters 4, 5 and 6 give specific details from each of these three angles, i.e. consumer interviews, knowledge transfer and an overview of the research projects and their results, including the use of the point scoring system. Chapter 7 summarises and provides a perspective of the importance of organic research in a wider sense and its outlook. The report starts in Chapter 1 with a recapitulation of the organic research programmes and the development in the organic sector in that period.

We hope the report will convince the reader of the value of support for research and development in organic farming and food systems – both the support previously given and the support that will hopefully be given in the future.



## Summary

ICROFS (International Centre for Research in Organic Food Systems) has produced an analysis of the effects of organic research in the period 1996-2010 on the organic sector and on society in general. In the 15 years from 1996 and until 2010 there have been four research programmes in organic food and farming in Denmark financed via special government grants that amounted to just over 500 million DKK.

The analysis itself is carried out as a collation of information from three viewpoints that each has been independently documented:

- ▶ Interviews with (representatives of) end-users of research and development (R&D) results and their assessment of the challenges for the sector in the period 1996-2010,
- ▶ Assessment of the R&D endeavours in different thematic areas (Dairy/milk, Pigs, Crops, etc.) as they related to expected end-users.
- ▶ Documentation of the dissemination of R&D results in relation to themes and challenges in the sector.

The recommendations in action plans I and II have furthermore been compared with the challenges in the sector identified by the end-users and with the corresponding R&D projects addressing these. The result shows very good correspondence between the perception of the challenges in the sector by the end-users, the R&D initiated in the four research programmes, and the publication of research results and other forms of knowledge transfer. The analysis documents direct effects of the research initiatives directed at the challenges in the sector in this period. This applies both to higher yields, weed and pest control, animal health and welfare, the potential for phasing out the use of antibiotics in Danish dairy herds or the use of fungicidal seed treatment in primary production, in addition to a description of effects that in some instances may be absent or lower than expected. In contrast, the analysis shows that the effects of the research in the processing industry and among relevant governmental and non-governmental organisations are of a more indirect character. In commerce there is clear affirmation that research has helped stabilise the supply and quality of raw materials at a time of growing demand and sales. For the governmental and non-governmental organisations



involved in policy development, the response also indicated a more indirect effect. On the other hand, organic research generates new knowledge and leads to new opportunities that can provide inspiration for a green conversion and growth in agriculture.

The analysis shows that the research under the DARCOF programmes and CORE Organic overall has been very applied and directed at the barriers in the sector in order to support the general market and growth conditions for the organic sector. Having in this way laid a solid foundation, the private sector has been able to grasp the commercial opportunities when demand grew while adhering to the policy objectives of a market-driven growth in the organic sector.



# Chapter 1 Introduction

ICROFS (International Centre for Research in Organic Food Systems) has conducted an overall analysis of the effects of organic research on the organic sector and on society in general for the period 1996-2010. This publication contains the most important conclusions of the analysis and focuses on how the results from the research programmes DARCOF I-III and CORE Organic have been implemented in industry and society.

## 1.1 The political background for research in organic farming

Since the mid-1980s organic farming has been promoted through political initiatives. The policies of the various governments have included financial support for the conversion of conventional farms, regulation and control, an advisory service, information campaigns, education and research in organic farming. At the end of the 1980s and start of the 1990s Danish research in organic farming was primarily carried out on private farms and in long-term crop rotations at research stations around the country. Both the action plan for the promotion of organic food production (Action Plan 1) in 1995 by the then Ministry of Agriculture and Fisheries (now the Ministry of Agriculture, Food and Fisheries) and the national strategy for agricultural research from 1994 specified that research in organic farming should be priori-

tised and existing structures strengthened. They suggested that the boost could be achieved by establishing a cross-institutional and cross-disciplinary research centre. Action Plan I additionally recommended that research in organic farming should be given a higher priority in order to ease the conversion and increase organic production and in this way satisfy consumer demand. On this background the Ministry of Agriculture and Fisheries initiated the establishment of the Danish Research Centre for Organic Farming (FØJO/DARCOF) in September 1995.

Action Plan I and Action Plan II from, respectively, 1995 and 1999 contained recommendations for the implementation of research initiatives to solve certain challenges in the sector. The DARCOF I projects have predominantly had the expected effect on the primary production. The projects in DARCOF II, DARCOF III and CORE Organic have moreover had the expected effect on industry (including processing), society (including environment and health) and at consumer level (including credibility). Organic research has thus followed the general growth and development of the sector and embraced new issues throughout the supply chain.

The continued development of organic farming and organic food systems may present considerable opportunities for society. This is both in the form of a sound foundation for the development of competitively-priced, high-quality organic food products, and in the implementation of a balanced and sustainable development of rural districts and the food



industry. Research in organic farming additionally has the potential to solve a number of global issues. A prerequisite for the continued development of organic farming is better knowledge of the health, quality, security and competitive potentials of organic foods. Another prerequisite is knowledge of production potentials within the framework of the organic standards that incorporate considerations for nature, environment, animal health and society.

## 1.2 Development of research in organic farming under DARCOF/ICROFS

### – review of research programmes, focus areas and grants

DARCOF I, which had a budget of around 100 million DKK, was based on the recommendations in Action Plan I. The programme involved 15 institutions and around 100 scientists and focused largely on primary production. Projects included crop production and livestock production, but also society and environment, long-term effects of organic farming and the communication and development of research. In 2000, DARCOF initiated a new round of research activities, DARCOF II, based on the political ambitions in Action Plan II, with a total grant of more than 220 million DKK. About 200 scientists from 15 institutions were involved in the programme, which had a somewhat wider focus that included consumers and also had a stronger focus on society and environment.

The international evaluation of DARCOF II had a considerable influence on the drafting of DARCOF III entitled “International research collaboration and organic integrity”

and on CORE Organic, but both were principally based on proposals from scientists. The two programmes had an overall budget of around 200 million DKK. Approximately 200 scientists from nine institutions took part in DARCOF III and 11 scientists from four institutions in CORE Organic. These programmes had an even wider focus and included bioenergy as a new theme.

In all three DARCOF programmes funds were allocated to coordination, communication and dissemination. In DARCOF I and II funds were also allocated to knowledge syntheses, research methodology and to research education (PhDs).

Following the conclusion of these programmes (which form the basis for the analysis), the research and development initiative within organic farming and food systems has been continued by ICROFS under the auspices of GUDP with a research and development programme called ‘Organic Research, Development and Demonstration’ and a budget of 91 million DKK over three years. The European collaboration in ERA-NET has continued under CORE Organic II. Project themes can be seen on [www.icrofs.org](http://www.icrofs.org).



### 1.3 Organic research and development under a different hat

In addition to the research effort undertaken under DARCOF/ICROFS, research and development has also received funds from other sources. The Foundation for the Promotion of Organic Agriculture has provided funds for pure research projects as well as grassroots research, development, etc. Funds granted under the Innovation Act have also been used for organic research and development and other Danish and EU research projects have focused on this area. The research undertaken under other external sources has not been included in this analysis.

### 1.4 Development in the organic sector in the period 1996-2010

**Primary production:**

Figures 1.1 and 1.2 show the increase in the size of the area under organic farming and the number of organic holdings in the period of the research programmes, 1996-2010. In the 15 years, the area increased from 20,058 ha to 148,145 ha, corresponding to an average annual increase of 8,500 ha, but the growth has been moderate in recent years. In the same period the number of organic holdings rose from 1,166 to 2,671, averaging around 100 farms per year. The average size of the holding has increased from 17.2 ha in 1996 to 55.5 ha in 2010. In 1996 the percentage of organic farms of total number of farms was 1.8% and in 2010 this had risen to 6.7%. The area under organic farming, including the area under conversion, was 1.7% of total farmed area in 1996 and 6.4% in 2010.

The development in the number of organic livestock for the period 1996-2010 is shown in Figure 1.3. The total number of organic farm animals was in 1996 around 381,000, partitioned into 45,500 cattle, 19,300 pigs and 381,000 poultry. The number has fluctuated somewhat in the period, but in 2010 the total number had grown to 1,500,000, of which 165,000 were cattle, 181,000 pigs and 1,200,000 poultry.

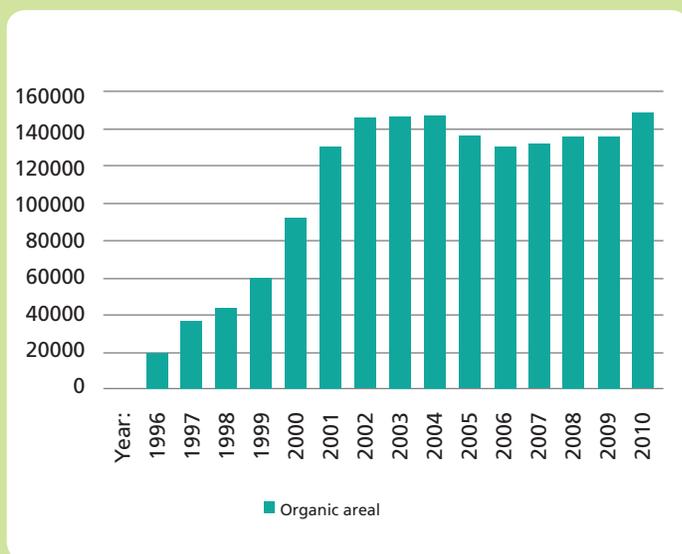


Figure 1.1 Development in the organic area in the period 1996-2010

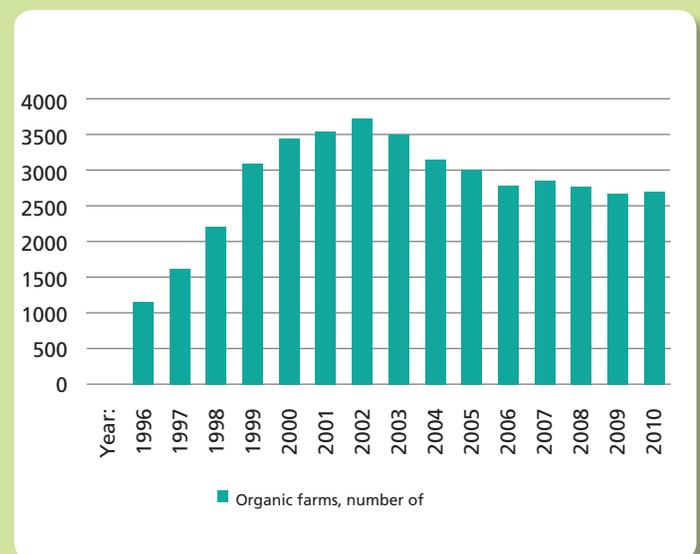


Figure 1.2 Development in the number of organic farms in the period 1996-2010

In 1996 the organic animals accounted for 1.2% of the total number of livestock, while this had grown to 4.6% in 2010. In the same period the percentage of organic cattle grew from 2.2% to 10.5%. Milk production was throughout the period the most important production line in organic farming.

**Market and consumption:**

Figure 1.4 shows the development in the sales of organic foods in the retail sector in the period 1996-2010. The market share of organic products rose from around 0.5 billion DKK in 1996 to 5.1 billion DKK in 2010. Since 2007 the growth has been very strong and sales rose in 2011 by a further 7% to 5.5 billion DKK (Organic Denmark: Økologisk Markedsnotat, June 2012).

In addition to the sales of 5.5 billion DKK in convenience stores, another 0.8 billion DKK was sold via wholesalers/ caterers to commercial kitchens, school kitchens, private canteens and restaurants, and another 0.7 billion DKK via alternatives sales outlets such as box schemes, farm shops and farm-gate sales. Finally, sales also take place via, for example, mini markets and petrol stations, which means that total sales of organic foods in Denmark in 2011 was 7.5 billion DKK, corresponding to an average per capita consumption of 1350 DKK. The most popular organic products in 2011 were oats with a market share of 39.4% of total sales, carrots (30.6%), milk (30.2%) and eggs (24.6%).

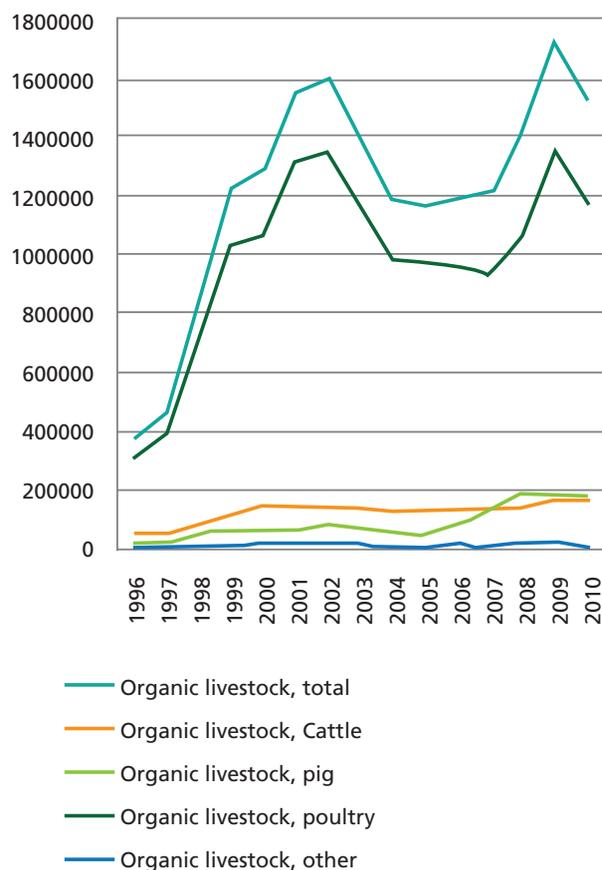


Figure 1.3  
Development in organic livestock numbers in the period 1996-2010

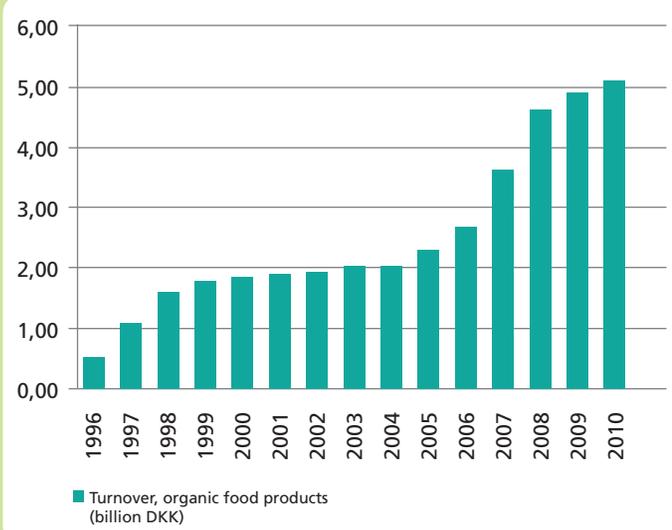


Figure 1.4  
Development in the retail market share of organic food products in 1996-2010

### Denmark's European ranking in sales of organic products

The market share of organic produce of total food sales is higher in Denmark than in any other European country (Figure 1.5) and Denmark has the second-highest per capita sales following Switzerland (Figure 1.6). This contrasts with the ranking for the percentage of organic farmland of total farmland which at 6.1% puts Denmark outside the top 10 (Figure 1.7). On the other hand, we have the advantage of having only one controlling organ, which reduces the opportunities for cheating and thus enhances consumer confidence in the organic products.

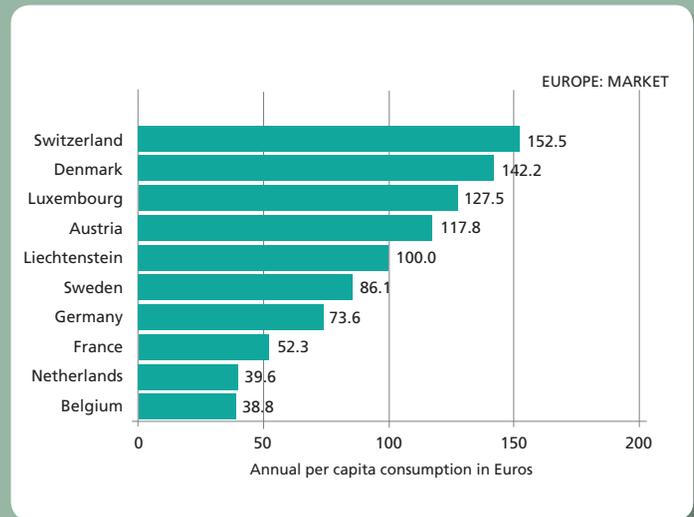


Figure 1.6  
Ten European countries with the highest per capita expenditure (€) on organic foods in 2010

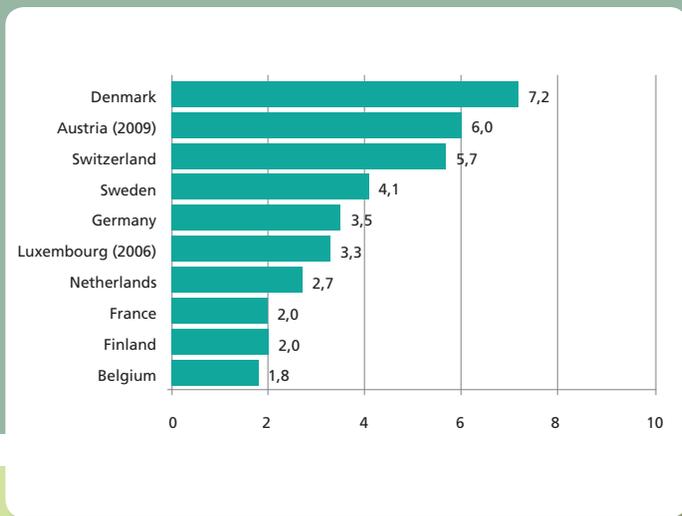


Figure 1.5  
Ten European countries with the largest share of organic food products, as a percentage of total food sales in 2010

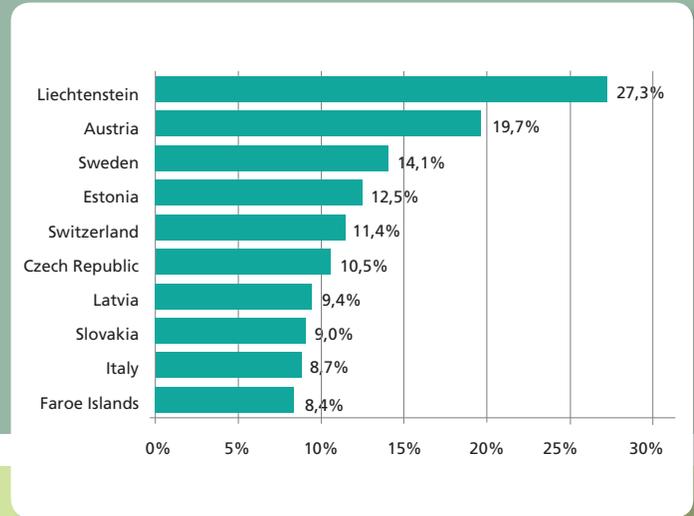


Figure 1.7  
Ten European countries with the largest percentage area under organic cultivation in 2010



## Chapter 2 Analysis of the importance of research – indirect measuring methods

It is often difficult for individual users of the results of research and development to identify which bits of their knowledge and practices stem from or are inspired by the results of research projects unless they have been directly involved themselves in the practical or economic aspects of the research and development activities. An analysis of the effect of R&D in organic agriculture and foods must therefore build on indirect measuring methods in an attempt to define how farmers, the consultants, the industry and others have benefited from the results.

### 2.1 Purpose of the analysis

Because of the breadth of the focus areas in the organic R&D programmes, the group of end-users is expected to be very diverse. They will range from actors in primary production and processing to organisations that represent the environment, consumers, animal welfare, etc., and to the civil service and politicians. The purpose of the analysis is to achieve a deeper understanding of the utilisation and the effect of the research results in practice, which is why both a qualitative and a quantitative approach has been used to analyse the influence of the results on the agricultural sector.

### 2.2 Information from three viewpoints

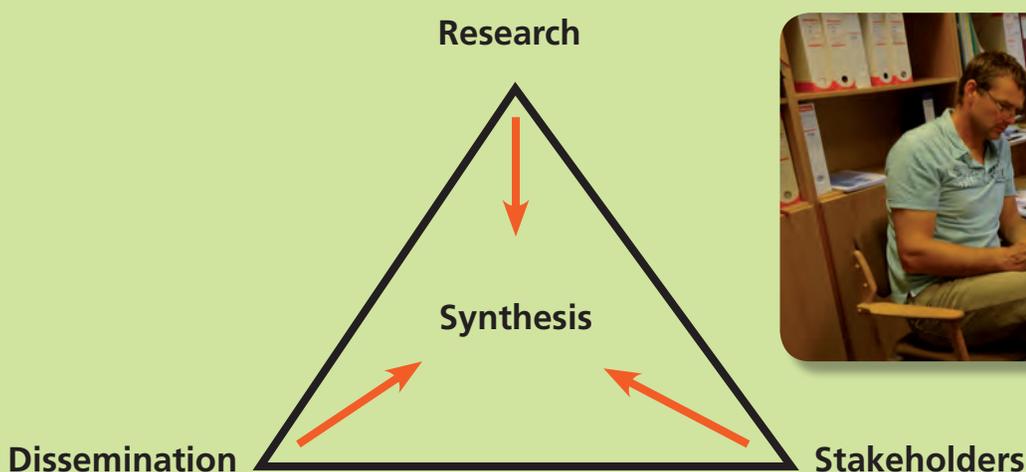
The analysis has been performed as a combination of information from three perspectives, each being independently documented:

1. Interviews with (representatives of) end-users of R&D results,
2. Inventory of R&D achievements into the various thematic areas and in relation to the expected end-users
3. Documentation of the dissemination of results

At the convergence of these three perspectives, we attempt to document the influence of individual R&D results on the development of the organic sector within specific areas and in a wider sense. The number of publications has been counted and a point score system used for each DARCOF programme following a method that has previously been used for evaluating research programmes within food science. A few research cases have in this connection been selected to illustrate the triangulation between research, dissemination of results and the utilisation of results by end-users.

In the following we describe the method used for each of the perspectives and how an integrated synthesis has been made, and also how selected examples are subsequently described in more detail.

Figure 2.1 The principle in the triangulation method that has been used to support the conclusions on the effect of research and development



**Triangulation method**

The interview part of the analysis primarily collected information from the advisory service about the challenges and barriers the different subsectors in organic agriculture have overcome. Consultants were subsequently asked whether this achievement could be attributed to R&D results and how they and primary producers utilise the research results. At the same time, a census and inventory was made of the projects implemented under each of the DARCOF programmes, their focus areas and how these match the challenges identified by the advisory service.

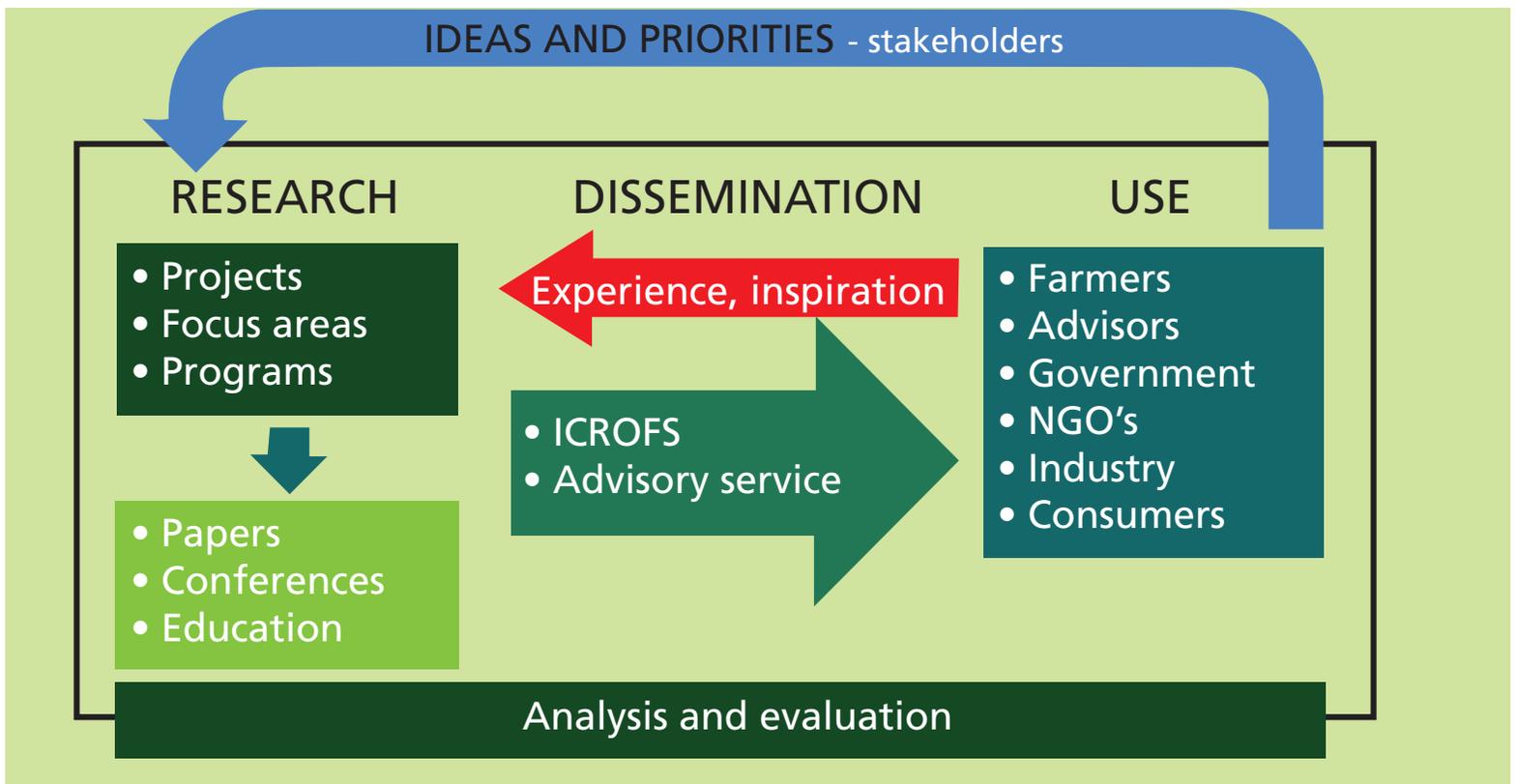
The recommendations from Action Plan I and II were likewise compared with the identified challenges and associated projects, and the correspondence between them analysed. The method of communicating results of these projects was subsequently studied, with focus on the dissemination of results from the primary production by the advisory service and on the other dissemination activities of the projects and of ICROFS (DARCOF) in this connection.

The purpose of the triangulation method is to create a solid foundation for any conclusions on the areas on which R&D has had an effect. By combining the three part-analyses, we expect that a robust analysis of the effect of the R&D effort in the period in question can be made. The three part-analyses are 1) the views of stakeholders on how their part of the sector has developed and the extent to which this has been supported by R&D, 2) the documentation of the results that have been communicated from R&D projects to stakeholders with the projects categorised into the different



focus areas and 3) the results that scientists are expecting to achieve from these projects. As shown in Figure 2.2, the triangulation follows the traditional interpretation of the relation between R&D and the utilisation of the results via a dissemination process. However, this simplistic view ignores the fact that there is a continuous influence on research by the stakeholders via a number of processes. These include consumer influence on programmes where representatives of the sector influence the focus in the projects, and also influence from within the projects insofar as the scientists are affected in the design of the experiment by their dialogue with end-users. This feedback is not systematically included in the current analysis, although the formal influence on

Figure 2.2 Phases and workflow



the research themes via DARCOF's user group/programme committee has been described. Several examples are also given on the informal influence in interviews with the users. Figure 2.2 also illustrates the difference between research results and research effect. The results include the direct products of R&D projects, such as scientific articles, conferences and PhD dissertations, while the effect has to be measured from the utilisation of the acquired knowledge, methods, etc. This division – in other contexts referred to as output and outcome – is also used by, for example, the Advanced Technology Foundation.

### 1. Information from end-users on their utilisation of results from organic R&D end-users

This viewpoint is based on questionnaires and interviews with key persons within the advisory service and with companies in the organic sector and a number of other possible end-users in organisations and public authorities.

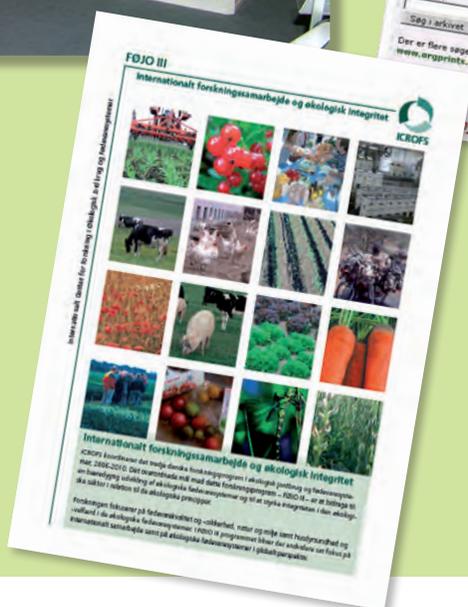
Primary production: Centrally placed consultants within, respectively, organic crop production, milk, pig, poultry, and fruit/vegetable production have been interviewed in a systematic process. Local consultants in crop production and livestock production were subsequently interviewed using a combination of questionnaires and follow-up interviews. In both types of interviews, the consultants' own understanding of the development in their subsector over the last 10-15 years formed the basis for the discussion. What were

the challenges for the sector, how have they been overcome in practice, how has the production otherwise evolved and to what extent would the consultants attribute this development to the results of R&D? It should be noted that systematic interviews with farmers have not been carried out, since they cannot be expected to know how much of the continuing development and improvement in knowledge can be attributed to R&D.

Companies: A questionnaire was sent to a total of 15 companies that, partly or completely, process and retail organic products. Staff responsible for the organic production was asked to what extent organic R&D has influenced the development of their company and new products and the supply of commodities.

For selected cases the questionnaire was followed up by an in-depth interview.

Organisations and authorities: A number of R&D projects have focused on topics relevant for society such as the impact of organic farming on environment, animal welfare, etc., and consumer motivation for purchasing the products. To analyse the effect of these results, a questionnaire was sent to five persons from four public authorities in charge of legislation in the area of organic agriculture and the environment, etc., and to ten persons from seven relevant, private organisations. Key persons were here asked in a questionnaire to give their views of the most important challenges that the organic sector has been facing in the period 1996-2010, and to what extent organic research has contributed to solving these. Details can be found in Chapter 4.



## 2. Documentation of dissemination

To be able to document the extent to which knowledge and results from R&D projects have been accessible to consultants, an overview of the communications directed at primary production, advisers, scientists and other interested parties has been prepared. The Knowledge Centre for Agriculture (VFL) will regularly update consultants with the latest knowledge via the netbased LandbrugsInfo, and some of this information refers directly to R&D projects and their investigations and results.

By carrying out a search on LandbrugsInfo for results of the DARCOF projects and on the themes that were identified under viewpoint 1 as important for the different parts of the sector, it has been possible to determine whether new knowledge in these areas has been conveyed to the local consultants and to the farmers. Due to the large number of articles, an exhaustive search has not been made, as sufficient documentation was found for a dissemination having taken place from projects to end-users in the relevant areas. In a few cases, an in-depth search has, however, been made to illustrate the volume of dissemination.

In all the R&D programmes, DARCOF/CROFS has taken the initiative to disseminate knowledge from the projects via their own and external media, also ensuring that scientists take turns to write a column in the agricultural press and by supporting web-based communication, the preparation of newsletters, pamphlets and arrangements where the results are presented. Since the start of DARCOF II the projects have been asked to report and archive their articles and other written communication in the open-access web-database Organic Eprints. The dissemination effort is described in more detail in Chapter 5.

## 3. Detailed description of the focus of the R&D effort

The description of this viewpoint is based on three sources: a split of the projects into the thematic areas cattle/milk, pigs, crops, cultivation systems, etc., based on project descriptions and thematic areas in final reports; the scientists' indications of which results they expect to have had an effect and for whom, and a quantification of the published articles, reports, etc., based on project final reports.

The focus of the research projects has also been compared with the relevant recommendations in the two action plans for the development of the organic sector prepared by the Danish Council for Organic Foods under the auspices of the Ministry of Food, Agriculture and Fisheries in 1995 and 1999.

The inventory of the direct output of the research projects in the form of publications, PhD studies, etc., is based on the method devised and used by the Institute of Food and Resource Economics for the evaluation of the research programmes under the Ministry of Food, Agriculture and Fisheries. The research programmes and grants, the subject areas of the projects and the number of publications produced can be found in Chapter 6.

## 2.3 The synthesis

On the background of the material under points 1-3, an analysis has been carried out to identify the areas where R&D can be documented to have had an effect and the extent of this effect. As a rule, R&D results were deemed



to have had a positive effect when there is coincidence between the end-users' identification of useful results and the dissemination of these results via projects that have focused on these areas – in other words, when there is coincidence between the three perspectives in the triangle, Figure 2.1. In most cases, these three perspectives have been uncovered independently of each other, but in a few cases, a direct attempt has been made to show a connection. This applies to some of the more detailed examples, where, for example, the results suggested by a scientist as having had a large effect have been verified through targeted interviews with the users that may also have been identified by the scientist.

Since the user survey is based on a limited number of interviews, the persons interviewed may of course not have been aware of the practical implications of specific results from R&D, although these results in reality have been of consequence for other users. This analysis is therefore conservative in its conclusions.

Based on the interviews under 1 and the inputs from scientists under 3, examples of results, that apparently had significant influence on specific areas have been selected. These are described in more detail via the use of additional interviews and other information.

The analysis has been conducted by consultants from the Knowledge Centre for Agriculture (VFL) (parts 1 and 2) and from the Institute of Global Food & Farming (part s 1 and 3) as well as staff from ICROFS, under the coordination of the chairman of the ICROFS programme committee.



## Chapter 3. Analysis of the influence of organic research

This chapter presents the synthesis of the material from the independent trilateral analyses of the effects based on the following components:

- A synopsis of the focus areas of the four organic research programmes for the 1996-2010 period
- The identification by the agricultural advisory service of the main challenges to the organic sector in the period 1996-2010 and the contribution of research to their solution
- Quantification of research output in relation to the different themes of the research projects and to the challenges facing the sector
- A presentation of research cases that document the consistency and coherence between the results from the three viewpoints of the effect triangle
- Analysis of the processing industry's evaluation of the contribution of organic research to the development of the organic market and sales
- Analysis of the assessment by governmental and non-governmental organisations of the contribution of organic research to important consumer and social aspects such as legislation/regulation, environment, climate, animal welfare, etc.

### 3.1 Research programme thematic and focus areas for the period 1996-2010

All four research programmes in the period from 1996 to 2010 have had six main themes: Cattle/milk; pigs; poultry/eggs; crops; cropping systems, fertilization and soil (shortened to cultivation systems in the following); and society and environment. The DARCOF II, III and CORE Organic research programmes additionally included the thematic areas of consumption, fish and bioenergy.

Table 3.1 shows that there have been a total of 95 research projects under the nine research themes, with 30 projects under DARCOF I, 43 under DARCOF II, 15 projects under DARCOF III and seven under CORE Organic. The number of relevant recommendations from Action Plan I and II are shown for each research programme and subject area. There were five under DARCOF I and 23 under DARCOF II. The recommendations are listed in Appendix 1 which can be found on <http://www.icrofs.dk/Sider/appendix.html> (in Danish)

Table 3.1 Total number of research projects partitioned into thematic areas and research programmes. Although many of the research projects have dealt with more than one research theme, we have categorised them according to where most of the research effort was deemed to take place

Thematic area	Research programmes, number of projects and action-plan (AP) recommendations					
	DARCOF I	AP I Rec.	DARCOF II	AP II Rec.	DARCOF III/CORE Organic	Total
Cattle/milk	1		7	2	4	12
Pigs	5	1	4	1*	2	11
Poultry/eggs	1	1	1	*	0	2
Fish					1	1
Crops	7	1	13	7*	5	25
Cultivation systems	14	*	10	2*	3	27
Bioenergy					1	1
Consumption			1	2	2	3
Society and environment,	2	2	7	9	4	13
<b>Total</b>	<b>30</b>	<b>5</b>	<b>43</b>	<b>23</b>	<b>22</b>	<b>95</b>

\*Recommendations apply to several thematic areas

Another way to illustrate the prioritization of research projects within each programme and between topic areas is the allocation of funds. In DARCOF I there were, for example, seven and 14 research projects under, respectively, 'Crops' and 'Cropping systems', see Figure 3.1. The percentage allocation of funds is 20% to Crops and approx. 40% to Cultivation systems. The allocation of funds is described in Chapter 6.

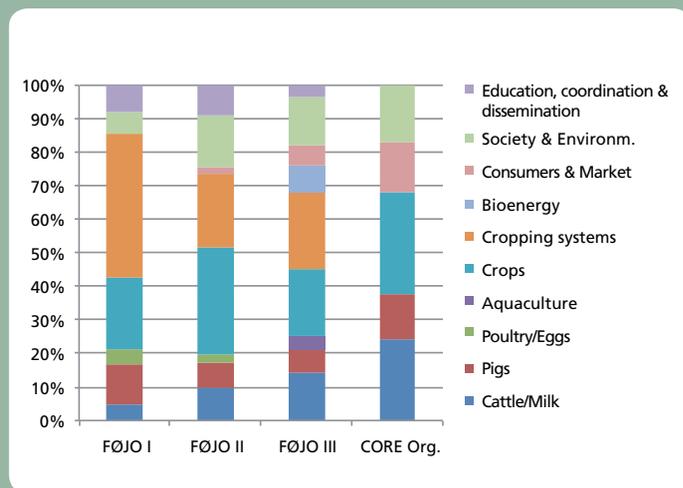


Figure 3.1  
Allocation of funds between thematic areas in each of the four research programmes.  
Dissemination and coordination in DARCOF I and II also included research degrees and scientific reviews

In the following section, the relevant recommendations of the action plans will be highlighted in relation to the challenges identified by the agricultural consultants as the most important in their field in the period 1996-2010. These are then compared with the research projects that have been implemented to solve them. Similarly, a table quantifies the technical communications under the different programmes to illustrate the coherence in applied organic research between the challenges facing the sector, the recommendations of the action plan, the number of concerted research actions and the dissemination of results.

### 3.2 Sector challenges, research contribution and number of publications

There has generally been a high degree of consistency between the identification of specific challenges in the sector by the consultants and the corresponding research projects, which indicates that the research effort has been very concerted and much applied. On the other hand, many of the answers show that the close collaboration of advisers with the primary production means that challenges and research topics in the areas of consumer and society do not figure as prominently.

In the rest of the chapter, the statements of the consultants on the challenges facing the organic sector will be dealt with under their respective areas of expertise (crops, cattle, pigs, etc.).

#### Crops

The consultants in organic crop production at the Knowledge Centre for Agriculture identified five challenges they believed to be the most important within their area for the period 1996-2010.



The consultants regarded crop rotation, nutrients, perennial weeds, sales, and seed production to be the most important challenges for organic crop production. The four research programmes had a total of 35 projects covering these research areas, of which 10 took place under DARCOF I, 16 under DARCOF II and nine under DARCOF III and CORE Organic. Of the 35 projects, 29 were from the categories Crops and Cultivation systems, while the remainders were from the categories Consumption, Society, and Environment.

Action Plan I had one recommendation that concerned the challenges identified by the consultants. Recommendation 28 related to the research themes Crops, Cultivation systems, Society, and Environment. The recommendation was for the establishment of an organic research station as a basis for research and development. Action Plan II contained four recommendations (numbers 1, 4, 11 and 12) that could be related to the challenges identified by consultants. Two related to the thematic areas of crop and the other two to consumption. Recommendations for studies were sales and consumption, the nutrient requirements in purely arable farms and the general promotion of organic crop production with focus on yields, economy, production barriers and environment.

The projects from the thematic areas of crops and cultivation systems produced a total of 955 publications, of which 381 were in Danish.

Regarding the impact of research-based knowledge, the consultants at VFL indicated that the DARCOF programmes have particularly helped solve challenges within the planning and use of fertilization, crop rotations and weed



control. To get a better idea of whether research-based knowledge and associated knowledge transfer has had an effect in the local advisory services, a number of local agricultural consultants have been interviewed. They had to give their views on three of the five challenges identified by the crop production team at VFL on crop rotation, nutrients and perennial weeds.

The local consultants find that there is a good level of knowledge about the planning of crop rotations and weed control and on the efficient use of nutrients. They find that the research-based knowledge has been useful for their advisory service and that it has had practical implications for the farmers (3 out of 7 "to a high degree", the rest "to some degree"). The consultants' assessment has been supported by the focus of a large number of research projects and by the communication that has taken place via Landbrugsinfo and via other channels. Several of the consultants stated that it is difficult to determine the origin of new knowledge and that research also affects practices via

Table 3.2

The association between sector challenges in plant production and the number of research projects and publications. The list of projects may not be exhaustive.

End-users Consultants' list of challenges to organic produc- tion	Research programmes and projects				Communication
	DARCOF I	DARCOF II	DARCOF III/ CORE Organic	Total	LandbrugsInfo
Crop rotation	3	3	2	8	6
Nutrients	6	4	2	12	20
Perennial weeds		1	1	2	10
Sales		3	3	6	1
Seed production	1	5	1	7	10
<b>Total</b>	<b>5</b>	<b>10</b>	<b>9</b>	<b>35</b>	<b>47 (53)</b>

more circuitous routes. Inspiration for innovative thinking is therefore important, as are specific results, and dialogue with scientists (for example via demonstration of field experiments) has been very important for the development of new methods. Quotes from two of the interviewed local consultants confirm this:

*The Danish DARCOF projects have been outstanding in terms of communication. We were initially introduced to organic farming research at the research stations and it was here, that the scientists communicated the most important results. The knowledge was directly applicable in practice and we could make use of it straight away. I have been very inspired by the discussions with the scientists and their dynamic way of crop-rotation thinking. The dialogue with the scientists lends credence to our practical recommendations. (Sven Hermansen)*

*Scientific results are often the basis for a good discussion. (Jesper Hansen)*

Several consultants, however, are of the opinion that the knowledge does not always find its way into practice. They

believe that only about half of the farms in their area plan optimal crop rotations or achieve the most efficient use of nitrogen. An explanation could be that for many arable farmers there is too little economic incentive or too few market outlets to include the green manures or specialist crops that could alleviate the problems in fertilization, nutrient recycling and weed control. Arable farms therefore have too much cereal in their crop rotations.

Regarding yields, the consultants profess that without the acquired knowledge about nutrients and perennial weeds, yields would be roughly 10% lower than current levels.

### Organic research and relevance for conventional farming

Some of the organic research projects within crop production have generated knowledge and methods that are also relevant for conventional farming. One such example is the R&D in organic seed production.

## The story of organic seed production

In 1990 a study involving organic farmers found that 30% of organic wheat fields contained more than 1000 spores of common bunt per gram of harvested wheat (Borgen, 1992). Such a high level of infection meant the wheat could not be used for flour production and as much of the wheat was not suitable for fodder either it had to be destroyed. Barley stripe and Ramularia leaf spot also led to yield loss in barley but did not lead to the total rejection of the crop. However, in organic farming a yield loss of 30% due to fungal attacks would not be economically viable.

The organic research projects in cereals and legumes were therefore a direct response to this situation and aimed at minimising the damage and risk from seed-borne diseases. Many methods were tested as replacements for conventional fungicides, including fungicidal treatment with mustard and other remedies not currently used in Denmark where they are prohibited. They are, however, used in other countries such as Germany, Austria, Switzerland, the Netherlands, England and France, where they help to keep common bunt under control. In Denmark the concept of damage thresholds is used instead and the consistent use of this has helped to minimise common bunt and other seed-borne diseases. Nowadays incidences of seed-borne diseases in organic crops are a rarity. The concerted research effort has in practice solved a serious problem for the sector, which has been a prerequisite for the expansion of the area under organic farming with feed- and bread-quality cereals. Research projects in organic seed production have also formed the basis for the provision of advice on damage thresholds and the projects have been able to prove/disprove different alternative solutions. Research in organic seed production has also revealed that the use of fungicides in conventional farming can be reduced by 80-90% or even phased out completely. According to senior scientist Bent Jørgen Nielsen, Aarhus University, for spring-sown cereals it is possible during the winter to analyse for seed-borne diseases and avoid the use of fungicides if the incidence is below threshold level. For winter cereals, a concerted effort is necessary, due to the short interval between harvesting and sowing, and it will also require liaison between the different stakeholders so that the propagation and spread of the disease and the incidence of new infectious strains in the population of pathogens is avoided.

**For cereals alone, more than 20 tons per year of active fungicidal agents is used (Miljøstyrelsen, 2010) costing farmers approximately 43 million DKK. About 30% of the agricultural area is currently devoted to spring-sown cereals.**

## Conclusion, organic crop production

As evidenced above, there has been a good balance between the most important challenges in organic crop production and the focus in a large number of R&D projects under the DARCOF programmes, and the results have been communicated to and made use of by the consultants. R&D has made an important contribution in the identification of solutions to the most important challenges in crop production and the consultants believe this has been useful and helped increase yields, etc. However, according to the consultants, not all farms apply this knowledge to ensure optimal crop rotations and management of nutrients and weeds. It is unclear whether this is due to lack of knowledge or other factors.

## Fruit and vegetables

Three consultants within organic fruit and vegetable production identified ten challenges that they

regarded as the most important for the sector in the period 1996-2010. These were yields, fertilization, weed control, cover crops, root development, variety testing, pest control, disease, quality, and sales (Table 3.3). The four research programmes included a total of 23 projects that focused on these areas, of which eight were in DARCOF I, ten in DARCOF II and five in DARCOF III and CORE Organic. Several of the projects addressed more than one of the ten challenges and are therefore marked with an \*). Of the 23 projects, 20 cover the research themes crops and cultivation systems. There were altogether 52 research projects covering crops and cultivation systems.

Action Plan II contained six recommendations (4, 13, 14, 15, 16, 23), which were for a stronger research effort in fruit and vegetable production, greenhouse vegetable production, quality standards, optimal grading, and consumer surveys.

In the area of knowledge dissemination, 16 articles were published in Landbrugsinfo. All articles could be linked to most of the challenges. In several of the published articles there were references to FØJO report no. 15-2001 and to research project II.2 (cover crops and vegetables) in DARCOF I and to VEGQURE (Production systems and vegetables) in DARCOF III.

The general impact of the research on the challenges in the fruit and vegetable sector was, according to the consultants, good and relevant. Exceptions are the areas of diseases, pests and the procurement of organic fertilizer, which have not been fully solved. The consultants also deem the impact of research at farm level to be good within most of the identified challenges.

## Conclusion, Fruit and Vegetables

There has been a reasonably good balance between the most important challenges within organic fruit and vegetable production and the research projects under the four DARCOF/CORE Organic programmes. The results have likewise been both communicated to and used by the consultants. R&D has made an important contribution to identifying solutions to challenges such as yields, weed control, variety testing and sales. In contrast, there is still a need for research in organic fertilization for fruit and vegetable producers, in disease prevention and quality control.

Table 3.3

The association between sector challenges in fruit and vegetable production and the number of research projects and publications. The list of projects working in this area may not be exhaustive

end-users Consultants' list of challenges to organic production	Research programmes and projects				Communication
	DARCOF I	DARCOF II	DARCOF III/ CORE Organic	Total	LandbrugsInfo
Yields	1	1		2	1
Fertilization	2	1	1	4	1
Weed control	1	1		2	1
Cover crops	1	1	1	3	1
Root development	*)	*), *)			
Root development	3	2		5	9
Root development	*)	*)			1
Diseases	*), *)	1		1	1
Quality	*)	1	2, *)	3	
Sales		2	1	3	1
<b>Total 10</b>	<b>8</b>	<b>10</b>	<b>5</b>	<b>23</b>	<b>16</b>

## Cattle

Consultants at VFL identified seven challenges that they regarded as the most important within this sector in the period 1996-2010. Table 3.4 lists these as calf mortality, roughage supply, udder health, protein supply, consumption/marketing, grazing, and milk and meat quality. The four research programmes have included a total of 12 projects on these challenges, five of which addressed more than one of the challenges (identified by \*). The 12 projects are split into one in DARCOF I, six in DARCOF II and five in DARCOF III and CORE Organic. 11 of the projects fall under the Cattle/milk thematic area and the remaining project under Society and environment focused on the challenge Consumption/Society. All research projects under the Cattle/milk area addressed the challenges that the consultants identified.

Similarly, Action Plan II had five central recommendations (1, 4, 10, 75 and 78) corresponding to five of the seven challenges identified by the consultants. Two came from the category milk, two from consumption and one from crops/field. The recommendations specifically identified requirements for research initiatives in animal welfare, animal health, disease prevention, feed supply in animal production and consumer and marketing analyses.

In the area of knowledge dissemination, a total of 15 articles on cattle production and marketing were published in Landbrugsinfo. All 15 articles could be linked to the seven challenges identified by consultants and a few of them even directly referred to specific research projects. The projects under the Cattle/milk thematic area produced a total of 261 publications and 100 of these were in Danish. Similar to crop production, a number of consultants were

interviewed to test the impact of the research-based knowledge. In this connection they had to consider three of the seven challenges identified by the specialist cattle team at VFL. These were roughage, udder health and consumption of antibiotics. The local consultants found that new knowledge has had a considerable effect both on the advisory service and on farming practice and that more than 50% of the farms use roughage that gives a high milk quality, good udder health, and has reduced the consumption of antibiotics in the herd. The consultants finally found that without the acquired knowledge on optimal roughage quality and udder health, the income per dairy cow would have been, respectively, 15% and 12% lower than today, while the consumption of antibiotics would have been 14% higher than today.

## Conclusion, Cattle

As can be seen, there has been 100% agreement between the most important challenges in organic cattle farming and the associated research projects under the milk category in the four DARCOF/CORE Organic programmes. The results have likewise been communicated to and used by consultants. R&D has made a significant contribution to defining solutions to the most important challenges in cattle farming and the consultants find that this has helped to increase milk yield and to reduce the use of antibiotics. According to local consultants, more than 50% of the farms in their districts make practical use of this knowledge.

Table 3.4

The association between sector challenges in cattle production and the number of research projects and publications. The list of projects working in this area may not be exhaustive

Consultants' list of challenges to organic production	Research programmes and projects				Communication
	DARCOF I	DARCOF II	DARCOF III/ CORE Organic	Total	LandbrugsInfo
Calf mortality		1		1	1
Roughage	1	1	2	4	2
Udder health		1	1 + *)	3	3
Protein supply	*)		1 + *)	3	4
Consumption/Sales		1		1	1
Grazing		*)	*)	2	3
Quality milk/meat		2	1	3	1
<b>Total</b>	<b>7</b>	<b>6</b>	<b>5</b>	<b>12</b>	<b>15</b>

## Organic research and relevance for conventional agriculture

Some of the research projects within organic cattle production have developed knowledge and methods that are also applicable to conventional farming. One such example is the R&D on the reduction of the use of antibiotics. The following account is by the scientists involved, senior scientist Mette Vaarst and Cand.med.vet., Ph.D. Torben W.Bennedsgaard, both from Aarhus University.



### The use of antibiotics in milk production can be completely phased out

Research into animal health and welfare in organic farming has shown that the use of antibiotics can be reduced to only a few percent of current consumption.

In organic herds the objective is to keep animals healthy and improve their welfare. Although chemical products are prohibited, sick animals are allowed veterinary medication. The level of disease in Danish organic herds has generally been only a little lower than in conventional herds, which means it has remained a hot topic for discussion among organic farmers for many years. In 2004 the producers at Thise Dairy (organic dairy) decided that they would actively work towards phasing out the use of antibiotics. They approached the agricultural scientists (now part of Aarhus University) and Organic Denmark (Danish association for organic farming) who carried out a concerted research project with 23 milk producers. The project developed a concept where groups of farmers from 5-8 farms collaborate in a very defined and focused way. The farmers take it in turns to visit each other and the host prepares a programme for the visit with two problems that they will help each other to solve. In addition, they have a success story that they would like to share.

Farmers participating in this network managed to reduce the use of antibiotics by 50% in a year and the level of antibiotics consumption in herds was eventually reduced to about 10% of that in conventional milk production. Subsequent studies in the DARCOF project ECOVIT and in the CORE Organic project ANIPLAN have documented that this level can be maintained, even after five years and without any adverse effects on animal health. Follow-up experiments in the ECOVIT project also showed that the abandonment of a routine treatment for retained placenta did not have a negative effect on animal health. This may be because the phasing out of treatment in reality has the dual objective of both avoiding treatments that have little or no effect and the phasing out of disease. This can only be achieved with general improvements in the herd where farmers become better at recognising that disease symptoms in the animals are a sign that changes need to be made to their care. The interesting thing about the improvements made by the farmers was that all improvements involved very basic elements and routines in herd care, such as awareness of the requirements for fresh air, better hygiene, feeding, milking and a general focus on animal welfare.

The good results can be explained by the fact that about 40% of typical mastitis treatments in Danish herds involve cows that would have recovered without the use of antibiotics anyway. About 30% of the treatments furthermore involve cows where the effect is short-term and the cow remains chronically infected after the treatment has finished. When the farmers become aware of this, their motivation for and focus on preventing the spread of infection and thus reduce the incidence of disease is increased. The difference in the cost of treatment and in lost production in a typical conventional herd and in an organic herd with a low use of antibiotics corresponds to, respectively, 80 and 20 cases per 100 cows, at around 1400 DKK per cow-year. At this price it is possible to finance comprehensive initiatives for the further improvement of animal health and welfare.

## Pigs

Senior adviser at VFL, Tove Serup, identified eight challenges that she regarded as the most important within the sector in the period 1996-2010. According to Table 5 these are welfare, mortality, environment, balanced feeding, product differentiation for meat, feed supply security, sales, and labour. The four research programmes have had a total of 13 projects targeting seven of the eight challenges. Of these, six were in DARCOF I, five in DARCOF II and two in DARCOF III and CORE Organic. Four of the projects from the research programmes cover more than one of the selected challenges and are marked \*).

All 13 projects belong to the pig category, which means that all research projects have targeted seven of the eight identified challenges for the sector. None of the projects has dealt with the question of labour versus economy that Tove Serup highlighted as a challenge for the sector.

Action Plan I and II contained a total of six recommendations (1, 4, 54, 75, 77, 78) that coincided with three of the challenges identified by Tove Serup. Two came from the consumption category, while the other four belong under the pig category. The recommendations were directed at the challenges associated with animal welfare, animal health and prevention of disease in organic pig production and with sales.

In the area of knowledge dissemination, 15 articles on organic pig production were published in Landbrugsinfo, ten of which could be directly related to the identified challenges. Seven of the 15 articles referred directly to FØJO report no. 8-2000. The research projects under the pig thematic area produced a total of 208 publications, 81 of which

were in Danish. In terms of research contributing to solutions within the eight identified challenges, it has according to Tove Serup had an impact on the first five challenges in Table 3.5 – welfare, mortality, environment, balanced feeding, and product differentiation for meat. The research effort in animal welfare scored highest in this regard. There are, however, still problems with product differentiation for organic pig meat, mortality, environmental issues and balanced feeding, where the contribution from research to solving these challenges has been below average.



Table 3.5

The association between the challenges in the organic pig production sector, number of research projects and publications. The list of projects working in these areas may not be exhaustive

Consultants' list of challenges to organic production	Research programmes and projects				Communication
	DARCOF I	DARCOF II	DARCOF III/ CORE Organic	Total	LandbrugsInfo
Welfare	2	2	1	5	1
Mortality	*)	*)	*)		1
Environment	1	1		2	1
Balanced feeding	1	1		2	5
Product differentiation of meat		1	1	2	
Security of feed supply	1	*)		1	1
Sales	1			1	1
Labour				0	
<b>Total</b>	<b>8</b>	<b>5</b>	<b>2</b>	<b>13</b>	<b>10 (15)</b>

## Conclusion, Pigs

There has been good correlation between the identified important challenges in organic pig production and the research projects under the pig category in the four DARCOF/CORE Organic programmes and corresponding recommendations from Action Plan I and II. The results have likewise been both communicated to and used by the consultants. R&D has managed to find solutions to the most important challenges for pig production. This applies particularly to welfare problems, while the questions of mortality, environment and balanced feeding are not yet near a solution.

## Poultry/Eggs

The consultant specialising in organic poultry and egg production at VFL, Niels Finn Johansen, identified six challenges that he regarded as the most important for the sector in 1996-2010. Table 3.6 shows these as health, welfare, optimal production systems, economy, environment, and egg quality. The four research programmes had four projects addressing the challenges in the primary sector with two in DARCOF I, one in DARCOF II and one in DARCOF III and CORE Organic. Some of the projects cover more than the one challenge and are therefore marked with an \*). As the table shows, research has mainly targeted health, welfare and production systems, and egg quality.

All four poultry research projects have focused on four of the six challenges for the sector identified by the consultant. Two challenges – economy and environment (leaching, NH<sub>3</sub> emission) – were not addressed by the four research projects. Overall, this means that the initiated research projects have addressed two-thirds of the challenges identi-

fied by the consultant as the most important in the area. Action Plan I and II each held one recommendation (46 and 78) for the poultry sector that identified, respectively, additional research in welfare, animal health and disease prevention, and the initiation of a development project for the marketing of broilers as important.

In the area of knowledge dissemination, four articles on organic poultry were published in Landbrugsinfo. All could be directly related to the thematic areas of Production systems, Health, Welfare and quality in egg production. The latter with direct reference to FØJO report no.11-2011.

The projects under the Poultry/eggs thematic area produced a total of 75 publications, of which 33 were in Danish. Regarding the impact of the research on the challenges of poultry and egg production, Niels Finn Johansen finds that it has helped to control several serious diseases and certain challenges in animal welfare and behaviour. For these areas the research effort achieved a high score. On the other hand, the problems associated with huddling have still not been solved and therefore achieve a low score.

## Conclusion, Poultry and eggs

There has been good coherence between the important challenges in organic poultry and egg production and the research projects under the four DARCOF/CORE Organic programmes. The results have also been both communicated to and used by the consultants. R&D has made an important contribution to solutions to challenges such as cannibalism, Erysipelas and Pasteurellosis, nutrient uptake in the chicken coop, E. coli, and feather-pecking. Research has also had an effect at farm level in the areas of nutrient uptake, parasites, welfare, fodder and feeding.

Table 3.6

The association between the challenges in the organic poultry and egg production sector, number of research projects and publications. The list of projects working in these areas may not be exhaustive

Consultants' list of challenges to organic production	Research programmes and projects				Communication
	DARCOF I	DARCOF II	DARCOF III/ CORE Organic	Total	LandbrugsInfo
Health - Parasites (E. coli),	1	1		2	1
Welfare (cannibalism, huddling, feather-pecking)	1	*)		1	1
Production systems	*)	*)			1
Economy					
Environment (leaching NH <sub>3</sub> emission), emission)					
Egg quality			1	1	1
<b>Total 6</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>4</b>	<b>4</b>

## Fish

Organic aquaculture is a relatively new and alternative form of production in Denmark that received its official approval and set of organic regulations in 2004.

Consultant Villy Larsen from Dansk Akvakultur (Danish Aquaculture Association) has identified three areas where organic research has had a significant impact on the growth potential of the industry. As Table 3.7 shows, these are welfare, environment and development of organic fish feed. The research project ORAQUA from DARCOF III was the first research project to address organic aquaculture and it focused on the critical barrier to the utilization of the growth potential in the industry, namely the production of an organic fish feed. Fishmeal and fish oil are in this connection unique sources of protein and fat in fish feed due to the high contents of, respectively, amino acids and Omega-3 fatty acids. But this resource is severely limited, which is why the ORAQUA project focused on alternative sources of organic plant products and thus paved the way for the inclusion of a higher content of organic protein-rich crops in the feed for farmed organic trout. As Villy Larsen puts it:

*Research and development in this area has been absolutely critical for the establishment and development of a Danish organic fish farming industry. No organic fish feed – no organic fish farming.*

Research into the development of fish feed in organic fish production has also been instrumental in directing focus onto animal welfare in organic fish farming, which has meant that the use of medicine and chemicals in organic aquaculture has been minimised.

## Conclusion, Fish

There is clear coherence between research in organic aquaculture and the objective of solving the considerable obstacle to the continued expansion of the industry of producing an organic fish feed. Problems with the procurement of high-quality competitively-priced feed can become a strongly limiting factor to future potential growth, particularly for fledgling niche productions such as organic aquaculture where – unlike most other types of farming – the feed has to be imported to the farm.



Table 3.7

*The association between the challenges in the organic aquaculture sector, number of research projects and publications. The list of projects working in these areas may not be exhaustive*

Consultants' list of challenges to organic production	Research programmes and projects				Communication LandbrugsInfo
	DARCOF I	DARCOF II	DARCOF III/ CORE Organic	Total	
Welfare					
Environment					
Organic feed			1	1	
<b>Total 3</b>			<b>1</b>	<b>1</b>	

### 3.3 The impact of research on government and non-government organisations and private processing companies

A number of the R&D projects have focused on topics relevant for society, such as the impact of organic agriculture on environment, animal welfare, etc., and on the motivation of consumers for purchasing organic products. In order to analyse the effect of these results, a questionnaire was sent to 15 processing companies and ten government/non-government organisations. These include the government offices in charge of legislation for the organic sector and a number of consumer and environmental organisations. Key persons in the 15 processing companies and ten organisations were sent a questionnaire where they were asked for their assessment of the effect of organic research, either indirectly in the form of, for example, processing companies being able to secure a stable supply of feedstocks in a market of increasing demand, or directly through different stakeholders or governmental organisations using the research for new regulatory measures.

The results will be discussed in the following sections, starting with the processing industry and followed by governmental and non-governmental organisations.

#### Processing industry:

Despite the low return rate of questionnaires (six), the answers and follow-up interviews indicate that:

- 1) The research has helped the general development of the organic market potential
- 2) For small companies the research is considered most important in the areas of development and marketing of new products
- 3) The research is important for the securement of a stable, high-quality supply of commodities from primary producers
- 4) The research has helped to direct focus towards environmental aspects and animal welfare in the processing industry
- 5) The research is valued differently at the processing level, depending on the sales markets, volumes and processing clusters that the companies are operating in. Apparently the organisational structure of the company also has an effect on how important the research is deemed to be. Larger concerns producing organic basics as a niche production line (Arla Foods, Stryhns and Rose Poultry) often have a specialised and divisional organisation where the organic profile and evaluation of research impact are not the sole responsibility of one or a few persons. Smaller organic companies will, on the other hand, often have just a few persons representing the company and the organic product portfolio from the purchase of commodities to the sale of the final product.

The replies from the companies endorse those from the advisory service that the research in the DARCOF and CORE Organic programmes to a very high extent has managed to improve the general market and growth conditions for the organic sector, but that it also has been very focused on the removal of the barriers that have prevented the supply of larger volumes of high-quality products. The research has therefore helped engender consistency between the challenges of the industry and the focus of the research. Research has thus complied with the political ambition of creating market-driven growth, giving a better foundation for the continuing utilisation of companies of the commercial opportunities within the organic sector.

#### Government organisations:

Questionnaires were sent to five persons in four government organisations, of whom three responded and the other two were contacted by telephone and subsequently responded via mail. According to the representatives from the two government organisations that are most involved in organic legislation at national and international level, The Danish AgriFish Agency, the perception is that the organic farming area is regulated by common EU legislation. As a rule, Danish organic research therefore does not have a direct influence on policy-making. The effect of the research initiatives is thus difficult to quantify. Their experience is also that proposals for changes to EU regulations for organic farming normally are at the initiative of stakeholders, i.e. the organic farming associations, but that these often use the research results to underpin their suggestions/requests. On this background they believe that the research results have a more indirect effect on, for example, policy design.

EU regulations also apply in the area of food security, but in the Danish Veterinary and Food Administration they are aware that research has looked at whether there is a higher risk of food security attached to the production of organic fruit and vegetables because of the recycling of animal manure. This does not mean that the research results from the projects mentioned are being used as background for new legislation, but that they will probably use the results for the allocation of animal manure in connection with the agency's initiatives to increase the food security of fruit of vegetables. Conversely, organic research generally contributes new knowledge and can in this way specify new opportunities that can give inspiration for both a green conversion and increased growth in agriculture.

The three respondents from the governmental organisations generally agree that the organic sector has been involved in important issues within the thematic areas of animal welfare and environment in the period 1996-2020, while there are fewer references to climate, legislation, sales and consumers.

The two respondents from, respectively, the Environmental Protection Agency and the Danish Veterinary and Food Administration have answered questions on the extent to which research-based knowledge has been useful within their own area and in relation to the selected themes, and they both responded that the research results have been useful within their own areas of environmental legislation in agriculture, particularly the livestock area.

**Non-governmental organisations:**

Questionnaires were sent to ten people in seven private stakeholder organisations covering the interests of organic farmers and consumers, nature and environment, and animal welfare. These organisations also have a body of specialists, and questionnaires were therefore sent to them to obtain as much information as possible on the themes in the questionnaire.

Similar to the respondents from the governmental organisations, there is general agreement that the organic sector in the period 1996-2010 has been concerned with many important aspects within the thematic areas of animal welfare and environment. Under animal welfare, the welfare problems relating to poultry production achieve a particularly high score and under environment particularly the problems with nitrogen are thought worth mentioning.

Within the other themes, the comments are more varied and depend on which organisation the respondents come from. There is, however, for the most part consensus that legislation, including harmonisation of the EU countries and sales has been very important factors for the organic sector and several respondents mention in this regard also integrity as well as consumers as important areas.

Under the other themes, the following aspects were also mentioned as having been important in the period: Health and food quality, escalating the conversion to organic farming, impact of financial crisis on the development of organic agriculture, including improving production economy and sustainability.

On the question of how much the respondents thought the results from organic research had contributed to solving the problems within the specific themes, the respondents graded the effects. For animal welfare and the environment, there is

broad consensus that organic research has either 'to some degree' or 'to a high degree' helped solve problems within these areas. The opinions in the climate area are more divided – from 'to a lesser degree' (Danish Agriculture and Food Council) to 'a high degree' (Aktive Forbrugere [active consumers]) and the other respondents falling in between.

Regarding legislation, the prevailing attitude is that organic research 'to a high degree' has contributed to solutions. However, the Danish Society for Nature Conservation believes that research only 'to a lesser degree' has contributed to solutions. For the thematic areas of sales and consumers, the respondents agree that research has contributed only 'to a marginal degree' or 'to a lesser degree' – with most scoring 'to a lesser degree'.

All six respondents answered the third question on the degree to which research-based knowledge has been useful within their own field of work in relation to the selected themes. The weighting here clearly reflects the areas that the respondents work with, either as a generalist or a specialist.

**Conclusion**

The effect of the research for the processing companies has been to generally develop the organic market potential and to create a stable supply of high-quality commodities from the primary agricultural sector in response to increasing consumer demand. Organic research has also directed the focus of the companies towards animal welfare and environmental problems. For the governmental organisations involved in policy development, the impression is that the results of research have had a more indirect effect on policy formulation.

Conversely, organic research more generally generates new



knowledge that can furnish new opportunities and give inspiration for a green conversion and increased growth in the agricultural sector. The responses from the non-government organisations agree with those from the government organisations that the organic sector in the period 1996-2010 has been involved in many important aspects within animal welfare and the environment. There was likewise broad consensus that organic research

has contributed 'to some degree' to 'a high degree' to solve problems within these two areas. How useful research-based knowledge has been for respondents' respective lines of work is clearly reflected in the weighting. This applies both to the generalists and the specialists.

### **Innovative product partnership between scientists, farmers and the dairy industry**

*By senior scientist Søren Krogh Jensen, Aarhus University*

With stipulation of a 100% organic feeding regime, restriction on the use of synthetic vitamins and the ambition to use alternatives to antibiotics, the DARCOF III ECOVIT project showed that health in organic dairy herds could be improved by the incorporation of herbs in the grassland. The CORE Organic PHYTOMILK project likewise showed that mixtures of grass and herbs in the feed for dairy cattle can change the milk composition, making it more nutritious and with a lower content of saturated fats. The assumption is that the herb mixture affects the breakdown of fat in the rumen which then affects milk composition.

As a spin-off from these two organic research projects, a pilot project has shown that the content of healthy Omega-3 fatty acids is twice as high in milk from cows fed herbs and the Omega-6 content is 40% higher if the grass silage is replaced by herbs. The fatty acid profile is similar for herbs and grass, but in milk it nevertheless ends up being quite different. Obviously it is possible to produce healthy dairy products by feeding the cows a slightly different diet, resulting in a drop in the content of saturated fats while the Omega-3 and Omega-6 contents increase. Omega-3 and Omega-6 fatty acids belong to the group of essential fatty acids, which means we cannot synthesise them ourselves and they therefore have to be supplemented via the diet.

Saturated fat is regarded as unhealthy and half of our current intake of saturated fat in Denmark originates from dairy products such as cheese and butter. A production of more nutritious dairy products with low concentrations of saturated fat but large concentrations of the unsaturated Omega-3 and Omega-6 fatty acids through alterations to the dietary composition of cattle would therefore have interesting commercial perspectives. This Dairy is therefore participating in the project by manufacturing milk products based on milk from cows fed herbs and will be making a pilot production of cheese, butter and drinking milk in the early part of 2013. Three farmers participate in the project and they have planted a total of 40 hectares with a herb mixture. The project will look at whether the different soil types and cultivation systems have an effect on milk production. The project will also look at how individual herbs develop over time and how they compete against each other, which will ultimately affect the composition of herbs in the diet.

The herb mixture is composed of great burnet, chicory, cumin, plantain, birdsfoot trefoil, lucerne, white sweet clover, borage, yarrow and red clover, where individual species make up between 2 and 12% of the mixture. The herby milk is in many ways an interesting case. It shows first and foremost how solid traditional research originally founded on the idea of promoting the health in organic dairy herds now forms the backbone for scientists, farmers and the processing industry becoming partners in an innovative collaboration on development and marketing of new milk products because the industry imposes regulations on itself for a 100% organic feed and restrictions in synthetic additives.

## Chapter 4. The end-user view of research effects

The following chapter is a collection of input from end-users about their use of results from research. Centrally located consultants in the field of organic crop production, dairy, pig, poultry, and fruit and vegetable production, respectively, have been interviewed in a systematic process. Local crop and livestock consultants were subsequently interviewed using a combination of questionnaires and follow-up conversation. Both types of interview were based on the consultants' own understanding of the development in their subsector over the last 10-15 years.

### 4.1 Interviews with consultants in organic crop production

**New research knowledge in the area of crop production has had a considerable effect both on the advisory service and on farming practice.**

Interviews were carried out with seven organic crop consultants and a group interview with three organic farming consultants from the Knowledge Centre for Agriculture (VFL). The consultants were asked what the main challenges had

been in organic crop production in the period 1996-2010 and which challenges have been solved most successfully. They were also asked whether the solutions were the result of the research undertaken in the period.

Overall, the study shows that the majority of the interviewed consultants find that new knowledge has had a considerable effect both on the advisory service and on farming practice.

Generally, the seven local crop consultants find that the knowledge of the advisory service is above average ("to some degree" or "to a high degree") in the area of planning crop rotations, retaining nutrients in the field and the long-term repression of perennial weeds. Particularly significant is the knowledge of nutrients, where the consultants believe that there "to some degree" or "to a high degree" is sufficient knowledge about how to retain nutrients. For the farms in the consultants' respective areas, they estimate that half of the farms plan optimal crop rotations, while less than half of them manage to retain nutrients sufficiently. However, they estimate that the most farms have sufficient control of perennial weeds.



When asked what crop yields generally would have been like without the knowledge of, nutrients and perennial weeds, respectively, the consultants respond that yields would have been 0-20% lower (response average = 10% lower yields).

To the questions on the effect of the last 15 years of research and development, it is clear that most of the interviewed consultants find that this information has been helpful in their advisory work and has had an effect on farming, just as most of the consultants "to some degree" or "to a high degree" were familiar with the DARCOF or CORE Organic programmes.

The most important challenges in organic crop production for the period 1996-2010 were thought to be:

- ▶ Crop rotations
- ▶ Nutrients (N)
- ▶ Perennial weeds
- ▶ Sale
- ▶ Healthy and vital seeds

**Which challenges have been most successfully solved?**

Table 4.1 below sets out the ratings for how far the consultants believe we have come since 1996 in solving the challenges in crop production. The table contains a summary of the identified challenges, the challenges that have been most successfully solved, what effects/changes in organic crop production these challenges have produced, and whether research has contributed to these effects/changes.

The challenges were given a rating between 1-10, where:

- ▶ 1 = no progress has been made since 1996 in solving the challenge
- ▶ 10 = the challenge has been solved

**Crop rotations**

**Comments on crop rotations and nutrients:**

The dialogue with the scientists working in organic crop production has likely been very important, according to the consultants:

*The dialogue with the scientists is good in the way that it can confirm your own theories and show farmers that this is how it is, so it is important that research and experiments are carried out. The results from research can often lead to a good discussion, such as Ilse Rasmussen's message that a green manure crop in the rotation works just as well as a cereal. (Jesper Hansen)*

*I have been very inspired by the talks with the scientists and by their dynamic way of thinking about crop rotations. When we have a system that is pumped dry of nitrogen, we need to think in new ways, but this can also work very well. The dialogue with the scientists lends credence to our practical recommendations. (Sven Hermansen)*

*All the consultants are 110% up-to-date on their crop-rotation knowledge, and this is due to the DARCOF III programmes – they certainly find that the research results give them background support. Without this knowledge, I believe we would have seen a larger number of reconversions to conventional farming, because the consultants would not have been able to offer*

Table 4.1.

Organic crop production: Summary of challenges, solutions and contribution from research

Challenge	Success rating	Effects/changes at farm level	Did research <sup>1</sup> contribute?
Crop rotations	6	Partial break with conventional thinking	Yes
Nutrients	7	Optimised fertilizer plans; prioritisation of fertilization; crop-dependent fertilization	Yes
Perennial weeds	7	New strategies for perennial weeds. Total control of couch grass. Machine testing.	Yes
Marketing	7	The here-today-gone-tomorrow shops have gone, leaving only the professional firms; focus on customer contact; new market outlets, for example Aarstiderne; own brands; some farmers are active market actors; organic credibility maintained with consumers despite organic farms growing and specialising.	No
Healthy and vital seeds	6	-	

<sup>1</sup>Research is here understood as DARCOF I, II and III and CORE Organic programmes

*the best advice to farmers. This has given us a more stable development. (Michael Tersbøl)*

*I still use the N-uptake curves for different crops. They could probably do with being updated because they are useful for prioritising fertilizer type. The effect is a saving in the environmental cost of N and a 10% improvement in yields because of this knowledge. (Thomas Vang Jørgensen)*

## Perennial weeds

### Comments on perennial weeds:

Generally, the consultants believe that new knowledge on nutrients and control strategies for perennial weeds has meant that yields now are approx. 10% higher than in a hypothetical scenario where this knowledge would not be available.

*In 1996 we talked about weeds generally – not perennial weeds specifically. At that time 99% of the farmers converting were dairy farmers.*

*In 2002 everyone was talking perennial weeds and the mini summer fallow had been tested at Jyndevad in 2000. (Margrethe Askegaard, Inger Bertelsen)*

For perennial weeds, there was consensus that much had been achieved in solving this challenge – see for example the comments below:

*On perennial weeds we have made great strides and farmers who use our recommended methods succeed in controlling perennial weeds. (Peter Mejnertsen)*

*Farmers who have carried out experiments with perennial weeds have really accepted the results and spread the word. (Inger Bertelsen)*

*The Danish DARCOF projects have been outstanding in terms of communication. We were initially introduced to organic farming research at the research stations and this is where the scientists communicated the most important results. The knowledge was directly applicable in practice and we could make use of it straight away. I have been very inspired by the discussions with the scientists and their dynamic way of crop-rotation thinking. The dialogue with the scientists lends credence to our practical recommendations. (Sven Hermansen)*

### Sale

On the question on whether DARCOF projects, etc., have had any effects on marketing opportunities, the group agreed that they had no knowledge of DARCOF programmes having an impact on this.

### Seeds and seed production

One consultant indicates here that grass seed crops are virtually always successful, and that a successful seed crop likely contributes 10 to 20% to the total economy of the crop rotation. One of the two consultants refers to the research of Birte Boelt at Flakkebjerg, while the other refers to knowledge and experience of both organic and conventional seed growers and the seed industry.



**Other areas in organic crop production, where the consultants believe significant changes in cultivation practice have taken place in the last 15 years:**

**Protein crops**

- ▶ Pulses/introduction of broad beans and lupine
- ▶ Broad beans – cultivation
- ▶ Use of legumes

The consultants who suggested the above broadly agree that the knowledge on broad beans does not originate from research but rather from the national trials, practical experience and from abroad. For lupine, soybean and quinoa, research is cited as the source of knowledge.

**Technology**

The first crop row guiding systems and robot technology were tested at Rugballegaard. These were particularly used by the vegetable producers, but also by large arable farms. The advantages are a better control of weed seeds and a saving in labour input as the capacity, for example for row cultivation, probably is increased by as much as 30-40%.

*Technological development makes a serious difference in vegetables such as carrots and potato, whereas it has no effect on weed control in cereals (Thomas Vang Jørgensen)*

**General impact of research**

There was an appreciation of the positive impact of research project, although it is difficult to separate out the different projects and programmes.

*If we look at the sum of the effects we have described, I believe that 70-90% of the effects can be traced back to the DARCOF I-III project results from, for example, the crop rotation experiments – particularly on nutrients, weeds and cropping practices, while the concept of fertilizer type has also been introduced. VFL has contributed particularly on economy. (Peter Mejnertsen)*

**Fruit and vegetables**

A group interview was carried out with two specialist consultants within fruit and vegetable production and also with a local consultant. They were asked what they believe have been the main challenges within organic fruit and vegetable production in the 1996-2010 period and which challenges have been solved most successfully.

Ratings were given on a scale from 1-10 where:

- ▶ 1 = no progress has been made since 1996
- ▶ 10 = the challenge has been solved



Table 4.2 shows the ratings according to how much progress has been made in solving the challenges within the fruit and vegetable area since 1996. The table contains a summary of the identified challenges, which challenges have been most successfully solved, which effects/changes there have been within organic fruit and vegetable production as a result of these challenges, and whether research has contributed to these effects/changes.

#### Comments on varieties:

Variety was one of the first challenges to be addressed and some of the initiatives were DARCOF-generated. For vegetables we now have an indication of which species and varieties are best suited for organic production and this has been a good development. For fruit, we have now tested ten varieties of red currant and eight varieties of blackberry. (Hanne Lindhard Pedersen and Richard de Visser)

*The variety testings have been important for organic fruit and berries. With the continuous emergence of new infectious strains, it is a never-ending research topic. The importance of this effort can be measured in yield rises of up to 60-90% through stable productions and consistency in size and quality. At the moment we are working on getting baking powder approved as a fungicide. (Maren Korsgaard)*

#### Comments on weeds:

*Weeds are an important factor. Research has contributed new knowledge on the harrowing of weeds and weed-harrowing in vegetable production was a research project in DARCOF I. Steam-treatment of weeds was a project in DARCOF II. The DARCOF project had the effect that regulations were altered to allow only the steaming of part of the soil. The steaming of weeds saves time on manual hoeing and gives a reduction in labour input of about 100 hours/ha. (Maren Korsgaard)*

Table 4.2.

Organic fruit and vegetables: Summary of challenges, solutions and contributions from research

Challenge	Success rating, veg. production	Success rating, fruit production	Effects/changes at farm level	Did research <sup>1</sup> contribute?
Yields	6	5	- Intensive fruit production - Planting system - Variety selection	Yes
Pests	5		- Flower strips (balance predators-pests)	Yes
Varieties	5	5	- Regular variety testing for many species of fruit and veg - Development of stable varieties in organic production - Quality control	Yes
Weeds	7	4	- Mechanical control - Flaming - Soil cover - Development of new technology - Crop rotation	Yes
Market growth Sales	7	6	- Large demand leads to import - Rationalisation, efficiency improvements, specialisation - Consumer focus	Yes
Product development	5	5	- Consumer focus	-
Teamworking: organic and conventional farmers	8	6	- Open house/farm visits, seminars - Publications	Yes
Credibility	8	5	- Discussion, openness and information - Debate - Political responsiveness - Visible producers	-
Eggs/fruit			- Organic project demonstrating a good idea	Yes

<sup>1</sup> Research is here understood as DARCOF I-III and CORE Organic

*Weeds were the next challenge to be addressed where cover crops, mechanical weed control and perennial weeds were major topics. For fruit, some reasonable solutions to the challenges of weed control have been achieved. (Hanne Lindhard Pedersen and Richard de Visser)*

**Comments on quality:**

*At the beginning some consumers bought the vegetables purely because they were organic, but later the consumer segment expanded to include a new type of consumers who also wanted quality. The growth in the organic sector depended on quality, and quality continues to be a problem now and again. (Richard de Visser)*

**Comments on fertilization:**

*It was not until fairly late in the period that they started discussing the phasing-out of conventional fertilizer, and we still have not sorted out where to get the fertilizer from if you are only growing vegetables. (Hanne Lindhard Pedersen and Richard de Visser)*

*The Aarslev research project using green manure in a crop rotation was unique and has had a large influence on the sector and possibly also a knock-on effect on conventional farming. This work shows that nitrogen does not need to be a problem but is something we can control. Mobile green manuring as an alternative to other fertilizers has also been used in the industry. This*

*has meant that we have been able to keep the distance to the conventional production and thus maintained credibility as we are prepared for the phasing-out of conventional fertilizer. (Maren Korsgaard)*

## 4.2 Interview with consultants in organic livestock husbandry

### Good teamwork between scientists and consultants – but better dissemination of knowledge to farms is needed.

A survey based on interviews of the organic livestock consultants at VFL and five local consultants on the impact of the research in the last 15 years shows that the majority of the consultants find that the new knowledge has had a considerable impact, both in the advisory service and on farming practice.

### Livestock – forage, health and grazing

The VFL organic livestock consultants reckon that some of the most important challenges in the cattle area have been within:

- ▶ calf mortality
- ▶ udder health
- ▶ forage quality
- ▶ protein supply
- ▶ consumer perception of organics
- ▶ grazing



Based on the above challenges, the local consultants were asked whether new knowledge has emerged in these areas and subsequently whether the research in the programmes encompassed by this analysis has contributed new knowledge. More specifically, the local consultants were asked:

- ▶ Have you benefited from new knowledge regarding on-farm production of protein?
- ▶ Have you benefited from new knowledge on the persistence and feed value of pasture crops?
- ▶ Have you benefited from new knowledge on the production of milk with health-promoting compounds?
- ▶ Have you benefited from new knowledge on the inclusion of herbs in the feed?

Most of the consultants are of the opinion that knowledge on the above subjects originates from research. Three of the five consultants believe that knowledge on the on-farm production of protein and on pasture crops originates from research, while four out of five consultants believe that knowledge on milk with health-promoting compounds and knowledge on herbs originates from research.

All five of the local consultants interviewed thought that there "to some degree" or "to a high degree" is sufficient knowledge at advisory level about how to ensure optimum

forage quality. Four of the five respondents believed that the consultants "to some degree" have sufficient knowledge about udder health, and likewise four of the five consultants believe that the advisory service today "to some degree" or "to a high degree" has the required knowledge for minimising the consumption of antibiotics. The consultants were also asked to which extent this knowledge is applied at farm level. Here they estimated that an average of more than 50 % of the farms in their respective areas use forage that gives a high milk quality, maintains good udder health and has reduced the consumption of antibiotics in the herd.

### Which challenges have been solved most successfully?

Table 4.3 below shows how well the different categories scored according to how well the consultants believed the challenges in organic livestock production have been solved since 1996. The table contains a summary of the identified challenges, the challenges that have been solved most successfully, the effects/changes that have taken place in organic cattle production as a result of these challenges, and whether research has contributed to the effects/changes.

Table 4.3 Organic livestock husbandry: Summary of challenges, solutions and contribution from

Challenge	Success rating <sup>2</sup>	Effects/changes at farm level	Did research <sup>2</sup> contribute?
Grazing - efficiency - land allocation	3	Regulation Fields with persistent plant cover close to housing Efficiency in feed value	No Yes Yes
Calf mortality	6	Drop from approx. 6.5 to 5% Campaigns Farmer field schools Milk for calves pasteurised	Yes
Udder health	4	Better economy Better animal welfare Better milk quality Less use of antibiotics/project on phasing-out of antibiotics	Yes
Forage quality	5	Improved - Variety selection - Plant breeding Admixing of herbs means less feed supplementation	Yes
Protein supply	4	Supply security Lower environmental load Higher sustainability Growing protein crops Developing/testing methods for feed value	Yes
Consumer perception of organics	3	A guarantee of milk quality Milk production with healthy ingredients Less antibiotics Herbs in the pasture (diversity, milk composition, etc.)	Yes

<sup>1</sup> Research is here understood as the DARCOF I, II and III and the CORE Organic programmes

<sup>2</sup> The scores are given by the consultants at VFL, but the comments, challenges and responses to whether research has contributed are from all interviewed consultants. The livestock consultants from VFL explain that their experience does not go as far as the very start of the period of analysis, which is why the change for them has not been as significant, resulting in a lower rating.

The challenges were given a rating from 1-10 where:

- ▶ 1 = no progress has been made since 1996
- ▶ 10 = the challenge has been solved

### Comments on grazing:

Consultants have seen significant changes, for example in:

- ▶ Pasture control for optimal production in the field and in the stable
- ▶ High-yielding grass mixtures
- ▶ Grazing strategies/AMS (automatic milking system)
- ▶ Housing systems with AMS

*We have farmers asking whether we have any new knowledge they can use, and then information travels back and forth, for example via the meetings at Foulum. I, therefore, use scientists as sparring partners in the quest for new knowledge in my advisory work. However, not all knowledge can be directly converted to practice due to the cost or due to practical considerations. (Kirstine Lauridsen)*

*There have been some useful behavioural studies in connection with the automatic milking systems in DARCOF projects, and the recording of animal behaviour at Rugballegaard. (Søren Lykke Jensen)*

### Comments on calf mortality:

*Knowledge on pasteurisation of milk for calves has emerged within the last five years. Calf mortality has been much higher, partly because of a selenium deficit which gave rise to many stillborn calves, and partly because the warm milk from milking robots upset the calves' stomach. Now the highest growth rate for calves in our area is as a matter of fact on two organic farms. Their calves have a 10 per cent higher rate of growth than the average. (Ida Ringgaard)*

### Comments on udder health:

The prevention of disease and minimisation of the use of antibiotics is an area that receives a lot of attention:

*The organic research project was probably the actual start of the focus on reducing the usage of antibiotics, but at national level it was actively taken up by many dairy farmers. The vets have a large influence on the choices made by farmers. Some vets have taken the knowledge from the Thise project and other research results to heart so that the reduction in the use of antibiotics has become a general trend. (Helle Sievertsen)*

*The vets have joined the initiative to reduce the consumption of antibiotics. We also discuss between us which antibiotics have an effect on the cows. The cows that are not receptive or who are resistant to treatment are put out to grass. The knowledge we have on reducing antibiotics in organic cows is now being passed on to the conventional farms. (Ida Ringgaard)*

### Comments on forage quality:

The importance and value of forage in the production is evident from the following comments:

*Had we not had the benefit of the new knowledge in the period, the 10% lower yield would have corresponded to 1000-1200 kr. per cow-year. (Søren Lykke Jensen)*

### Comments on protein supply:

*On this issue we are well-informed, but much is still on a trial basis. The dairy farmers are definitely interested in finding alternatives that can compete on price – it is an interesting topic. At the advisory level, we discuss how far we can get with the protein in the forage we have available. (Helle Sievertsen)*

*We have made advances with broad bean, lupine and peas. It is still a relatively new area, but the question is still whether the quality is good enough. (Søren Lykke Jensen)*

*Now that self-sufficiency is an important issue for organic farmers, the blend and stability of the protein supply has become an important part of self-sufficiency. The scientists can therefore take a good deal of the credit for where we are today. (Kirstine Lauridsen)*

### Comments on consumer perception of organics:

#### On milk with healthy compounds:

*Organic farming has benefited from the consumer perception – certainly more than we have been able to directly use it in our advisory work. (Helle Sievertsen)*

*This is not something I use in my work as such, but both producers and I are pleased to work with something where this is the case and health is an important part of the core values. (Aase Holmgaard)*

#### On the question of herb content:

*The herbs are a kind of spice condiment to the feed although the effect is difficult to quantify, but it has been a good marketing feature. (Søren Lykke Jensen)*

#### Generally:

Several of the local consultants mentioned the dialogue with the scientists as an important aspect:

*The DARCOF projects have been the place where we have been able to experiment within organic farming and obtain new knowledge. (Søren Lykke Jensen)*

When the five local consultants rate the importance of the last 15 years of research and development, they arrive at the following average evaluations:

- ▶ Without the current knowledge on forage quality, the income per dairy cow would have been 15 % lower than present level (average of responses).
- ▶ Without the current knowledge on how to maintain good udder health, the income per dairy cow would have been 15 % lower than present level (average of responses)
- ▶ Without the initiatives to minimise the use of antibiotics in dairy herds, the consumption would have been 14 % higher than present level (average of responses).



### Research in organic pig production – responsiveness and creativity

Within organic pig production, the specialist consultant at VFL, Tove Serup, estimates that the challenges primarily have been:

- ▶ Fodder
- ▶ Mortality
- ▶ Animal welfare
- ▶ Sale/economy
- ▶ Meat quality
- ▶ Environmental impact

In her opinion, the research has made a contribution specifically within health and welfare. Table 4.4 lists her view of the challenges in organic pig production in the 1996-2010 period, the extent to which they have been solved, and whether she believes that the research in the DARCOF I-III and CORE Organic programmes has contributed.

Tove Serup graded her answers on a scale from 1-10 where:

- ▶ 1 = no progress has been made since 1996
- ▶ 10 = the challenge has been solved

On **mortality and welfare** Tove Serup, consultant at VFL, says that a considerable amount of work has been done to reduce mortality and increase welfare, but it has barely been implemented yet.

Table 4.4. Organic pig production: Summary of challenges, solutions and contribution from research

Challenge	Success rating	Effects/changes at farm level	Did research <sup>1</sup> contribute?
Welfare generally (Boars)	8 (0)	Increased focus on - early treatment - culling - 'read' behavioural changes in herd - control of worms	Yes
Product differentiation in meat	4	- finishers on grass/Jerusalem artichokes - breeding	Yes
Mortality	4	- more systematic management - vaccination - attention	Yes
Environment	3	- crop rotation in enclosures - willow and poplar in enclosures	Yes
Balanced fodder	2		Yes
Marketing	-		No
Security of feed supply	-		No

<sup>1</sup>Research is here understood as the DARCOF I, II and III and the CORE Organic programmes

On **consumption of antibiotics and disease** Tove Serup explains that the organic farmers generally have a low use of antibiotics, but that it has been a challenge to prove that organic pig production has a future. So it has been really useful that research has been able to clarify this, she says.

On **product differentiation** the consultant acknowledges that there is no difference in flavour between organic and conventional pork. In addition organic pig meat is tougher, but research has in respect to this focused on identifying cause and effect.

**Generally**, on research in organic pig production, Tove Serup says:

*In general, I would say that research has done a good job and shown creativity, for example with energy crops in pig pens or finishing pigs on grass and Jerusalem artichokes. The scientists should also be applauded for inviting people from the outside to give input to ideas and methods of testing.*

*... even though research may not have solved all the challenges, the process must of course continue, including the collaboration.*

### Research in organic poultry – producers have applied the knowledge

In organic poultry production, the specialist consultant at VFL, Niels Finn Johansen, identifies animal welfare and behaviour, and economy and environment as the largest challenges. He has this to say on the development:

*In the beginning, the organic egg producers took the same care of the animals as in conventional productions, but an organic production requires a higher input, and*

*producers today have acquired this knowledge and are now professional.*

The areas where research has primarily contributed solutions in the 1996-2010 period are, according to the consultant, the following:

- ▶ Nutrient uptake in chicken yards
- ▶ Parasites
  - ▶ Poultry mites
  - ▶ Intestinal worms
- ▶ Behaviour/welfare
  - ▶ Welfare assessment system
- ▶ Fodder and feeding
  - ▶ Large project under the DARCOF programmes on egg flavour and quality and on egg yields

The largest challenges in organic poultry production, whether they have been successfully solved, and whether the research has contributed have been listed in Table 4.5, and Niels Finn Johansen has graded his answers on a scale from 1-10 where:

- ▶ 1 = no progress has been made since 1996
- ▶ 10 = the challenge has been solved

The interviewer asked whether it was possible to evaluate the impact of these aspects on the economy, animal welfare, environment and regulation of organic egg production. Niels Finn Johansen thought that this was difficult, but gave an estimate of the effect compared to a situation where the practice had not been altered:

#### Disease:

The changes/improvements to practical disease prevention have resulted in an increase in yield of up to 100%, according to Niels Finn Johansen.



**Behaviour:**

**Huddling**, where the birds at the bottom of the pile die due to suffocation when other birds hop on top of the pile, can – according to the consultant – be divided into two types of challenge, namely huddling as an expression of fear, which is no longer a large problem, and huddling because of social behaviour, which has been and continues to be a problem that is difficult to solve. The changes to practice that have taken place regarding huddling due to fear are estimated to have resulted in a 25 per cent higher yield.

**Cannibalism:** Here it is difficult to estimate the size of the loss, but when there are incidents of cannibalism, the producer loses money because of dead chickens, a lower production and the additional cost of buying a protein-rich feed supplement.

Research has helped develop new projects, for example on ammonia emission and nutrient leaching, which Niels Finn Johansen refers to in the following (the projects referred to are not under the DARCOF programmes).

**Ammonia emission:**

Niels Finn Johansen explains: For ammonia emission the removal of manure has had a large impact. Previously, the manure remained in the production unit throughout the

production period, where the recommendation now is that the manure is regularly removed – this reduces ammonia emission from 40% to about 15% of the nitrogen in the manure.

The consultant adds here that this change in practice requires an investment in a new system, which is why only about 50% of the organic egg producers have made the investment necessary to regularly remove the manure. Another initiative is to add collected rainwater to the manure to make it into a more watery substance (slurry).

**Nutrient leaching:**

A collection ditch filled with mussel shells is established in an adjacent area, from where water and nutrients are pumped to a willow copse.

- A copse is established (willow, poplar and other cop-pices)

Niels Finn Johansen explains that moveable pens used to be a requirement (the chicken yards are moved to a new location every year, whereafter the area is typically sown to a cereal crop), but that leaching of nutrients can take place from the yards over the winter, which is why perennial crops are preferred. It is not yet clear how large the reduction in N leaching will be.

Table 4.5 Organic poultry production. Summary of challenges, solutions and contribution from research

Challenge	Success rating (average) <sup>1</sup>	Effects/changes at farm level	Did research <sup>2</sup> contribute?
<b>Disease:</b> Erysipelas and Pastorella (8) <i>E. Coli</i> (7)	8	Vaccination Reduced infection pressure For <i>E. Coli</i> : avoid stress  Feeding Good indoor climate Avoid damp litter Avoid dust	Yes
Predators	5		?
<b>Behaviour:</b> Huddling: reaction to fear (7) Huddling: social behaviour (1) Feather-pecking (6) Cannibalism (9)	6	<ul style="list-style-type: none"> <li>• Stable physical surroundings and management</li> <li>• Due diligence</li> </ul> Consistent management over time (feeding, etc.) Stable climate control <ul style="list-style-type: none"> <li>• Optimal nutrition</li> <li>• Stimulating environment</li> </ul>	Yes
Economy	9	Market opportunities have controlled the size of the production; experiments with own packaging facility	?
Ammonia emission – from housing	8	Chicken manure regularly removed from housing Manure best stored as slurry	?
Nutrient leaching from chicken yard	6	Chicken yard as paddock grazing Chicken yard in combination with perennial crops	Yes

<sup>1</sup>Research is here understood as the DARCOF I, II and III and the CORE Organic programmes

<sup>2</sup>Figures in brackets in left-hand column are ratings for individual parameters.

### 4.3 Impact of research on industry

In order to assess the impact of the contribution of organic research within the processing and sale of organic products, a joint questionnaire was prepared to gather the opinions of key persons from relevant processing companies.

The questionnaire had the following four general questions:

1. Has organic research contributed to the growth and market potential of the company?
2. Has organic research contributed to the development of new production processes and products?
3. If yes to 2, which effect has it had on the turnover of the company?
4. How has organic research contributed to the stable supply of commodities, the economy of the primary producers and focus on welfare and use of antibiotics?

Under the individual questions, a number of topics were listed for inspiration. Respondents were also given the option of adding their own comments.

For all questions, the respondent was asked to assess the contribution from research by choosing one of four categories: "to a high degree", "to some degree", "to a lesser degree" and "not at all".

#### Companies

Questionnaires were sent to 15 key persons in 15 processing companies. The list below shows the companies that returned the questionnaire.

Company
Arla Foods (Dairy)
Danespo A/S (Seed and ware potatoes)
DLG Food (Plant products, food service)
Friland (Slaughterhouse)
Thise Mejeri (Dairy)
Søvind Mejeri (Dairy)

Arla Foods announced that their code of practice on the integration of organic principles throughout the concern and the partitioning of its organisation into different areas and divisions with respectively marketing, product development, export, contact to supplier, etc., made it difficult for one person only to answer the questionnaire on behalf of the company.

To question 1 on whether organic research has contributed to the development of the organic market potential, Thise answered "to a high degree", while Arla, Søvind Mejeri and Danespo answered "to some degree". Friland answered "to a lesser degree". Friland had the following comment under this point:



*“Research into and the subsequent development of the primary production has been instrumental in placing us in a very advantageous competitive position. It is difficult to quantify the effect, but there is no doubt that it has contributed to turnover and growth.”*

To the question on the impact of research on the turnover of the company, most of them responded “to a lesser degree”.

On question 2, there is general consensus that research either “not at all” or “to a lesser degree” has contributed to the development of new production processes in the company. In contrast, research has “to some degree” had an impact on the development and sales of new organic products in the smaller companies. This is true for Thise Mejeri, which gives examples of products such as ‘Vestershavsost’ and ‘Himmerlandsmælk’, and for Danespo for the development of potatoes.

To question 3 regarding the impact of research on company turnover, it was clear that when the response to question 2 was that research only “to a lesser degree” or “to some degree” contributed to the development and sales of products, then the influence on company turnover would likewise be limited.

To collect information on the indirect contribution of research to company development, question 4 refers to the importance of both supply and quality of the primary products. Here two of the companies end up at opposite ends of the scale, namely Søvind Mejeri and Thise Mejeri. Søvind Mejeri explains, that their production is based on organic goat milk and they do not believe that research has been involved or been active in the development of this niche

production. Thise Mejeri, on the other hand, has based its raw materials supply on cows’ milk and believes that the organic research “to a high degree” has contributed to a stable supply of high-quality milk.

Likewise, has research been important for processing companies’ focus on various environmental and animal welfare topics such as grazing, consumption of antibiotics, castration, tail-biting, or provided inspiration for the development of quality and control standards on Arlagården.

## Conclusion

Despite the small number of processing companies responding, a picture has emerged that the contribution from research primarily has been of an indirect character for the companies.

The companies are aware of the broader contribution from research in the area of the general development of the organic market and its focus on animal welfare and environmental standards. There is likewise a clear acknowledgment that research has helped ensure a stable supply of primary products of a consistent quality.



#### 4.4 Research impact on government institutions and private organisations

A joint questionnaire was prepared in order to collect comments from key people within the relevant government institutions and non-governmental organisations (NGOs) on the contribution of organic research to the development of the organic sector. The questionnaire had three main questions:

1. What in your opinion have been some of the largest societal and consumer issues that the organic sector has dealt with in the period 1996-2010?
2. To what extent do you believe that the results from organic research have contributed to solving the above issues?
3. To what extent do you estimate that research-based knowledge has been useful within your field of work and in relation to the chosen topic areas?

Under question 1, seven topics had been entered for inspiration: Animal welfare, environment, climate, legislation, sales, consumers, and "other topic".

Under question 2, respondents were asked to assess the contribution of organic research to the solution of issues within the above seven topic areas by rating them into one of four categories: "to a high degree", "to some degree", "to a lesser degree" and "not at all".

Under question 3, the respondents were also asked to assess how useful the research-based knowledge had been within their field(s) of work.

#### Governmental institutions

Questionnaires were sent to five persons in four governmental institutions:

Governmental institutions
<b>Etisk Råd:</b> The Danish Council of Ethics The Council advises and creates debate on biotechnology that affects human life, nature, the environment, and food.
<b>Fødevarestyrelsen:</b> The Danish Veterinary and Food Administration (DVFA) is responsible for food safety and health from farm to fork.
<b>Miljøstyrelsen:</b> The Danish Environmental Protection Agency is the advisory and legislative arm of the Ministry of the Environment.
<b>NaturErhvervsstyrelsen:</b> The Danish AgriFish Agency guides, regulates and controls the green development of the Danish food sector.

The respondents from the two governmental institutions most involved in the legislation in the organic sector at national and international level (The Danish AgriFish Agency and The Danish Veterinary and Food Administration), have not completed the questionnaire, but instead sent emails with comments that were subsequently expanded on in a telephone interview.

Malene Kjer Andersen, The Danish AgriFish Agency (formerly the Danish Plant Directorate), drew attention to the fact that the organic farming area is regulated by common EU regulations and being the reason why Danish organic



research does not directly have an influence on the legislative process. She explained that proposals for changes to EU organic farming regulations normally take place at the initiative of the users, i.e. the organic farming organisations, but that these often use research results to underpin their proposals. Thus, you could say that there is an indirect use of the research results in the development of legislation within the organic sector. Organic research also generally contributes new knowledge and helps to identify new opportunities that can be an inspiration for both a green conversion and for growth in the agricultural sector. It was also her impression that organic research in Denmark was highly regarded for its professional approach and that this has led to the initiation of many international research projects that have had a wider impact on the organic sector.

Lisbeth Landstrøm, from the Chemistry and Food Quality section at the Danish Veterinary and Food Administration, referred to the general mechanisms for conception of legislation at EU level in the organic sector, as also explained by The Danish AgriFish Agency. It was moreover the opinion of Lisbeth Landstrøm that the completed research projects had not been directly relevant for the regulated areas in the EU organic regulation in terms of the processing and marketing of organic foods.

The organic research and development can, however, be important for food security, for example in relation to the risk of pathogens and parasites in meat and eggs from free-range pigs and poultry and the transfer of pathogens and parasites from animal manure to vegetables. Lisbeth Landstrøm, therefore, forwarded the questionnaire to the department of Food and Feed Safety. Annette Perge, Food and Feed Safety, had the following comments:

*"We have not yet used the research results in the projects mentioned for the preparation of new legislation in the food security area, but we expect to do this in connection with our initiative to improve the food security of fruit and vegetables. Particularly would the issue of using animal manure in the organic production of vegetables and associated risk of the incidence of pathogenic bacteria be relevant for us."*

Completed questionnaires were received from respondents in the Danish Council of Ethics (Anne Lykkeskov), The Danish AgriFish Agency (Morten Lautrup-Larsen) and the Environmental Protection Agency (Helga Hjort).

The most important societal and consumer aspects that the organic sector has been dealing with in the period 1996-2010 were identified and categorised into six topic areas:

Helga Hjort, Environmental Protection Agency, also mentioned that the knowledge synthesis was a good compendium covering a wide range of areas.

The three respondents from the government institutions agreed that the organic sector has been addressing important issues within the two topic areas of Animal welfare and Environment in the period 1996-2010.

To the question on the degree to which they believed that the results from organic research had helped solve the problems within the different topic areas, the respondents gave the following ratings of the effects:



Topic	Danish Council of Ethics	Environmental Protection Agency	The Danish AgriFish Agency
Animal welfare		Knowledge of the natural behaviour of animals with a view to adapting systems to give the highest possible animal welfare while protecting the environment.	Find solutions to the bones of contention in organic farming relating to animal welfare.
Environment		E.g. nutrient budgets and nutrient leaching, comparison of conventional and organic farms, biodiversity and comparative analyses.	Document environmental benefits of organic production (credibility).
Climate	Danish Council of Ethics has mainly been occupied with climate change in recent years where the organic ideology does not have as much of a role to play as in environment and animal welfare issues.	Effects on climate at different crop management methods, etc.	
Legislation		Knowledge of the above	
Marketing			Potential to increase demand for organic products.  Ensure a more uniform EU market for organic products.
Consumers			Reasons why consumers choose organic products and what is the instrument to increasing demand.



The three respondents generally agreed that the organic research “to some degree” or “to a high degree” had helped solve the problems within the areas of Animal welfare and Environment. The effect on Marketing had been “to some degree”, while the effect in the areas of Climate, Legislation and Consumers was somewhat less (“to a lesser degree” or “to some degree”). The Danish Council of Ethics has also specified a large effect within the food quality area.

The two respondents from the Environmental Protection Agency and The Danish AgriFish Agency, respectively, replied to the third question on the degree to which research-based knowledge has been useful within their own field of work and in relation to the chosen topics.

Helga Hjort, Environmental Protection Agency, found that research-based knowledge “to a high degree” has been useful within her area of management and policy development.

Morten Lautrup-Larsen has “to some degree” benefited from research-based knowledge within environmental legislation in agriculture, particularly in the livestock area.

Private independent organisations (NGOs)  
Questionnaires were sent to ten persons in seven NGOs covering organic farming and consumer interests, nature and environment and animal welfare interests. The reason for questionnaires being sent to more than one person in some of the organisations is that these persons cover more than one topic area, and they will therefore be able to elucidate different aspects of the above-mentioned topics.

Six respondents from five of the seven private organisations replied:

Organisation
<b>Aktive Forbrugere</b> (Active Consumers – a green consumer organisation promoting the production of eco-friendly products)
<b>Danmarks Naturfredningsforening</b> (The Danish Society for Nature Conservation – works for a sustainable society with a rich and diverse nature and a clean and healthy environment)
<b>Landbrug og Fødevarer</b> (Danish Agriculture and Food Council – a private trade organisation whose purpose it is to strengthen the political and commercial interests of farmers and the food industry)
<b>Udviklingscentret for Husdyr på Friland</b> (Friland – Organic and Free-range Meat [owned by Danish Crown] – aims to increase free-range production under sustainable conditions and high animal welfare)
<b>Økologisk Landsforening</b> (Organic Denmark – organises organic farmers, companies and consumers in order to strengthen and development the organic production of foods).

The most important topics for the organic sector for the period 1996-2010 according to the replies received from the NGO representatives questioned.



Topic	Active Consumers	Danish Society for Nature Conservation	Danish Agriculture and Food Council	Friland – Organic and Free-range Meat	Organic Denmark	
					Sybille Kyed	Henrik Hindborg
<b>Animal Welfare</b>	Culling of newborn bull calves, feather-pecking, cannibalism in organic broilers and egg production.	Clearly a priority, but the organic sector does not always appear to have the area under control.	Focus on general disease prevention and health for organic livestock – including welfare problems such as feather-pecking in egg-layers, leg problems with broilers, weaners, and calf mortality. There has been focus on improving animal welfare via production systems and to a lesser extent through selection of suitable breeds.	Strong focus on animal welfare in the period which has been characterised by the burgeoning castration debate, and by it no longer being acceptable to surgically castrate pigs without an anaesthetic or analgesic. Focus on organic production not automatically equating with optimal animal welfare. Several of the projects in DARCOF I, II and III and in CORE Organic have addressed this problem, which has helped to remove some taboos.	Animal welfare, particularly in organic poultry farming. Lower consumption of antibiotics for cattle – also relevant in relation to product quality and consumers.	Important to constantly challenge the regulations for animal welfare for the individual production sectors to ensure a high standard.
<b>Environment</b>	Point-source pollution from chicken yards; general utilisation of fertilizer.	Environment, climate, nature are all subjects that crop up in connection with organic farming. How can the organic sector deliver yet more services? Unfortunately we have not yet succeeded in getting a majority of politicians or scientists to accept the basic premise that organics is a package that delivers on a number of fronts and therefore overall is a common good, but where there can be significant differences in individual parameters between organic and conventional production.	Focus has primarily been on the aquatic environment and protection of groundwater. Particularly nutrient balances and potential N-leaching have been under scrutiny.	Good and important focus on nitrogen issues, which has defined the debate.	Organic farming as a tool to reduce N-losses. Figures from organic livestock farming show the virtue of organic methods. Sewage sludge and human urine as fertilizer in organic fields. N-loss from free-range pig production and minimum distances to neighbours for outdoor productions. GMO and spread to neighbouring areas.	The environmental policy of using no synthetic pesticides or fertilizers is very important for the organic movement. It is important that the organic production evolves and preferably also incorporates other environmental aspects.



Topic	Active Consumers	Danish Society for Nature Conservation	Danish Agriculture and Food Council	Friland – Organic and Free-range Meat	Organic Denmark	
					Sybille Kyed	Henrik Hindborg
<b>Legislation</b>		Much focus on EU legislation in relation to, for example, the Danish regulations in organic farming.	Development of organic legislation both nationally and at EU level so that the organic production comes across as both profitable and efficient, credible and conforms with the organic principles. There has been a degree of focus on the harmonising of organic legislation in the EU and the free movement of goods. Parts of the organic sector have used many resources on preparing, developing and adapting EU organic regulations.	In the 90's, there were virtually no livestock regulations at EU level. The period has therefore been characterised by a certain adaptation to the EU regulations and the somewhat more rigid administration from having regulations both at the EU, DK and association level. Several projects have dealt with the differences and similarities in the interpretation of the EU regulations in different countries, which has been good.		Harmonisation of the organic regulation within the EU and the introduction of regulations for organic non-food products. Important how the regulations are updated within the individual productions and that the flag is kept flying for the organic regulatory framework, so that consumers' more factual arguments for choosing organic products are backed.
<b>Marketing</b>	Considerable focus on mainstreaming organics in the supermarkets and on making organic products a standard option in the product range.	Both the domestic market and export have been intensively discussed throughout the period. - should the organic sector be driven by demand or by regulations? The most important target, from the DN point of view, is that those who get the largest subsidies are the producers (primary or processing), who have the most eco-friendly production, and that any taxes are charged to the polluting products or productions.	The marketing of organic goods has undergone a significant development in the period – probably mainly because of the development of the companies and the retail sector.			A strengthening of the marketing of organic foods is crucial for the expansion of the organic sector. The organic companies have close partnerships with, amongst others, the Danish Organic Association on campaigns and other joint promotions.
<b>Consumers</b>	Telling the story of the product – creating closer relations with consumers.	A bit difficult to spot the consumer in the debate – and particularly the question of what is needed to get people to choose organic products could do with closer study.	Much focus on the credibility of organic production and on which factors to ring-fence to maintain consumer trust in the organic production. Studies of consumer behaviour and market segment analyses have likewise had an impact on product development.			Important that consumer trust in organic production is high. Consumer knowledge of organics and the advantages of the organic production form is crucial for the continuance and expansion of their support for the organic ideals.

**Other important topics identified by the organisations questioned as having had an impact on the organic sector in the last 15 years:**

Food quality and the continuing discussion on the health aspects of organic farming. Also conversion, pricing and the economy of individual farms were identified as important focus areas.

Henrik Hindborg from the Organic Denmark also had the following comment on the importance of research in relation to Consumer: *Knowledge of the consumer of organic products is crucial. Research could have a larger role to play here if there was a bit more focus on new data and faster reaction/completion times for research activities.*

Similar to the respondents from the government institutions, there is general agreement that the organic sector in the period 1996-2010 has been involved in many important aspects within the areas of Animal welfare and Environment. Within Animal welfare, particularly the welfare problems associated with poultry production get a high score, and within Environment, particularly the nitrogen issues are mentioned. For the other topics, the comments are more wide-ranging and influenced by which organisation the respondent is working for. There is, however, generally agreement that legislation, including the harmonisation in EU countries, and marketing have been very important aspects for the organic sector and several respondents also mention credibility vis-à-vis the consumer as an important area. Under the other subject areas, the following aspects were mentioned as also having been important in the period: Health and food quality, expanding the conversion

to organic farming, the importance of the financial crisis for the development of the organic sector, including the improvement of production economy and sustainability.

On the question of the degree to which the results from organic research have contributed to the solution of problems within the various topic areas, the respondents have rated the effect.

All six respondents replied to the third question of how useful research-based knowledge has been within their own field of work in relation to the identified subject areas.

Jeppe Juul, Active Consumers, found that the research-based knowledge "to some degree" had been useful within his working area of Consumers, while within Climate and Health he had found it to be useful "to a high degree".

Rikke Lundsgaard found that research-based knowledge "to some degree" had been useful within her areas of Environment, Climate and Nature.

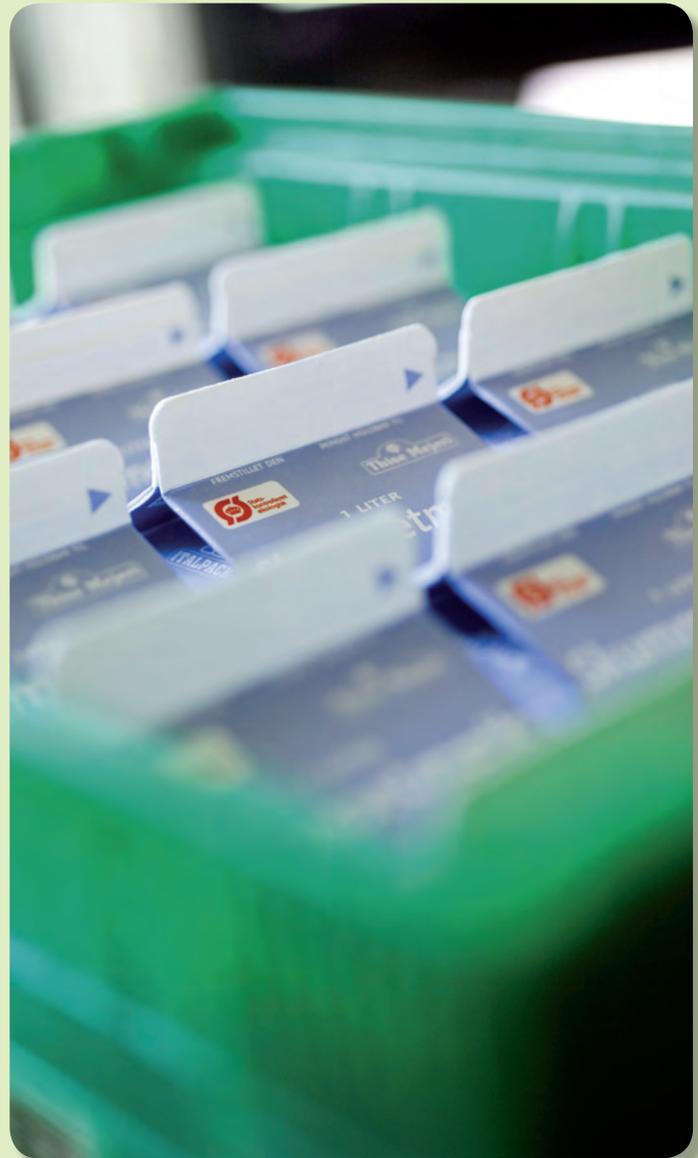
Lars Holdensen, Danish Agriculture and Food Council, has "to a high degree" drawn on research-based knowledge within his field of legislative work and lobbying.

Simme Eriksen, Friland – Organic and Free-range Meat, has "to a high degree" been able to use research-based knowledge in her work which involves teaching Organic animal husbandry and Production growth in animal husbandry, and has also "to some degree" benefited from research-based knowledge within the Climate impact of organic husbandry. Sybille Kyed, Organic Denmark, has "to a high degree" been using research-based knowledge within her expert



areas of Action Plan for the Aquatic Environment, Poultry welfare and GMO co-existence.

Henrik Hindborg has “to some degree” benefited from research-based knowledge within his job (Knowledge about organic consumers, Marketing-oriented work – the Danish model for a market-driven development of the organic sector, and within Food service), where there has been a good and close collaboration with the sector on the generation and dissemination of knowledge about organic products in commercial kitchens – including “best practice”. He has also “to a lesser degree” been able to utilise the research-based knowledge about differences/similarities between consumers across national borders. Henrik Hindborg made the comments on the knowledge relating to consumers of organic products, that it is useful but takes far too long to be generated, and that it is now a very long time since there has been any new knowledge on consumer differences and similarities in the different countries and their attitudes to organic products and motivation for buying organic products.



# Chapter 5. Knowledge transfer

This chapter gives an overview of the transfer of knowledge from organic research addressing primary production, the extension service, scientists and other stakeholders. The Knowledge Centre for Agriculture (VFL) will regularly bring consultants up to date with the latest knowledge via the internetbased LandbrugsInfo. DARCOF/ICROFS have also in all the research programmes initiated the dissemination of knowledge via their own and other media. Transfer of project results has taken place both via scientific publications, via trade journals, the web and by direct communication at meetings, seminars, field visits, etc.

## 5.1 Landbrugsinfo

The LandbrugsInfo database contains expert knowledge with its store of more than 100,000 articles of information which covers anything from experimental results and analyses to the interpretation of regulations. LandbrugsInfo is primarily used by consultants in the advisory service, who in turn pass this information on to the farmers. The database that has 27,000 page referrals per day and about 55,000 visitors per week is divided into roughly 700 subsections.

A search has been made on the LandbrugsInfo pages using different key words relating to organics. The numbers of articles found with clear references to results originating from DARCOF I-III and CORE Organic are listed in Table 5.1. However, not all articles in LandbrugsInfo contain a pre-

cise reference to the source of the programmes. There are therefore likely to be many more articles in LandbrugsInfo than those listed in Table 5.1 where the knowledge is based on the research programmes. An example is an article on the control of perennial weeds from the WEEDS project in DARCOF III, where neither the project, nor the programme or ICROFS are mentioned in the article.

The search method therefore has the drawback that it is mainly articles with references to projects where DARCOF, ICROFS or CORE Organic are mentioned that have been included in the search results.

LandbrugsInfo is also used to advertise farm days and open-day arrangements at the organic research sites and workshops where research results are presented (typically in collaboration with VFL), and the website often has references to DARCOF newsletters and web pages. These announcements have been omitted from the listing below unless they contained additional technical information. It is important to point out, however, that such arrangements have served to show the constructive cooperation on the communication of research results between on the one side DARCOF/ICROFS and research projects and on the other the Knowledge Centre for Agriculture and LandbrugsInfo. It is not always easy to divide the articles into themes, as some of the themes naturally overlap. If you look at the main focus of the articles directly referring to the DARCOF or CORE Organic programmes, they can be categorised into the

Table 5.1  
Example of number of articles from LandbrugsInfo directly referring to DARCOF or CORE Organic programmes, divided into thematic areas

Theme	Number of articles
Dairy/milk	15
Pigs	15
Poultry	4
Cultivation systems	53
Society/environment	2



same thematic areas as the projects in the other chapters, as shown in Table 5.1.

There are articles in LandbrugsInfo on all the production challenges within the areas where research (according to the consultants) has helped solve the challenges, see Chapter 4. At least 19 articles have been found, for example, on nutrients in crop production, nine on seed production and six on weed control. Section 5.3 gives a detailed picture of the extent of dissemination from a central area in crop production.

The following are examples of articles from LandbrugsInfo directed at consultants, where research results have been processed:

From DARCOF I: Storage, composting and use of deep bedding. Reference to results of project that looked at nitrogen losses in deep bedding with different types of storage and land application compared with slurry.

From DARCOF II: Use cover crops in organic farming: Preliminary results show that overwintering nitrogen-fixing cover crops on a sandy soil give the highest yields in spring barley the following year. In the actual experiment, red clover and white clover performed best and supplied nitrogen to the following crops corresponding to 80 kg N per ha in synthetic fertilizer.

From DARCOF III: Hydrated lime can cause burns. Hydrated lime has an effect on digital dermatitis but can cause burns.

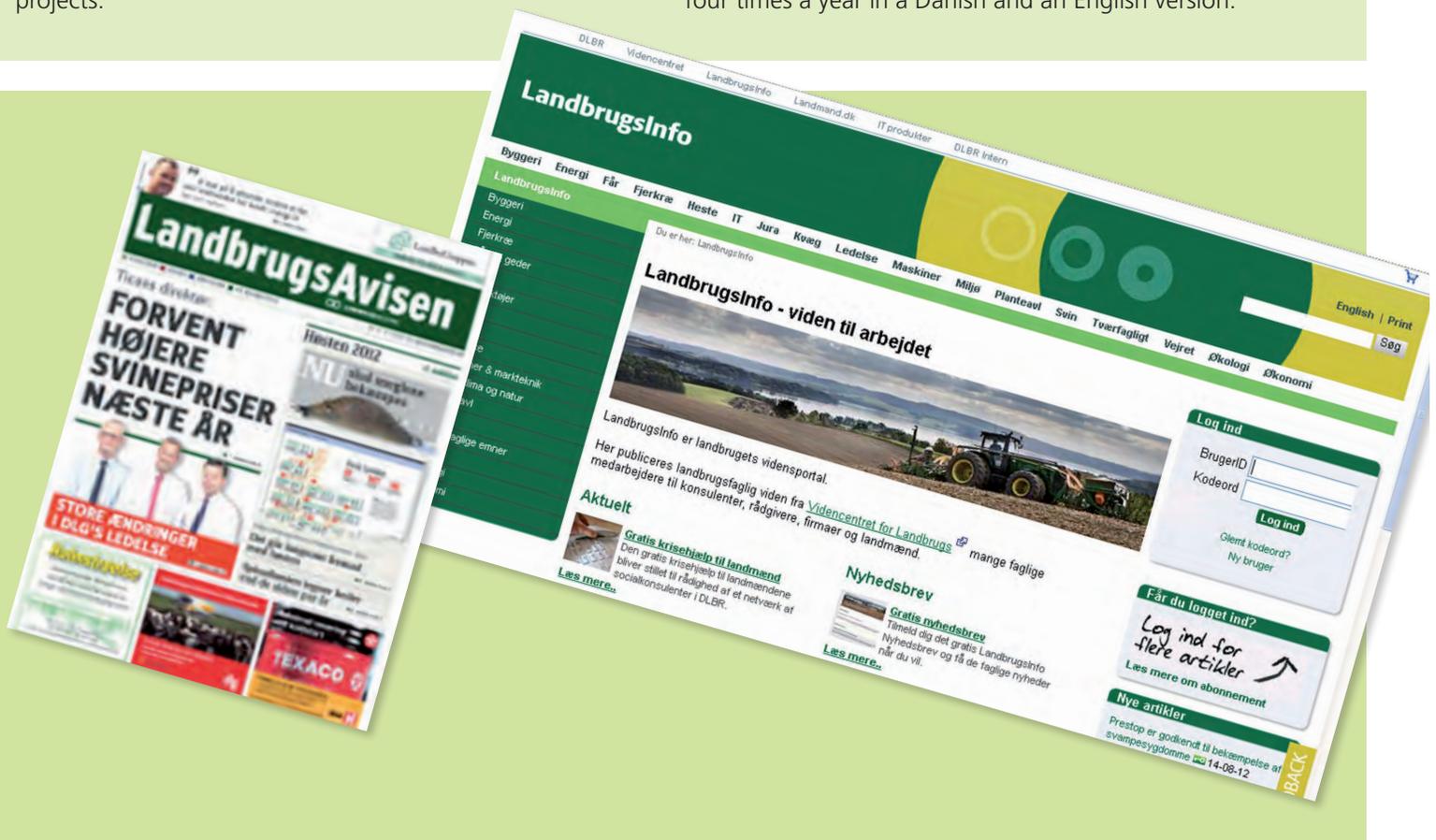
As previously mentioned, there are numerous other articles that contain results from DARCOF and CORE Organic projects.

## 5.2 Knowledge transfer at ICROFS

One of the purposes of ICROFS is to help communicate the research results and practical applications to the organic sector, including organisations, commercial enterprises, authorities and partners in- and outside the country. On this background, ICROFS publishes its own newsletters both in Danish and English, and collaboration agreements have been set up with external media, including the newspapers Økologi & Erhverv and Landbrugsavisen on the writing of, respectively, columns, technical features and brief notes in collaboration with scientists. ICROFS also produces books and reports on the results from research projects and has also authored a number of scientific reviews on central topics in organic farming and food systems (Table 5.2). ICROFS also creates information pamphlets and posters that describe individual research programmes and projects. The centre has also published a series of fact sheets in English summarising the results from research in organic farming and food systems. ICROFS is finally an active co-organiser of a conference on organic farming (Økologikongressen) held every other year (Table 5.3). In the following sections you can read about the different dissemination products and activities.

### Newsletters

One of the purposes of the electronic newsletters ICROFSnyt and ICROFSnews (formerly FØJOenyt and DARCOFenews) is to brief on aspects of research, on new publications and results, seminars, farm days and other arrangements. In this way the newsletter strengthens dialogue and interaction between agriculture, food production and research, both nationally and internationally. The newsletter is published four times a year in a Danish and an English version.



### Flyers and project websites

ICROFS designs flyers for individual research programmes and projects and also creates project pages on the ICROFS website, [www.icrofs.dk](http://www.icrofs.dk), where project aims, activities and results are published.

### Columns and articles in printed media

Columns are for short and often more personal contributions on the research in organic farming and food systems. The columns are written in the fortnightly paper "Økologi & Erhverv". ICROFS also teams up with scientists to deliver articles and notes to Landbrugsavisen on newsworthy aspects of the research projects in organic farming and food systems. The articles are published under the 'academic background' in Landbrugsavisen once a month. For a number of years DARCOF also assisted with the editing and preparation of the Nordic journal, Forskningsnytt om Økologisk Landbrug i Norden, which aspired to communicate research results and news on research-related activities.

### Books and reports

In order to synthesise the research in the different disciplines and in this way contribute to a balanced and holistic communication, DARCOF published a separate series of

reports. Biennial reports were also prepared under DARCOF I together with a large number of internal reports. Two large compilations of results from DARCOF II, DARCOF III and CORE Organic have subsequently been prepared. All books and reports are available from [www.icrofs.dk](http://www.icrofs.dk).

### Knowledge syntheses

Knowledge syntheses play an important role in the development and communication of research taking place in ICROFS. A knowledge synthesis analyses, discusses and summarises existing knowledge on an unsolved and often widely debated topic from its main perspectives.

The latest knowledge synthesis from ICROFS, "Development, growth and integrity in the organic sector" was prepared at the instigation of the Ministry of Food, Agriculture and Fisheries and consisted of a thorough mapping of the Danish organic sector in collaboration with a number of scientists and representatives in the sector. This knowledge synthesis has recommended five important areas of action to secure the future organic market: a strengthening of the positive dynamics in processing and sales; boosting the conversion to organic farming; strengthening and maintaining consumer trust; creating synergy between organics and society and to meet the large demand for new knowledge. (See list of completed knowledge syntheses in Table 5.2.)

Table 5.2 Knowledge syntheses produced by ICROFS in the period 1996-2010

Knowledge syntheses
Development, growth and integrity in the Danish organic sector
Nitrogen leaching and N-balances in conventional and organic production systems
Health, welfare and medicine consumption at conversion to organic milk production
Challenges, opportunities and limitations in organic pig production
Nature quality in organic farming
Groundwater protection at conversion to organic farming
Organic foods and human health
Processing of cereals and pulses and seed production in organic farming
Implications of GM crops for organic farming
Reduction of fossil energy consumption and production of renewable energy in organic farming
Global development of Organic Agriculture: Challenges and prospects
Opportunities and barriers for the continued development, growth and integrity in the Danish organic sector



## Organic eprints

In 2002, DARCOF created an electronic archive for publications on organic farming research – Organic eprints ([www.orgprints.org](http://www.orgprints.org)). This is being used for storing all the publications stemming from the DARCOF II and III and CORE Organic projects, which makes project publications easy to locate and retrieve. But it has also become an international archive and now contains nearly 13,000 articles and other publications on research in organic farming from all over the world, but mainly from Europe. With a ranking as no. 50 in a rating of more than 1500 archives (July 2012), the archive is the highest-ranked agricultural archive.

## Congresses

Presentations and discussions of research are important aspects of research in organic farming. On this background ICROFS acts as a co-organiser of an organic congress (Økologikongressen) which is held every other year, just as DARCOF/ICROFS has helped present research topics at the Plant Congress, Cattle Congress, etc. ICROFS also participates in farm visits and organises workshops, both in Denmark and abroad.

## 5.3 An example of the connection between project publications and the dissemination on LandbrugsInfo

Here shown as an example is a comparison of the publications from the organic crop rotation project (which has continued through all three DARCOF programmes – although under different names) with the number of articles stemming from this project, and references thereto, on LandbrugsInfo.

On Organic Eprints a total of 215 publications on the crop rotation experiment have been archived. The projects have, however, also included other experiments, for example the organic vegetable rotation at Aarslev. Of the 215 publications, 42 are scientific peer-reviewed publications, 57 are other publications in English and 116 publications are in Danish. There has thus been a massive publishing activity, both at scientific level but also in a more popular form via other media channels.

When searching for “organic crop rotations” on LandbrugsInfo, more than 50 articles were found and a look through these reveals that all the articles are on experiments that have taken place under the DARCOF I, II or III projects. There has therefore been a wider communication of results from the experiments to the consultant over and above the Danish communications that the scientists were themselves the authors of.

Tabel 5.3  
Dissemination activities in FØJO/ICROFS since 1996.

Dissemination product/activity	Numbers since 1996
Electronic newsletters, Danish and English	75
Articles in FØJO/ICROFS news (Danish and English)	450
Books and reports	49
Columns in the newsletter “Økologi & Erhverv”	170
Articles in the newsletter “Landbrugsavisen”	40
Short notes in “Landbrugsavisen”	200
Project- and information leaflets	111
Fact sheets	4
Knowledge syntheses	13
Organic Congresses	6



## Chapter 6. Research: Programmes, funding and results

This chapter looks at the thematic areas of research projects and the distribution of funding between these areas. This is followed by a description of how research results, particularly publications, have been counted. This method is described and compared with programmes under the Ministry of Food, Agriculture and Fisheries. Finally, scientists give examples of how their research has been put to use in industry and society.

### 6.1 List of research programmes, thematic areas and grants

Three Danish research programmes (DARCOF I, II and III) have been completed under the Danish Research Centre for Organic Food and Farming (DARCOF/FØJO) which was replaced by the International Centre for Research in Organic Food Systems (ICROFS) in 2008, and an ERA-net was coordinated (CORE Organic). These completed programmes form part of this analysis, while the current research, development and demonstration programme (Organic RDD) and the new ERA-net (CORE Organic 2) do not. When DARCOF was founded, a board of directors was constituted with leaders from several research institutions as well as a user group where members were stakeholders from industry and different organisations. The user group helped to draw up the

research tenders and select the projects that were to receive funding. When ICROFS replaced DARCOF, an international board of directors was chosen but also assisted by a Danish programme committee (scientists were also represented), which continued to undertake the earlier user group's functions. In this way, industry and stakeholders have always had a large say in which areas research should focus on.

The projects in the four programmes have been divided into nine thematic areas for the purpose of this analysis. Livestock production is divided into the different types of livestock (cattle/milk, pigs, poultry/eggs and aquaculture). Crop production is divided into crops and cropping systems, fertilization and soil (shortened to cultivation systems). Thematic areas finally also include consumption, society and environment, and bioenergy.

The government's action plans I and II from, respectively, 1995 and 1999 include recommendations for the implementation of research initiatives for solving certain challenges in the sector. Table 6.1 shows the areas covered by the recommendations and the expected effects of the projects within each of the areas. The DARCOF I projects have primarily had the expected effect on primary production. The projects in DARCOF II, DARCOF III and CORE Organic have moreover had an expected effect on the



industry (processing) and on society, including environment and health, and at the consumer level, including integrity. The organic research has thus followed the general growth and development in the sector, embracing new issues along the entire supply chain.

The programme of DARCOF I was based on the recommendations of Action Plan I. As Table 6.1 and Figure 6.1 shows, the programme mainly focused on primary production. There were projects on crop production and livestock production, but also on society and environment, long-term effects of organic farming and on communication and development of research. About 100 scientists from 15 institutions took part in the projects. DARCOF II was based on the political goals in Action Plan II.

Table 6.1 and Figure 6.1 show that the focus of this programme was somewhat wider, and in addition to the themes under DARCOF I also included consumers and had a stronger focus on society and environment. About 200 scientists from 15 institutions participated. The international evaluation of DARCOF II had a large influence on the design of DARCOF III and CORE Organic, which also to a large degree were based on the suggestions of scientists. The focus was even wider in these and included the new theme of bioenergy. Approximately 200 scientists from 9 institutions participated in DARCOF III, and 11 scientists from four institutions in CORE Organic. In all three DARCOF programmes funds were allocated to coordination, communication and dissemination. In DARCOF I and II funds were also set aside for knowledge syntheses and research methodology and the training of PhD students.

*Table 6.1  
Expected effect of research projects for each programme within nine thematic areas (see text). X marks a direct effect, (X) an indirect effect. X can also include indirect effects*

Political ambition	Thematic area	Regulation & legislation	Expected effect of projects on challenges within the area				
			Environment	Primary production	Processing firms	Consumption	Professional organisations
Action Plan I	Dairy/milk			X			X
	X Pigs	(X)	(X)	X	X		X
	X Poultry/eggs			X			X
	X Crops		(X)	X	X	(X)	(X)
	X Cult. system	(X)	X	X			(X)
		Consumption					
	X	Society and environment	X	(X)	X		
Action Plan II	DARCOF II						
	X Dairy/milk		X	X	X	(X)	(X)
	X Pigs		X	X	X	(X)	(X)
	X Poultry/eggs			X	(X)	(X)	
	X Crops	(X)	X	X	X	(X)	(X)
	X Cult. system	X	X	X	(X)		(X)
	X Consumption	(X)			(X)	X	X
X	Society and environment	X	X	X	X	(X)	X
*	DARCOF III & CORE Organic						
	Dairy/milk		(X)	X	(X)	(X)	(X)
	Pigs			X	X	(X)	(X)
	Poultry/eggs			X	X	(X)	(X)
	Aquaculture			X		(X)	(X)
	Crops	X	X	X	X	(X)	(X)
	Cult. system		X	X	X		(X)
	Bioenergy	(X)	(X)	(X)	(X)		(X)
	Consumption	(X)		(X)	X	(X)	X
	Society and environment	X	X	X	X	X	X

\* No action plan

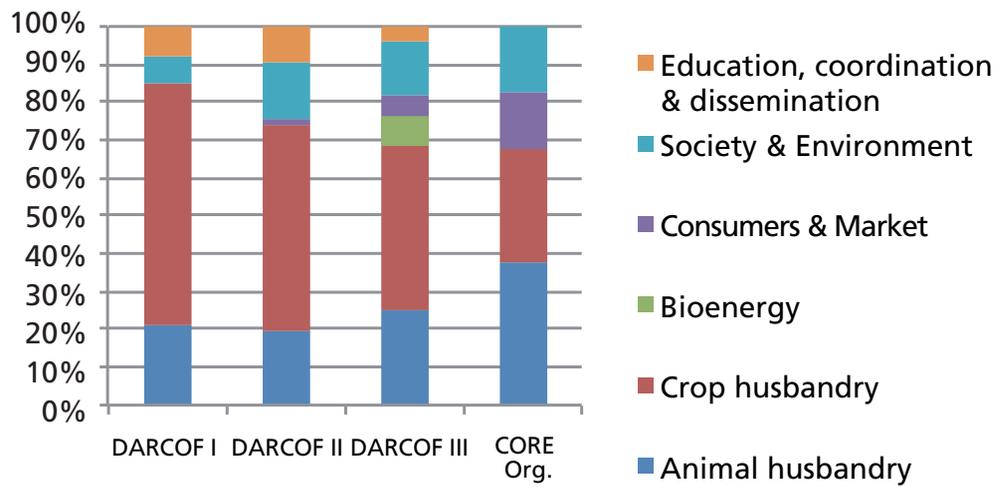


Figure 6.1  
 Programme funding divided into thematic areas. The different forms of livestock have, however, been combined as have the crop types. A full division into individual thematic areas can be found in Chapter 3

DARCOF II had the largest budget (Figure 6.2) with the budget of DARCOF III and CORE Organic combined at roughly the same level. The average annual grant per programme was for DARCOF I 25 million DKK, a little over 35 million DKK for DARCOF II, 34 million DKK for DARCOF III and a little under 5 million DKK per year for CORE Organic. For comparison, the total public spending on food research was in 2008 roughly 1 billion DKK.

By far the largest proportion of funding (65%) was spent on crop husbandry research in DARCOF I (Figure 6.1), while this share fell in the following programmes to 30-40% of, respectively, CORE Organic and DARCOF III. At approx. 20% animal husbandry received less than crop husbandry in DARCOF I and II, slightly more in DARCOF III at 25%, but takes almost 40% of the funding in CORE Organic. Society and environment received less than 10% of the grant in DARCOF I, but 15% in DARCOF II and III and CORE Organic. The

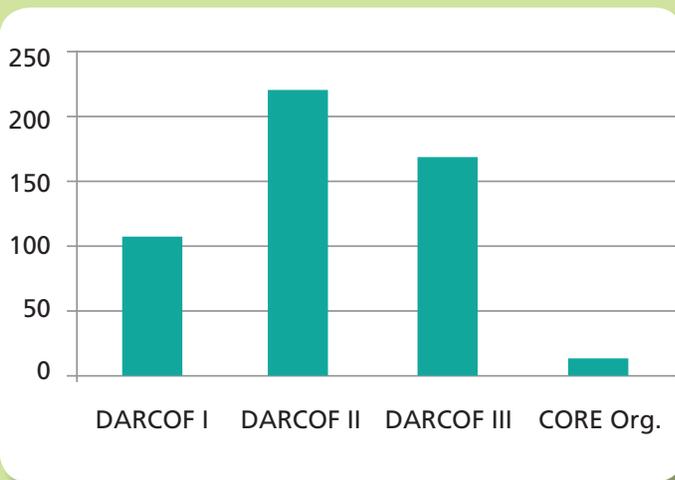


Figure 6.2  
 Level of funding for individual programmes, million DKK

consumer aspect it not included in DARCOF I; in DARCOF II it receives less than 2% of the funds, while in DARCOF III this has increased to 6% and is 15% in CORE Organic. Bioenergy is not included as a theme until DARCOF III where it received less than 10% of the funding. The expenditure allocated to education, communication and coordination was 8-9% in DARCOF I and II, but less than 4% in DARCOF III where education was no longer included but coordination and communication of CORE Organic was.

## 6.2 Quantification of research output

### Methodology for quantifying publications/products

Measuring direct research project output in the form of publications, PhDs, etc., is based on the methodology (point scoring system) devised by the Institute of Food and Resource Economics for evaluating some of the research programmes under the Ministry of Food, Agriculture and Fisheries (Table 6.2). The method counts the different outputs from the projects, which are then allotted points on a scale according to the type of output (publication, patent, completed PhDs, etc.). The indicators used for allotting points are divided into three groups: scientific significance, which includes scientific publications, books, reports, and conference contributions; embedding of knowledge, which includes education, patenting and development of methods and software, and industry and society, which includes scientific publications and presentations and other types of dissemination.

For the DARCOF II, DARCOF III and CORE Organic programmes, retrievals from Organic Eprints have been used. The procedure of retrieval, counting and point scoring is described in an internal document. A full quality control

has not been implemented, but an attempt has been made to capture clear errors such as article duplications, articles listed as journal papers that were actually published in trade journals, etc.

For DARCOF I it has not been possible to retrieve this information, as there was no requirement under DARCOF I for publications to be stored in Organic Eprints (which was not actually constructed until 2002 when DARCOF I had finished). The final reports have therefore been used to calculate the number of publications in the different categories and no points have been dispensed.

It has only been possible to achieve a comprehensive point allocation for the first indicator – scientific significance – since publications of scientific significance are the outputs most commonly archived in Organic Eprints. For imbedding of knowledge, the sources of information available in Organic Eprints are primarily PhD and MSc degrees and this figure is not exhaustive. Courses, guest lectures, patenting, method and software development are not included, or only to a very modest degree. For DARCOF II there is, however, a calculation of contributions to research education in a preliminary evaluation of research results, which is included in the assessment.

For industry and society, outputs archived in Organic Eprints are mainly in the form of publications in trade journals, while there is little in the way of lectures, newspaper articles, interviews, workshops, newsletters and websites. It is therefore not possible to make a direct comparison with the evaluated projects under the Ministry of Food, Agriculture and Fisheries. On balance, the method is, however, believed to be usable and to give a truer picture of the output value than a simple totting up of publications would do. Finally,

Table 6.2

Number of projects and size of funding for five of the research programmes under the Ministry of Food, Agriculture and Fisheries evaluated in Pedersen et al. (2011) and their point scores

Programme	No. projects	Budget, million DKK	Points/ million DKK	Scientific significance	Imbedding of knowledge	Industry and society
				% of total point		
Food quality with focus on food security	9	50	170	65	25	10
Biotechnology and use of genetics in processing	5	20	248	65	25	10
Interdisciplinary livestock research	10	70	150	50	15	35
Sustainable technology in agriculture	7	56	155	35	55	10
Agriculture from a holistic resource perspective	10	49	298	50	15	35
Total	41	245	193			

it is worth noting that DARCOF III and CORE Organic I will still be generating publications after this report has been completed, since there is normally a time lag between project completion and publication of results. The report does include the articles from DARCOF III and CORE Organic I that have been submitted to scientific journals, but not yet accepted, but not for DARCOF II.

We have not taken into account that some of the publications are only partly financed by the project, which means that all the publications that are attributed to the project in Organic Eprints have been included. We have based the cost-benefit analysis exclusively on the project funding via DARCOF/CROFS, so no external or internal co-financing has been included. As this is generally fairly insignificant anyway, it is not deemed to have had an effect on the results of the report.

**Value of publications and other research results**

Figures 6.3 and 6.4 show the distribution of points for the three indicators in DARCOF II and DARCOF III including CORE Organic. As the figures show, scientific significance scores between 35 and 65% of the points, except in the category coordination and dissemination. A lower percentage of between 0 and 35% is achieved by embedding of knowledge, while industry and society scores between 20 and 45%. This probably reflects that the information for scientific significance is more complete than any of the others and also that these publications score more points per article. Notwithstanding this, industry and society still manage a good score.

In the projects evaluated, scientific significance scores between 35 and 65% of achievable points, while industry and society scores between 10 and 35% (Table 6.1). Imbedding of knowledge achieves a higher score in most of the programmes evaluated in the article than they do in this assessment. For DARCOF II where the assessment is more complete, the level of knowledge embedded is the same as in the evaluated projects in the article. Scores for scientific significance are pretty much the same for all the different thematic areas, except for consumption under DARCOF II which has a slightly lower score. The high scientific significance of coordination and dissemination in DARCOF II is the result of the many knowledge syntheses, DARCOF reports and conference contributions produced.

**Cost-benefit analysis**

The points scored for individual themes divided by the project funding within the area gives a kind of cost-benefit indicator in points per million DKK for DARCOF II and III (figures 6.5 and 6.6).

In the research projects of the Ministry of Food, Agriculture and Fisheries programme evaluated in said article, the number of project points per million DKK varies from 50 to 585 with an average of 193 points (Table 6.1). DARCOF III including dissemination averaged 221 points and a few of the areas achieved around 300 points. It has not been possible to fully assess all indicators, so measured in this way DARCOF III results are fully comparable with the average of the programmes included in Pedersen et al. (Table 6.1). Not all publications from DARCOF III have been included

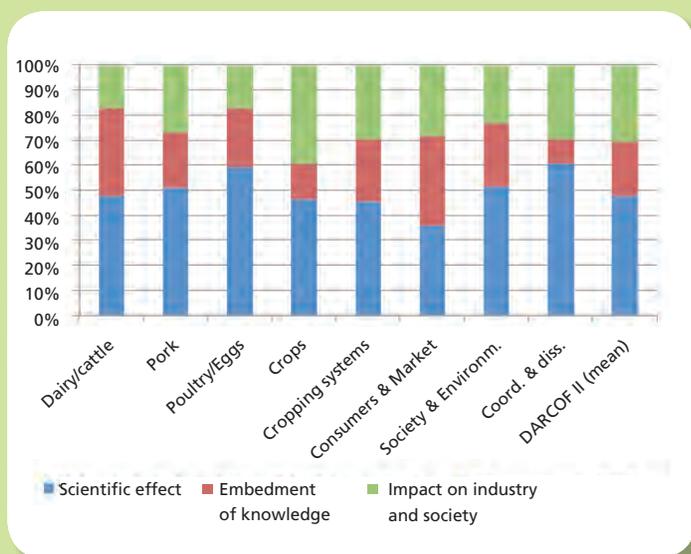


Figure 6.3 Points achieved within each of the themes in DARCOF II for scientific significance, embedding of knowledge, and industry and society. See explanation in text

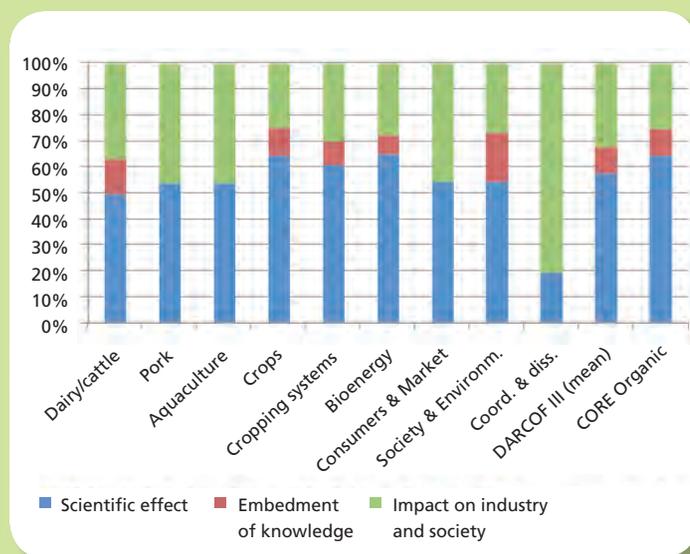


Figure 6.4 Points achieved within each of the themes in DARCOF III and CORE Organic for scientific significance, embedding of knowledge, and industry and society. See explanation in text. There has only been one joint project for pigs, poultry and eggs, shown under pigs

as many of the projects have only recently finished and therefore not been fully published yet. DARCOF II has a higher average for nearly all of the thematic areas, probably because all publications have been included. The average is 338 points with a single area achieving 480 points.

CORE Organic is a special case as it involves scientists from many countries. From the list of publications it is not possible to single out the contributions instigated by the Danish contingency as most publications have authors from several countries. The publications therefore do not reflect the Danish funding, but the output far exceeds what is achieved by projects exclusively funded from Danish sources. The entire CORE Organic programme achieves a score of 600 per million DKK funded from Denmark. This figure will drop if contributions from other countries are included, but it implies that there is a degree of synergy that gives a bonus return when compared with the amount of funding. Conversely, a smaller proportion of funds is used for dissemination to industry and society. More than 65% of the points is allotted to scientific effect, while industry and society only scores 25%.

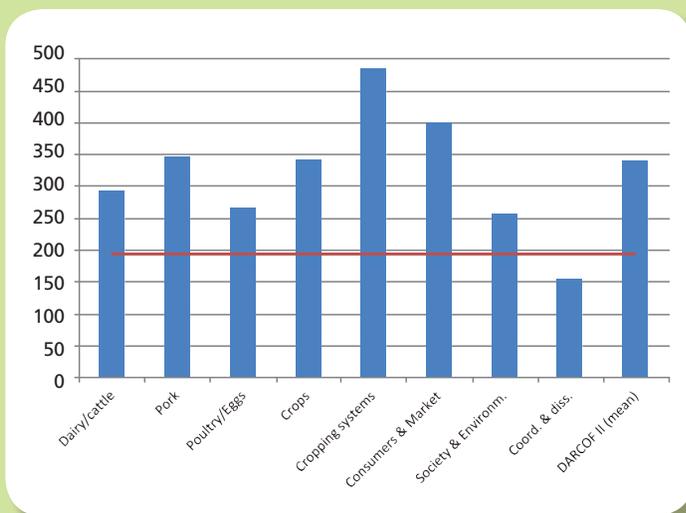
**DARCOF I publications compared with other programmes**

The numbers of publications archived in Organic Eprints for the four programmes (or for DARCOF I, counted on the project website) are displayed in Table 6.3.

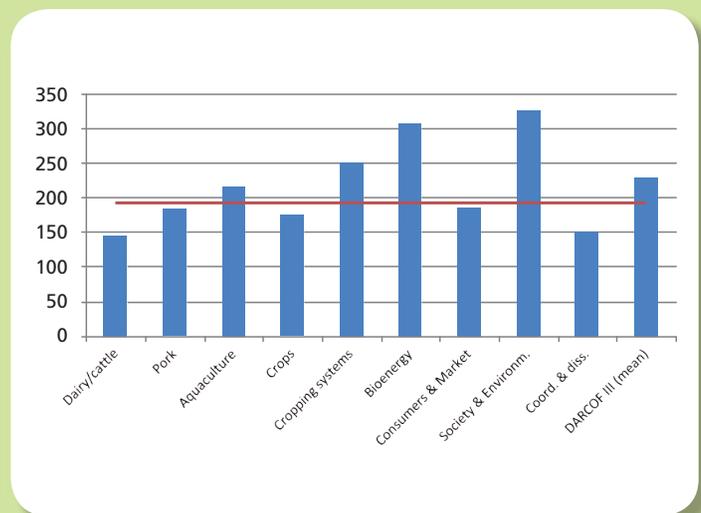
More than 600 scientific articles were published from the programmes. DARCOF I produced far fewer scientific publications than the subsequent two programmes. This is probably because the budget for DARCOF I was only about half that of the subsequent programmes. The lower publication record is offset by a large number of technical articles and other contributions to industry and society. An explanation could be that the project website includes more of this type of communication than will be archived in Organic Eprints. All in all, the funding for research in organic farming and food systems has resulted in a level of publication and contributions to society that is fully comparable to or better than that described for five food research programmes by Pedersen et al. (2011).

*Table 6.3  
Number of publications in the different categories for each of the research programmes.  
For DARCOF I, it is obtained from the project website; for the others from Organic Eprints.  
See text*

	DARCOF I	DARCOF II	DARCOF III	CORE Organic	Total
Scientific articles w. peer review	156	259	194	23	632
Other articles in English	253	530	335	193	1311
Communications in Danish	245	643	322	20	1230
Total	654	1432	851	317	3173



*Figure 6.5  
Points per million DKK achieved for the different themes under DARCOF II. The red line shows the average for the projects evaluated in Pedersen et al. (2011)*



*Figure 6.6  
Points per million DKK achieved for the different themes under DARCOF III. The red line shows the average for the projects evaluated in Pedersen et al. (2011)*

### 6.3 The scientists own examples of research impact

Project leaders for all the projects in DARCOF I, II and III and the Danish project participants in CORE Organic were invited to submit examples of their research having been put to good use in business or in society. The following are excerpts of some of these answers. As nowhere near all project leaders responded, it is unlikely that all areas where research has had an effect have been revealed by this response. Some of the examples from the scientists have been included in other chapters and have therefore been omitted here.

#### Generally about research

Several of the scientists pointed out that the work carried out in the DARCOF projects later led to new projects such as EU projects. One of the benefits of the DARCOF projects was the opportunity it gave to work on a subject over a number of years in a continuous chain of projects. The projects have also enabled scientists to participate in international collaboration creating fertile ground for mutual inspiration; see comments on weed control below, for example.

#### Crops, cropping systems and bioenergy

Projects on weed control under DARCOF I, II and III by Bo Melander, Aarhus University:

*"The earlier DARCOF-financed projects – and the more recent projects financed via ICROFS – have been crucially important for the development and improvement*

*of weed control in organic farming. The projects have optimised control strategies based on well-known technologies, for example weed harrowing, inter-row and intra-row weeding (finger weeding, brush weeding and torsion weeders). This has led to better guidelines for weed harrowing in cereals and the mechanical weed control in the crop row.*

*The research grants channelled via DARCOF and ICROFS have also helped to develop robotic weeding and one of the places where this took place was at the European working group for physical and cultural weed control ([http://www.ewrs.org/physical\\_and\\_cultural\\_weed\\_control.asp](http://www.ewrs.org/physical_and_cultural_weed_control.asp)) which Denmark has been in charge of since 2002. In the WEEDS project under DARCOF III, a completely novel concept for the eradication of couch grass based on extraction, exposure and destruction of root shoots was introduced, which will lead to a new patent if a commercial partner interested in providing the capital for its further development can be found. The concept has been introduced in Israel for controlling the pervasive weed species *Cyperus rotundus* after inspiration and dialogue with the WEEDS project partners. The results from Israel are so good that we are now working on a larger manufacture of tools for control of this species". (Bo Melander)*

NIT\_GRASS under DARCOF II by Jørgen Eriksen, Aarhus University:

*"In the NIT-GRASS project the results of the utilisation of nitrogen around the time of and subsequent to the ploughing-in of grass has had a large impact on practice, since the advice given to a large extent is based on the results of the project. Farmers are particularly mindful*



*of N losses after the incorporation of grass and we are pleased to see that the solution that was proposed in the project is very diligently used in practice". (Jørgen Eriksen)*

DARCOF II project CLOGS and DARCOF III project SEED by Birte Boelt, Aarhus University:

*"The project looked at the development of cropping strategies for the organic production of grass and clover seeds. It included, for example, different methods for establishment, weeding and fertilisation. Following a large drop in the size of the area in 2007, the area has subsequently increased to 3625 ha in 2011 – the largest ever in Denmark. Generally I believe that the early projects helped to develop cropping methods and strategies that allowed organic seed production to keep pace with demand in Denmark. The development activities are a collaboration with the seed industry which has invested many resources in the development of optimised crop management strategies.*

*Another issue are the pests in organic white clover – which we have not solved but have shown that it is an extensive problem that the producers need to plan their way out of, and it is my view that many producers now take white clover out of production for a year to reduce the incidence of clover weevil. I do believe we can allow ourselves to say that organic seed production is a success". (Birte Boelt)*

CARMINA under DARCOF II by Jesper Rasmussen, University of Copenhagen:

*"The idea of using ridge-planting for maize in Denmark, which was introduced and tested for the first time in the CARMINA project, has been important for the sector. Agricultural contractors, for example, offer to sow and tend maize on ridges in both organic and conventional farming". (Jesper Rasmussen)*

CROPSYS and the organic crop rotation experiments from 1996 to the present by Ilse A. Rasmussen, ICROFS:

*"Results from the crop rotation experiment were presented on a course for organic farming consultants arranged by the Knowledge Centre for Agriculture and held at Foulum in June 2012. One of the consultants asked how scientists could dream of sowing winter wheat after grass-clover. Other consultants pointed out that such was the practice in 1995, and that it was because the results from the crop rotation experiment revealed massive nitrate leaching with this practice that it was stopped". (Ilse A. Rasmussen)*

#### **Livestock (cattle, pigs, poultry, fish)**

DARCOF II project ManorPig by Jan Tind Sørensen, Aarhus University:

*In the ManorPig project we developed a concept for controlling health in organic sows, which was strongly inspired by the so-called HACCP concept (Hazard Analysis Critical Control Points) that is used all over the world*



to prevent breaches in food security. The concept was not quite market-ready, but we believed in the idea and applied for funding in a new project where the development of the concept was a central part. In the resulting international CorePig project, proper HACCP protocols were developed for four selected diseases in organic pig production. The idea was carried forward to the CORE Organic II project ProPig where the concept was extended to also include risk of environmental impact in organic pig production. Several small decision support systems were developed in the CorePig project and translated into several languages and these will be made available to organic pig producers and their advisors in Europe". (Jan Tind Sørensen)

Society and environment, including regulations/legislation Nitrogen fixation, recycling and leaching under DARCOF I by Henning Høgh-Jensen, AgroTech:

"What has made a valuable contribution to the public good is that the work led to the synthesis of an empirical model for nitrogen fixation. This model is now used in the Farm-N model, which all environmental staff in the local authorities use when they have to make an environmental impact assessment, when, for example, farmers wish to expand their pig production". (Henning Høgh-Jensen)

DARCOF II project BANHEAT by Bo Melander, Aarhus University:

"On the basis of the BANHEAT project and the innovation project – Organic carrot production: improved growing through weed steaming and biological activa-

tion – we have turned the steam-treatment of weeds and soil-borne diseases into an approved method in organic farming regulations, which has led to two producers in Denmark using the method and one company (Yding Smedie) offering technical solutions for weed steam control. This is a direct reward of the ideas and the research that stems from DARCOF and innovation funds". (Bo Melander)

Projects and knowledge synthesis on GMO and Co-existence by Birte Boelt, Aarhus University:

"The work on co-existence is very central – certainly for the implementation of legislation and perhaps also for the understanding of politicians of how large the risk of adventitious admixing is.

The knowledge synthesis "Implications of genetically modified crops in organic farming" was printed in 2002 (Gösta Kjellsson and Birte Boelt (Eds.).

The knowledge synthesis and its preparation was an important first step in the establishment of the dialogue that later turned out to be so characteristic of the Danish work on co-existence (I actually believe that dialogue and openness is the reason why Denmark was the first country to implement a strategy for co-existence). The conclusion from the synthesis was that the use of non-organic products should be phased out in organic farming as quickly as possible. Initiation of research and development activities was therefore suggested in order to develop an organic seed production, particularly for the species where organic seeds were in short supply, and also to develop a production of protein crops as



a replacement for soya. Different crop managements were also discussed (crop-specific). Finally – and maybe the most visionary – the conversion period from conventional to organic farming may be extended since the persistence of seeds in the soil became a focus area and the fact that organic farming should be given a chance to expand". (Birte Boelt)

Projects and knowledge synthesis on GMO and Co-existence by Christian Damgaard, Aarhus University:

"It is my clear belief that this is a particularly good example of research leaving a clear impression on subsequent legislation, since the minimum distances proposed were adopted in the law texts". (Christian Damgaard)

DARCOF III project Practical Relevance of Market and Politics (COP) by Carsten Daugbjerg, University of Copenhagen:

"A general problem with the assessment of the effect of socio-scientific research projects is that they are rarely directly applied. There are indications, however, that research results have been used by the Ministry of Food, Agriculture and Fisheries and organic associations. For example, a memorandum was prepared on the background of preliminary analyses of the project. The memorandum was sent via ICROFS to the ministry. We heard nothing else until the ICROFS project leader meeting in February 2009 where Niels Halberg informed us that the memorandum had reached the highest echelons in the ministry. One of the main messages of the project was that there should not be single-minded focus on expanding the area under organic farming. It was important to balance political initiatives for a conversion to organic farming with initiatives that increase the demand for organic foods. It is difficult to say whether this message from COP prompted politicians to include it in their vision for organic farming, but the fact is that the discussion shifted its strong focus on conversion to include a focus on demand.

This shift also became evident in the current government's policy for organics, which stipulates that minimum 60% of the food used in public canteens should be organic. As I said earlier, it is difficult to say how much of this is directly due to the results of the project, but I do believe that our results have helped shape the political and legal debate, both nationally and internationally. In 2011 the British Soil Association used and cited three of the publications from the project in the report "The Lazy Man of Europe" which recommended that the British government learn from the Danish experience as documented by the COP project. Finally, the COP project has supplied input to the EU Commission's report "Use and efficiency of public support measures addressing organic farming", which has just been published.

The project held a concluding workshop for stakeholders in the organic sector in December 2011. The participants represented organisations with an interest in organic farming policy, a member of parliament, and there were no less than 5-6 representatives from The Danish Agri-Fish Agency and the administration of the Ministry of Food, Agriculture and Fisheries. There was a lively debate among the delegates, following a presentation by COP project members and representatives from the Ministry and the organic associations. The interest in debating the issues may be an indicator that the results of the project have helped to nuance the debate.

Another indicator of practical relevance that is often used is citations by the press. The preliminary results gave rise to an interview for a feature in *Økologi og Erhverv* at the start of 2009. This feature was used as a source for a number of national newspapers, among them *Information* – and *Grønlandsposten*. In 2010 one of the project publications was chosen for an in-depth and positive review in the EU newsletter *Science for Environment Policy*, which is sent to 12,000 subscribers. Jan Holm Ingeman has given a series of interviews to the printed press and on TV, and Yonatan Schwartzman has taken part in interviews for features in *Økologi og Erhverv* and for the quarterly magazine *Økologisk*. As the above shows, there are indications that the COP project has had an impact on practice. Finally, as the final report of the project details, there has been considerable interest by research institutions in having the results presented in lectures. In these sessions a number of end-users of the results have also been present". (Carsten Daugbjerg)

CORE Organic – iPOPYP and other projects, knowledge syntheses and action plans under DARCOF I and II by Niels Heine Kristensen, Aalborg University:

"The new degree course IFS (Integrated Food Studies) has to a large extent been inspired by the projects under DARCOF/ICROFS. The students will thus become acquainted with the principles that guide organic farming and the dynamics in the development of the sector. They will likewise be carrying out projects on organic conversion in public catering, in primary production, etc. The students will need first-hand knowledge of how meals and food generation of the future has to be developed in a necessary collaboration between consumers and producers and they will need knowledge of the market, the technology and the food culture". (Niels Heine Kristensen).

The examples provided by the scientists highlight that although the scientists are very focused on doing research at international level that results in international publications, they are also very concerned with the appliance of science and they take pride in communicating this.

## Chapter 7. Conclusion and outlook

The projects under the FØJO and Core Organic research programmes have, as shown in chapters 3-6, produced many results and effects for the benefit of the organic sector in a wider sense – from farmer to business to consumer. In the following this will be discussed in relation to a differentiation that is used by the Advanced Technology Foundation under the heading “The multiple bottom line” where a distinction is made between so-called project results and project effects. In the analysis of organic research and development a distinction is therefore made between, on the one hand, the research results that can be listed as publications, patents/products, research education, careers, international contacts and, on the other hand, the effects that the research has had on the development of the organic sector through the multiple utilisation of results – and the derived effects on society. This report concludes with a discussion of how the close association between scientists and end-users in the DARCOF/ICROFS programmes has a large bearing on the effects achieved.

### Research results

In connection with an earlier evaluation of the results of a number of research programmes under the Ministry of Food, Agriculture and Fisheries, a standard point scoring system was developed, as explained in Chapter 6. Using the same method, the projects under the DARCOF programmes scored on average 30% higher per million DKK granted than the average score of the five research programmes in agriculture and food launched in the same time period. With this method, the organic programmes, DARCOF II and III, likewise resulted in a significantly higher output than the other five programmes. This is due to a combination of a significant publication record in scientific journals for most of the projects and a concerted communication effort and frequent contact with end-users. It has thus been possible to create applied research programmes that combine a high academic level at international standard with a strong focus on real-life practical uses.

Although many of the projects have had a very practical focus (as evidenced by the comprehensive knowledge transfer), the scientists have also published extensively in international scientific journals. This is a prerequisite for being able to attract new funds and for establishing a research career. The anonymous peer-reviewing of articles also works as a system of quality control of the papers and thus demonstrates that the research is novel and of international standard. This form of publication is, finally, also a way of ensuring that Danish scientists keep up-to-date with new international results in their area and the articles generate international respect and contacts to other research groups.

With this large output of publications a number of scientists have established careers (many at lecturer/senior scientist and professor level) based partly or wholly on results from the organic projects, also strengthening their international network via CORE Organic and EU projects on organic farming. This is also the case for scientists who have been critical of organic production. Several scientists also regard it as an asset that the organic research programmes gave strong support to and valued interdisciplinarity, a systems approach and the involvement of end-users (Chapter 6).

International networking means that results from other parts of the globe that are relevant for the Danish sector are brought to the attention of Danish scientists and can be implemented in the design of new projects or communicated directly to Danish users. The Danish results and knowledge may in turn inspire and support research in other countries, which down the line may also benefit the Danish sector. An example of this is the development of robot technology for weed control in row crops (part of the DARCOF III programme). Certain Danish vegetable producers use robots for weeding that have been built in England but were designed using Danish knowledge and inspiration. Likewise, Danish scientists are now collaborating with Chinese scientists interested in organic farming on the exchange of knowledge and ideas for the non-chemical control of pests in fruit and vegetables. Other Danish scientists are collaborating with Brazilian colleagues on the use of active plant ingredients for the control of livestock diseases.



The internationalisation of organic research has been actively supported by DARCOF via several initiatives. DARCOF initiated several large international projects financed by the EU framework programmes and they initiated and are coordinating a cross-collaboration between 20 European countries on the financing of transnational research projects within organic farming and foods under a so-called ERA-net, CORE Organic, as described in Chapter 1. DARCOF has also developed the open-access web archive Organic Eprints (Chapter 5), which is now the most widely used international archive for scientific publications on organic farming.

## Effect of applied organic research

### Direct effects on sector, growth and production forms

As chapters 3 and 4 show, there has been a large and significant effect of the research under DARCOF I-III and CORE Organic on the development of the organic sector. Both within crop production and animal husbandry have research projects contributed significant new knowledge and methods in response to the considerable challenges in primary production, from the handling of manure and weeds to diseases and feeding. The results have been widely applied, partly as a result of a strong focus on knowledge transfer and partly because many of the projects have been designed and selected as an answer to challenges formulated by the sector in the organic action plans and via the user group in DARCOF, etc. The consultants believe that organic production would have been much lower today if the research results had not been utilised. This is both because the production itself is more profitable (higher yields per cow, pigs of higher quality resulting in a higher kilo price, etc.), and because some important problems have been solved, which has reduced the incidence of reconversion to conventional farming (for example, improved perennial weed control and recycling of nutrients with the use of cover crops and good crop rotations).

The growing production and the ability to ensure a good and consistent quality and stability has also been a precondition for the establishment of a professional and profitable processing sector. The companies interviewed find that these conditions have had an important effect on their development opportunities. There are also a couple of good examples of research projects contributing to the development of new products and marketing opportunities as described in chapters 3 and 4.

Overall, this shows that the research in the DARCOF programmes and CORE Organic had a strong focus on the barriers in the sector and on improving the general market and growth conditions in the sector. The research has accordingly laid the basis for a stronger commercial exploitation of the opportunities and there has been good agreement between research focus and the challenges in the commercial sector and also the political ambitions for market-driven growth in the organic sector.

### Indirect effects, greater integrity and policy development

In addition to the direct effects, there are other – more indirect – effects on processing and marketing, such as a better understanding of consumer motives for purchasing organic produce and a higher degree of integrity as a result of research. Integrity – here understood as consumer trust that the organic sector lives up to its declared ideals and added values – has been improved in two ways. Firstly, the organic production itself has been improved in areas that are important to the consumer, and, secondly, studies have evaluated organic farming on its principles, consumer expectations and/or interests of society. In the first instance, research projects have – according to interviews with consultants and representatives of public authorities and organisation – enhanced animal health and welfare on organic farms through the development and description of better farm management, housing, feeding, etc. In the second instance, a series of projects have probed whether organic farming actually confers advantages compared with conventional systems or produce.

The projects are in this connection both concrete research projects and a large number of scientific reviews – the so-called knowledge syntheses – prepared under DARCOF/ICROFS programmes and with participation of scientists from the DARCOF projects. Some of these studies have documented positive effects of organic farming on, for example, nutrient balances in livestock farming and the conservation of nature, in hedgerows for example, as well as a higher nutritional content of organic produce. However, some results have also been critical on specific aspects of organic farming. Some projects found that not all organic systems are better than conventional ones when measured either on climate impact per kilo produce, on flavour or on general healthiness.

In several instances, such results have been used by organisations in the sector to launch campaigns to improve practical aspects of the systems. In other instances the sector (understood as the elected organs of the organisations and their employees, including consultants) has focused on improving animal health and welfare on members' farms on the background of research projects and reviews. It can be assumed that this willingness to admit to weaknesses in the organic systems and the readiness to seek solutions to these has helped maintain integrity in the eyes of the public and ensured the continued political backing, although there is no documentation for this. (The assumption is, however, supported by interviews with representatives of organisations and government, see Chapter 4.)

### Politics and regulation

This type of research could also be assumed to have had an effect on the development and modification of rules and regulations of the organic sector, but this is difficult to prove and quantify. In interviews with representatives of the government in charge of the implementation of new regulations they stress the fact that regulations for the organic

sector are governed by EU policies, which is why an effect of research in Denmark would be indirect. The research results are, however, used by the organisations proposing changes to the regulations as support for their arguments, and it is also emphasised that there is great respect in other EU countries for Danish research results. Other interviews from the ministries state that research-based knowledge in organics has been useful for administration and policy development, not just in a narrow sense in relation to ecology, but also in a wider sense in areas of environmental legislation and food security (see Chapter 4).

### Consumers and market

Some of the research projects have documented that large consumer segments favour organic produce for a variety of personal (health, quality, pesticide-free) and altruistic reasons (animal welfare, environment). The increased availability of organic produce both in terms of volume, product range and a reduced premium (which research has helped bring about) has therefore also had a positive effect on the welfare of many consumers. This is confirmed by the steady increase in demand over many years (as shown in Chapter 1) resulting in organic sales now making up more than 7% of food sales. It has not been possible to estimate the utility value of this wider availability of organic produce for consumers. In a wider perspective, a larger area under organic farming will also have a positive effect on citizens by virtue of a lower risk of pollution of groundwater and the conservation of biodiversity.

### Effects for conventional farming and from internationalisation

In addition to the described effects on the organic sector, the DARCOF projects have also produced results that are relevant for conventional farming and can aid a general green conversion. This is true, for example, for methods to replace seed dressing, non-chemical weed control, and a reduction in the consumption of antibiotics and in the supplementation of synthetic vitamins in animal husbandry. This could give large cash savings in the conventional sector if the methods were widely implemented and would further improve the reputation of Danish agriculture as an eco-friendly system supplying high-quality products.

The respect for Danish organic research and its contribution to the integrity of the organic system could moreover have a positive effect on Denmark's international reputation, which can turn out to be a positive thing in a market where the export of Danish organic produce is growing.

The effect of the international publication of results (OrganicEprints, CORE Organic, ISOFAR) is that Danish organic research environments are widely respected throughout the world, leading to requests for cooperation and knowledge exchange from other research environments. ICROFS has thus signed memoranda of understanding with institutions

in China, Korea, Canada and Brazil and has initiated a PhD education project in organic food chains with three East-African universities and the three organic farming organisations in Tanzania, Uganda and Kenya. These relations again mean access to new knowledge and methods from other research environments that can have a favourable impact on the competitiveness of the Danish organic sector.

The potential of internationalisation was also the reason why DARCOF was given an international mandate and an international management board under the new name of ICROFS in 2008 (Chapter 1). This initiative has opened up new opportunities for influencing international organic research and the sector and for supporting cross-national collaboration. This again boosts the international respect for the Danish research and organic sector.

### Organic research as a public investment

Approximately 500 million DKK worth of funding was made available for the three DARCOF programmes over 15 years, which corresponds to approx. 35 million DKK per year. This figure should be compared with the approx. 1 billion DKK spent on agriculture and food research per year in Denmark. Because of the high applicability of the results – direct and indirect – the R&D must be expected to have had a significant influence on the development of the sector described in Chapter 1. It is not easy to distinguish the influence of research from other factors, as explained in Chapter 2. There are, however, persuasive arguments for why the sector would have been much smaller and much less profitable today without this research, which is supported by testimonials from consultants and private companies. To put things into perspective a couple of examples are given of the relationship between the 500 million DKK of public funds spent on R&D and the value-creation in the organic sector. The annual market value of the organic production is just over 7 billion DKK (Chapter 1). This figure includes imported produce but not the export of Danish produce.

This figure is, despite its associated uncertainties, a good estimate of the economic value of the production and processing, etc., in the sector. The consultants have for different areas estimated that production would have been 10-15% lower without the research in the DARCOF programmes. These estimates appear somewhat conservative, judging by the production barriers which the same group of consultants believes have been overcome. Nevertheless, a simple calculation shows that if only 10% of the annual turnover of organic produce can be attributed to R&D (and according to the consultants this is not unrealistic), a single year with a turnover of 7 billion DKK more than recoups the 500 million DKK invested in R&D over 15 years.

The organic products are sold at a premium, which in the following is assumed to average 15%. This premium is also subject to VAT, whereby an extra tax income from VAT of around 200-250 million DKK is generated per year for a turnover of 7 billion DKK. This can be compared with the

approximately 40 million DKK per year of government funds spent on R&D.

These financial estimates are of course open to discussion, but what is certain is that the market value of the organic production does not include all the benefits of a growing organic sector. A calculation of the profitability of investing in R&D in organic farming should thus ideally also include the effects on animal welfare, use of resources, environment, etc. – for example, better nature protection and less groundwater pollution as a result of pesticide-free farming. Assigning values to these effects is a general problem and are therefore also difficult to incorporate as part of the return on the research investment.

### **The organic sector as a textbook example of the interaction between R&D, the advisory service and producers**

The very applied nature and relevance of the projects under the DARCOF programmes has been strengthened via the close and continuous contact with representatives of consumers, first and foremost in formal fora such as the user group in DARCOF and the programme committee in ICROFS. There has also been contact to the sector via the organic food council and a number of other actors involved in the preparation of the action plans and later on in the knowledge synthesis from 2008 on the potential for a market-based development of the organic sector. This influence at programme level has been – and continues to be – important for maintaining the relevance of the projects offered and funds granted in relation to the requirements of the sector, as shown in chapters 3 and 6.

At the same time, many of the projects have had contact to consultants and farmers whereby the acquired knowledge has been continually communicated and discussed. This has had two effects. Firstly, a rapid application of results, because the users have discussed the results of the research with the scientists and thus achieved a better understanding of how results and knowledge can be adapted to the specific practical situations; secondly, there has in many projects been an adaptation of research design and methodology as a result of practical experience. The scientists have been persuaded by the dialogue with the users to ensure that treatments are as relevant and practical as possible, without compromising the scientific standards. An example of this is the crop rotation experiment mentioned in Chapter 3.

This shows that there is a more complex connection between research, development and the application of knowledge in agriculture than the traditional route of one-way communication of scientific results via consultants to producers. There are clear indications that it is because the project structure and organisation in DARCOF has supported this complexity in knowledge generation and exchange that there has been a good effect of the projects measured in terms of the utilisation of the results and that main barriers in the sector have been overcome. An additional, but important, factor is that regardless of the 3-4-year duration of the research programmes, there has been continuity in many central research activities and facilities by new projects often building directly on earlier projects (of course with an independent evaluation of the research quality and relevance of each new project proposal).

Research in animal husbandry and crop husbandry has thus in many cases built upon results obtained in previous



projects and one important reason for, e.g., the crop rotation experiments being mentioned by the consultants as one of the most important sources of knowledge and inspiration for the development of crop production is that it has been a continuous research effort at the same localities over many years and over many research programmes. At international level there is also awareness of the need to improve the relationship between research, extension and agricultural production. In the "International Assessment of Agricultural Knowledge, Science and Technology for Development" which has the participation of more than 400 scientists and advisers, the conclusions stress the fact that it is necessary with a clean break with the model that these systems are normally based on, i.e. the traditional model mentioned above.

There is a need for the farmers' situation to have a stronger voice when prioritising and designing research projects and to integrate their local knowledge and experience. There is also a need to consider the complexity of agricultural systems – the agro-ecology – and the aspirations of the farmer and for the approach to be more interdisciplinary. The report also recommends that focus in research and development is altered from simple productivity targets to a wider inclusion of knowledge on the management of natural resources and with targets on food production and health. This agrees with recommendations in various EU committees on agricultural research, for example in the latest scenario report from the standing committee on agricultural research, SCAR.

The heart of the development in Danish organic research appears to be a textbook example of the type of organisa-

tion and research focus that is wanted. This is another good argument for retaining and expanding the international role of Danish organic farming research. The current Organic RDD programme, which is a continuation of the DARCOF programmes, now under the GUDP green development programme, contains similar elements of user involvement both at programme and project level, and the projects here are also expected to have significant relevance for the industry. The trans-European research effort has likewise continued under CORE Organic II and will hopefully be continued under the ERA-net scheme. Via other international networks outside Europe, the Danish experience with collaboration between research, extension and production and with other users is expected to be emulated where there is a need.

## Epilogue

This report has shown that the organic research programmes from 1996-2010 have delivered many and significant research results and have had considerable effect on agriculture and the organic sector in a wide sense. It should be emphasised that this could not have taken place without the help of a very active organic sector which during the period has become highly skilled and professional. But it is not least the important and central role played – and continuing to be played – by a large group of entrepreneurial and pioneering farmers and processing firms in the development of the organic sector that should be highlighted. The role of research has been to assist these pioneers in the development of production forms and products within the scope of the ideas, principles and regulations for organic farming.

