IV Experimental units for research in organic farming systems

Acronym: EXUNIT

Date: 29 July 2000

1. Summary

A number of field experimental units were established in 1996 as part of the joint effort on organic farming research in Denmark coordinated by DARCOF. These units primarily consisted of field experimental sites at Flakkebjerg, Foulum, Jyndevad, Årslev, Askov and KVL-Taastrup, and the long-term crop rotation experiments at Jyndevad, Foulum, Flakkebjerg og Holeby. The organic farming research station, Rugballegård, has also been available for this research. These experimental units cover all major organic farming practices and soil types in Denmark.

The aims of the experimental units for research in organic farming systems are three-fold:
1. To describe long-term effects of organic farming practices and crop rotations.
2. To function as workshop facilities for other, more specific research projects.
3. To assist in communication and dissemination of the results of research on organic farming.

2. Research group

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DIAS is Danish Institute of Agricultural Sciences
KVL is Royal Agricultural and Veterinary University

JEO is project leader, involved in the CRE experiment and responsible for the JYN, FO1 and FO2 experimental areas.
MA is involved in the CRE and NCE experiments.
BTC is responsible for the ASK experimental area.
JE is involved in the NCE experiment and responsible for the CGE experiment.
HLJ, JRP and JR are responsible for the KV1 and CFE experimental areas.
HLP is responsible for the ÅR2 experimental area.
FWO is responsible for Rugballegaard organic experimental farm (RUG).
IAR is involved in the CRE experiment and responsible for the FL1 and FL2 experimental areas.
KTK is responsible for the ÅR1 experimental area.

3. Introduction

Organic farming with a large proportion of grass-clover ley in the crop rotation in combination with a stock of ruminant animals has been shown to pose relatively few agronomic problems (Mäder *et al.*, 1999). Crop rotations comprising both grass-clover fields and arable crops have shown to be relatively robust in relation to most problems with weeds, pests and diseases (Dubois *et al.*, 1998). These rotations, however, receive large nitrogen inputs from N_2-fixation by the grass-clover pastures, which carries an associated risk of causing environmental problems through nitrate leaching if not efficiently managed (Høgh-Jensen & Schjørring, 1994; Loges, 1998).

More challenging problems exist in arable and vegetable organic farming systems. Such systems are necessary for the provision of sufficient organic raw and processed food for human consumption and feed for pig and poultry production (von Fragstein, 1996), which will be encourage through increased trade via supermarkets and as a result of the new EU Council Regulation 1804/1999 on animal production in organic farming. Within these systems there is a trade-off between the inclusion of nitrogen-fixing crops, which may not have an economic value, and high nitrogen demanding cash crops. These systems will tend to suffer from lack of nitrogen and be less competitive against annual weeds due to the higher proportion of cash crops and small proportion of grass-clover as green manure. Some of the problems with nitrogen availability and with weed control may be solved through judicious use of cover crops and any available animal manure (Masiunas, 1998; Williams et al., 1998). The optimal crop rotation and associated management will depend on soils and climate.

Many of these problems will only manifest themselves after many years, at which time they may be difficult to remedy. There is therefore a need for long-term crop rotation experiments in combination with more specific experiments and studies to gain applicable knowledge for practical use, so that these problems can be prevented.

A number of field experimental units were established in 1996 as part of the joint effort on organic farming research in Denmark coordinated by DARCOF. These units primarily consisted of field experimental sites at Flakkebjerg, Foulum, Jyndevad, Årslev, Askov and KVL-Taastrup, and the long-term crop rotation experiments at Jyndevad, Foulum, Flakkebjerg og Holeby. The organic farming research station, Rugballegård, has also been available for this research. The location of these experimental areas is shown in Figure 1 and the experiments are summarised in Table 1. The current status of these units is described in section 4 and the plans for their continuation is described in section 5.

Table 1. Overview of experimental units for research on organic farming systems in Denmark.

Acronym	Title	Location(s)
ASK	Long-term fertilisation experiment	Askov
CFE	Combined food and energy production	KVL-Taastrup
CRE	Crop rotation experiment	Jyndevad, Foulum, Flakkebjerg, Holeby
FL1	Cereal crop rotation	Flakkebjerg
FL2	Seed crop rotation	Flakkebjerg
FO1	Dairy crop rotation	Foulum
FO2	Pig crop rotation	Foulum
GCE	Grass/clover experiment	Foulum
JYN	Cattle crop rotation	Jyndevad
KV1	Dairy crop rotation	KVL-Taastrup
NCE	Nutrient cycling experiment	Foulum (FO1)
RUG	The organic experimental station	Rugballegård
ÅR1	Vegetable crop rotation	Årslev
ÅR2	Fruit crops and berries experimental area	Årslev

Figure 1. Map of location of experimental sites for organic farming in Denmark.

4. State of the art

Crop rotations in organic farming

The use of sound crop rotations in combination with selection of resistant varieties and the generally low nitrogen level prevents most problems with pests and diseases in organic farming (Olesen, 1999). Recent results from long-term experiments and on-farm studies in organic farming show that the size and the quality of the production of cash crops is mainly restricted by nitrogen supply and by weed control. These factors are thus among the main obstacles for conversion to organic farming (Dubois *et al.*, 1999).

Nitrogen supply and weed control interact strongly in most organic farming systems, because nitrogen availability determines the competitive ability of crops and weeds, and because weeds may restrict nitrogen uptake by the crop (Clark *et al.*, 1999; Liebman & Davies, in press). Weed interference can be decreased through the use of mechanical weed control (e.g. weed harrowing or hoeing), but these measures do not provide full weed control and they do thus not necessarily increase the subsequent competitiveness of the crop (Kristensen & Rasmussen, 1997). Experiments have shown that the competitiveness of the crop can be increased through an appropriate choice of timing and method of fertiliser application with a consequent enhancement of the effect of physical weed control (Rasmussen *et al.*, 1996). Little information is, however, available on how this manipulation interacts with the effect of residual soil nitrogen made available through the sequence of crops and the use of cover crops.

The long-term sustainability of organic farming systems is closely linked to the nitrogen balance, as nitrogen is often the nutrient that limits crop production (Eriksen *et al.*, 1999). Organic farming systems must rely on a close nitrogen cycle and on nitrogen input via N_2 fixation by legumes. N balances based on measurements and calculation models have shown that there are large variations in the N balance of current organic farming systems in Europe, ranging from relatively large positive to negative balances (Dalgaard *et al.*, 1998; Hansen *et al.*, submitted). This variation depends on both the natural resources (soils and climate) and on management, including stocking rate, type of crops in the rotation and use of cover crops. Many of these N balances depend on assumptions about the loss terms, which are often difficult to verify in practice. The N balances therefore need to be checked against results from long-term cropping systems experiments, where effects of cultivation history on soil N storage, N cycling and losses can be evaluated. Only a very limited number of such studies have been made (Askegaard *et al.*, 1999; Korsaeth & Eltun, submitted).

The ploughing of grassland is followed by a large increase in the mineralisation of N, and a well-organised crop rotation is important in order to utilise this huge pulse of N released (Eriksen *et al.*, 1999; Francis, 1995). In the DARCOF programme 1 it was shown that the release of N following the ploughing of 3rd year grass-clover could by controlled with good management (spring ploughing and use of catch crops). Thus, huge precrop effects were observed in two years after ploughing without increased leaching losses. It is necessary to use catch crops with large N-uptake after cereals or use main crops with a longer growth season and higher N-uptake potential.

A closer N cycle and an increase in N_2 fixation can be obtained through judicious use of green manure crops and legume cover crops. There is a large knowledge base on the nitrogen input through grass-clover crops, clover or lucerne leys and pulse crops (Heichel & Henjum, 1991;

Jensen, 1996b). The release and losses of nitrogen following incorporation of such crops have also been studied in relatively high detail, and to some extent have also been included in existing simulation models of nitrogen turn-over in the soil-plant-atmosphere system (Jensen, 1996a; Haynes, 1997). There is much less information on the accumulation and subsequent release of nitrogen from cover crops, including legume cover crops, and its relation to cover crop management (Thorup-Kristensen & Nielsen, 1998; Baggs *et al.*, 1999). This information is essential for the design of fertile systems for increased production of cereals and other cash crops in organic farming (Drinkwater *et al.*, 1998).

Plant productivity is intimately linked to soil fertility, the availability of plant nutrients playing a key role in this respect. To evaluate consequences of different levels and types of manure on the development in soil fertility and crop production potentials, a given nutrient management system must be continued for longer periods. The interaction between nutrient availability and plant performance feeds back on a number of fertility related soil parameters (e.g. soil organic matter levels and soil structure). To test the long-term interactions between nutrient management and soil fertility, long continued field experiments represent a unique resource of soil and plant materials.

There is also a need to better disseminate information to farmers in the optimisation of both the nutrient cycling and the cultural control of weeds. Crop rotations in practice are, however, determined not only by agronomic considerations, but also by profitability and the experiences and preferences of the farmer (Wijnands, 1999). Any guidelines on these issues must therefore be adapted to the conditions encountered on the local farm scale.

For several fruit crops, organic production is extremely difficult because of the high quality demands of the product. In Danish organic apple orchards the yield are only 14 percent of the conventional yield (Pedersen *et al.*, 1998). To make the same profit as a conventional grower the organic growers needs a sales prise 100 percent bigger than they already get (Daugaard *et al.*, l999). Apple scab and the rot disease gloeosporium cause the biggest crop losses in the apple production.

Experimental units for organic farming in Denmark

The experimental units all have different structures and roles for the research on organic farming in Denmark. Some of the research areas consist of crop rotations placed on traditional agricultural research stations on different soil types and the they represent different farm types, including dairy farms (FO1, JYN and KV1), plant and pig production (FL1, FL2 and FO2) and vegetable crop production (ÅR1). These sites vary in climatic and soil conditions. Each course of the rotation is represented with an area of about 1 ha (Mikkelsen & Mikkelsen, 1989). This allows for factorial field experiments within each field while at the same time maintaining a fixed rotation. The effects of the rotations are monitored through measurements in references areas not subjected to experimentation. The measurements include yields and nutrient balances (NPK) at all sites, and weeds, diseases and pests at some of the sites.

The CFE experiment represents fields of different lengths separated by hedges for energy production. Each field has a crop rotation and has room for experiments and studies.

The ÅR2 experimental area represents an experimental area for perennial fruit crops and berries. Soil nutrient status and occurrence of weeds, pests and diseases are monitored.

The ASK experimental area represents parts of the long-term fertilisation trial at Askov, which have now been converted to organic farming. The experimental treatments include different rates and types of application of animal manure. The measurements include yields and nutrient balances. Soil samples are taken every four years.

The NCE, GCE and CRE experiments all function as both individual experiments and as experimental areas for other projects. The measurements include yields, nutrient balances and measurements of nitrate leaching by use of suction cups.

The organic experimental station, Rugballegaard, (RUG) is the only facility where full scale production can be registered in relation to live stock grazing of cattle and pigs in different crop rotation systems under organically certified conditions.

Flakkebjerg (FL1 and FL2)

The experimental area at Flakkebjerg consists of two crop rotations (FL1 and FL2) (Table 2). Rotation FL1 was converted in 1996, while FL2 was converted in 1999/2000. The reason for also converting FL2 to organic farming was a large demand for experimental areas for organic farming at Research Centre Flakkebjerg. Conventionally produced slurry is used in amounts corresponding to 25% of the demand for nitrogen in the rotations. The fields have mainly been used for experiments on cereal production and on weed control.

Jyndevad (JYN)

The crop rotation at Jyndevad consists of grass/clover and cereals in a 7-course rotation that was initiated in 1996 (Table 2). Each of the seven fields are subdivided into three blocks each with five manure treatments as follows:

1. No manure
2. 0.8 LU/ha in slurry
3. 1.4 LU/ha in slurry
4. 0.8 LU/ha in deep litter
5. 1.4 LU/ha i deep litter.

The fields have primarily been used for experiments on grain quality of oats and on potato production.

Foulum (FO1 and FO2)

There are two organic experimental areas at Foulum, a dairy farm rotations (FO1) and a cereal dominated pig farm rotation (FO2) (Table 2). The dairy crop rotation has since 1994 been used for a project on "Plant production, nutrient household and crop protection on organic dairy crop rotations", which is continued in NCE-experiment described below. The nutrient balances of the organic dairy rotation has been followed since 1987 (Mikkelsen, 1999). The pig crop rotation has mainly been used for experiments with potatoes.

Table 2. Organic crop rotations at DIAS.

Location	Flakkebjerg		Jyndevad	Foulum		Askov	Årslev
Name	FL1	FL2	JYN	FO1	FO2	ASK	ÅR1
Area (ha)	16	9	9	7	7		6
Init. year	1996	1999	1996	1987	1996	1997	1996
Soil type	Sandy loam	Sandy loam	Sand	Loamy sand	Loamy sand	Loamy sand	Sandy loam
1. crop	S. cereal	Sp. cereal	S. barley	S. barley	S. barley	S. cereal	S. barley
2. crop	Lucerne	Wh.cl. seed	Grass/clover	Grass/clover	Grass/clover	Grass/clover	Grass/clover
3. crop	Lucerne	W. rape	Grass/clover	Grass/clover	S. oat	W. cereal	Vegetables
4. crop	S. cereal	S. cereal	Grass/clover	S. oat	S. barley	Root crop	S. barley
5. crop	W. wheat		Spring oat	Pea/barley	Potatoes		Vegetables
6. crop	Cereal/pulse		Winter rye	Beet			Peas
7. crop	Row crop		Potatoes				

Årslev (ÅR1 and ÅR2)

The organic vegetable crop rotation (ÅR1) at Årslev is a six-course rotation, where three of the fields are grown with vegetables (Table 2). The nitrogen supply is solely based on green manure, catch crops and an efficient use of the residual effects of crops (Thorup-Kristensen, 1999). The crop rotation has been used for a number of experiments on vegetable crop production and on catch crops.

The experimental area with fruits and berries (ÅR2) comprises areas where experiments on apples, black currant and strawberries can be conducted under organic farming conditions. Unsprayed crops of cherry trees are maintained for studies in these crops. In 2000 an area will be planted with hip to allow studies on effects of clones, soil tillage and manure application.

KVL-Taastrup (KV1 and CFE)

Two experimental areas are used for organic farming research at the KVL University Farms (Table 3). The organic crop rotation (KV1) is mainly used for studies on effects of soil tillage and weed control. Data from the farming system have been collected since the establishment in 1989 and published by Magid & Kølster (1995). This system has a prehistory of several similar rotations and has been managed organically since the establishment in 1988.

The idea of the CFE-system is to grow short rotation coppice in strips between food crops to get an energy crop in addition to the food crops. The principal goal is the generation of at least as much non-fossil renewable energy from fast-growing biomass as is consumed in fossil-energy in those parts of the system devoted to food and fodder production. The hedges act as the source of renewable energy and regrow naturally after harvesting (coppicing) every 4-5 years. The CFE system is 150 m wide as composed of four blocks with lengths of 50, 100, 150 and 200 m separated by shelter-belts of willow, hazel and alder. This allows studies on energy balances, biodiversity, shelter effects and N- and C-balances in organic cropping systems (Kuemmel *et al.*, 1998).

Table 3. Crop rotations at KVL research farms, KVL-Taastrup.

Name	KV1	CFE
Areal (ha)	5	9
Init. year	1988	1995
Soil type	Sandy loam	Sandy loam
1. crop	S. barley	S. barley
2. crop	Grass/clover	Grass/clover
3. crop	Grass/clover	Beet
4. crop	W. wheat	S. oat
5. crop	Beet	

Askov (ASK)

In 1996 one of the four blocks (B_4-marken) of the Lermarken site of the Askov Long-Term Experiments on Animal Manure and Mineral Fertilizers (established 1894) was converted to an organic farming workshop area. This block includes treatments with cattle slurry (three levels) and solid manure (four levels) and unmanured plots. At the time of conversion, the nutrient levels were already different, capitalising on the previous long continued nutrient inputs.

Soil and plant material from the long-term Askov experiments have been used in numerous specific studies on soil processes. The experiments are described in Christensen et al. (1994) and examples of more recent studies are summarised by Christensen (1997), Guggenberger *et al*. (1996), Christensen and Johnston (1997), Rubæk *et al*. (1999), Randall *et al*. (1995) and Schjønning *et al*. (1994). The experiment has been used by several projects during the first phase of DARCOF projects.

Nutrient Cycling Experiment (NCE)

A project on "Plant production, nutrient household and crop protection on organic dairy crop rotations" was conducted during the period 1994 to 1997/98 in the FO1 experimental area (Askegaard *et al.*, 1999; Eriksen *et al.*, 1999). The experiment had two levels of cattle slurry corresponding to 0.9 and 1.4 LU ha^{-1} sand two different manure management systems, slurry and deep litter/slurry. There were only small differences between the treatments with respect to yields and nitrate leaching. In 1998 the treatments were therefore change to increase the differences between treatments. The levels of manure application were changed to 0.7 and 1.4 LU ha^{-1} and the manure systems are now pure slurry and pure deep litter. Yields, nitrogen balances and nitrate leaching are measured in all treatments.

Grass/clover experiment (GCE)

An experimental area is located at Foulum for research on the effect of grass/clover management on effects on following crops an on nitrate leaching. This experimental site was used during 1994-96 for an experiment on different levels of protein-intake in cattle for grass growth and milk yield under grazed conditions. Six grass fields with widely differing history was thus ploughed in 1997. The effect of the history of the pastures on cereal crop yield and nitrate leaching was determined during 1997-99 (Eriksen & Søegaard, in press). This area will be used during 2000-03 to study the effect of age and composition of the grass/clover field for nitrate leaching during the grass phase and for effect on cereal yield and nitrate leaching after incorporation. The crop rotations are shown in Table 4.

Table 4. Crop successions in the grass/clover experiment (GCE) at Foulum

Year	Rotation 1	Rotation 2	Rotation 3
1994	1. year grass	1. year grass	1. year grass
1995	2. year grass	2. year grass	2. year grass
1996	3. year grass	3. year grass	3. year grass
1997	S. barley	S. barley	4. year grass
1998	S. wheat	S. wheat	5. year grass
1999	Pea/barley	Pea/barley	6. year grass
2000	Cereal	1. year grass	7. year grass
2001	1. year grass	2. year grass	8. year grass
2002	Crop 1	Crop 1	Crop 1
2003	Crop 2	Crop 2	Crop 2

Crop rotation experiment (CRE)

A field experiment is conducted which focuses on different aspects of crop rotations for cereal production in organic farming (Olesen *et al.*, 1999b; Olesen *et al.*, submitted). Three factors are included in the experiment in a factorial design with two replicates: A) fraction of grass-clover and pulses in the rotation (crop rotation), B) catch crop (without or with catch crop or bi-cropped clover), and C) fertiliser (without or with animal manure applied as slurry). The crop rotations during the first four years of the experiment are shown in Table 5. All fields in all rotations are represented each year. The experiment is conducted at four locations, representing different soil types and climate regions, but not all crop rotations are represented at all sites (Table 6).

The first course of the rotation is completed by year 2000. The rotations will be adjusted slightly for the next rotation as suggested in Table 7. These changes will optimise each crop rotation with respect to nutrient management and opportunities for weed control. This follows recommendation of an international workshop on "Designing and testing crop rotations for organic farming", where these rotations were discussed (Olesen *et al.*, 1999a).

Table 5. Crop rotations with and without catch crops in the crop rotation experiment (CRE) in 1997-2000. The sign ':' indicates that a grass-clover ley, or a clover, ryegrass or ryegrass/clover catch crop is established in a cover crop of cereals or pulses. The sign '/' indicates a mixture of peas and spring barley or bi-cropping of winter cereals and clover.

Catch crop	Rotation 1	Rotation 2	Rotation 3	Rotation 4
Without	S. barley:ley	S. barley:ley	S. barley:ley	Spring oat
	Grass-clover	Grass-clover	Grass-clover	Winter wheat
	Spring wheat	Winter wheat	Winter wheat	Winter cereal
	Lupin	Peas/barley	Beet	Peas/barley
With	S. barley:ley	S. barley:ley	S. barley:ley	S. oat:clover
	Grass-clover	Grass-clover	Grass-clover	W. wheat/clover
	S. wheat:Grass	W. wheat:Grass	W. wheat:Grass	W. cereal/clover
	Lupin:Grass	Peas/barley:Grass	Beet	Peas/barley:Grass

Yield is measured in all plots at harvest. The contents of nitrogen, phosphorus and potassium in the yield are measured. The occurrence of weeds are recorded in all plots with cereals and pulses. Leaching of nitrogen and potassium is measured using porous ceramic cups in selected plots.

Table 6. Experiment sites and treatments in the crop rotation experiment.

Location	Soil type	Irrigation	Replicates	Crop rotations	Manure	Catch crop
Jyndevad	Sand	Yes	2	1+2	Without/with	Without/with
Foulum	Loamy sand	No	2	2+4	Without/with	Without/with
Flakkebjerg	Sandy loam	No	2	2+4	Without/with	Without/with
			2	3	With	With
Holeby	Loam	No	1	2+3+4	With	Without

Table 7. Crop rotations with and without catch crops in the crop rotation experiment (CRE) in 2001-2004. The sign ':' indicates that a grass-clover ley, or a clover, ryegrass or ryegrass/clover catch crop is established in a cover crop of cereals or pulses. The sign '/' indicates a mixture of peas and spring barley or bi-cropping of winter cereals and clover.

Catch crop	Rotation 1	Rotation 2	Rotation 3	Rotation 4
Without	W. rye:ley	S. barley:ley	S. barley:ley	Spring barley
	Grass-clover	Grass-clover	Grass-clover	Spring oat
	S. barley	W. wheat/rye	Winter wheat	Spring wheat
	Lupin	Lupin	Beet	Lupin
With	W. rye:ley	S. barley:ley	S. barley:ley	S. barley:clover
	Grass-clover	Grass-clover	Grass-clover	S. oat/clover
	S. wheat:Grass	W. wheat/rye:Grass	W. wheat:Grass	Spring wheat:Grass
	Lupin:Grass	Lupin:Grass	Beet	Lupin:Grass

The organic experimental station, Rugballegaard (RUG)

The organic experimental station, Rugballegaard, is mainly used for experiments with livestock (cattle and pigs) and to study the interactions between crops and livestock (Oudshoorn & Kristensen, 1999). The RUG experimental station has fields of different sizes, though never less than three ha´s. In 1996 three crop rotations representing different farming systems were established on an area of 140 ha (Table 8). The production of crops and livestock is recorded and nutrient balances are calculated at the field and farm levels. The measurements also include assessment of weeds, diseases etc. The measurements can be taken in reference areas or at field and system levels.

Table 8. Characteristics of the three systems at Rugballegaard.

System	Area with grass-clover (%)	Cereals	Feed import[1)] %	Livestock density [2)] (LU ha^{-1})	Manure import (kg N ha^{-1})	Total area (ha)
Dairy	60	40	10	1.1	0	34.9
Pigs	20	80	25	0.7	45	30.9
Dairy/pigs	40	60	15	1.0	0	71.0

[1)] Feed import calculated as Scandinavian Feed Units (SFU).
[2)] 1 livestock unit (LU) is equivalent to one 550 kg dairy cow or one sow with 20 pigs.

The dairy crop rotation is as follows, with field 5 split into two sub-fields:

1 Spring barley with undersown grass-clover.
2 Grass-clover 1st year
3 Grass-clover 2nd year
4 Grass-clover 3rd year
5.1*) Spring oats with undersown rye grass
5.2 Winter wheat

The pig crop rotation is as follows with fields 3 and 4 split into two sub-fields:
1 Spring barley with undersown grass-clover
2 Grass-clover 1st year
3.1 Spring oats with undersown rye grass
3.2 Winter wheat
4.1 Winter wheat
4.2 Spring oats with undersown rye grass
5 Spring barley/peas with undersown rye grass

The mixed dairy/pig crop rotation is as follows with fields 4 and 5 split into two sub-fields:
1 Spring barley/peas with undersown grass-clover
2 Grass-clover 1st year
3 Grass-clover 2nd year
4.1 Spring oats with undersown rye grass
4.2 Winter wheat
5.1 Winter wheat
5.2 Fodder sugar beets

5. Objectives and expected achievements

The aims of the experimental units for research in organic farming systems are three-fold:
4. To describe long-term effects of organic farming practices and crop rotations.
5. To function as workshop facilities for other, more specific research projects.
6. To assist in communication and dissemination of the results of research on organic farming.

The range of experimental sites covered by the project will provide information for all major organic farming practices and soil types in Denmark.

In order to accomplish these goals during the 5-year project period, the project is divided into seven workpackages:
WP1: Project coodination.
WP2: Workshop areas at Jyndevad, Foulum, Årslev, Flakkebjerg and Højbakkegaard.
WP3: Long-term fertilisation experiment at Askov.
WP4: Workshop area on grazing intensity and residual effects of pastures.
WP5: Experiment on nutrient management in organic dairy farming.
WP6: Crop rotation experiment
WP7: The organic experimental station Rugballegaard

6. Description of workpackages including methods

The funding for the EXUNIT project is based on two separate funds. The first fund is given for the entire project period but aimed specifically at the CRE and RUG experimental units (WP6 and WP7). The second fund is for the period 2000-2002 for all experimental units, and the condition is that these experimental units shall be integrated into the basic infrastructure of DIAS. The experimental units in WP2 to WP5 are therefore only budgetted in EXUNIT for the period 2000-2002. This does not mean that these experimental units will be closed at the end of 2002. Some changes will, however, need to be made, unless additional funding is found. The NCE experiment (WP5) ends in 2001 and will be reported by the end of 2002. This is not the case for the GCE experiment (WP4), which on the contrary has an increasing intensity of measurements in 2003 and 2004, and this will require other sources of funding to complete the experiment. Other sources of funding will also be needed to continue the CRE experiment (WP6) at its current intensity. From 2003 all experimental units in WP2 and WP3 will have to rely on basic funding from DIAS and KVL and on financial support from the projects that use them. This can result in a drastic reduction in the measurements conducted in reference areas in these experimental areas. The need for such measurements will be reviewed at the end of 2002.

Table 9. Workpackage list.

WP No	Work package title	Responsible participant	Budget 1000 DKK	Start	End	Deliverable No
1	Project coordination	JEO	251	2000/01	2004/12	D1-D4
2	Workshop areas at Jyndevad, Foulum, Årslev, Flakkebjerg and KVL-Taastrup (CFE, FL1, FL2, FO1, FO2, JYN, KV1, ÅR1, ÅR2)	JEO, IAR, KTK, HLP, HLJ, JR, JRP	2664	2000/01	2002/12	D1,D4,D5
3	Long-term fertilisation experiment (ASK)	BTC	250	2000/01	2002/12	D1,D4
4	Workshop area on grazing intensity and residual effects of pastures (GCE)	JE	407	2000/01	2002/12	D1,D4
5	Experiment on nutrient management in organic dairy farming (NCE)	MA, JE	627	2000/01	2002/12	D1,D4, D6-D7
6	Crop rotation experiment (CRE)	JEO, MA, IAR	8476	2000/01	2004/03	D1,D4, D8-D11
7	Organic experimental farm Rugballegård (RUG)	FWO	2345	2000/01	2004/12	D1,D4

WP1: Project coordination

Workpackage number:	1
Start date or starting event:	2000/01
Responsible person:	JEO
Contributing persons:	JEO
Person-months:	5

Objectives

- To coordinate the project plans and reporting between the experimental units
- To assist in planning field days for farmers at the sites
- To ensure the continuation of the existing high standards for management and measurements at all sites

Description of work

Standards for description of measurement protocols and schedules for crop management will be set up based on the experience of the CRE experiment (WP6). These standards will be communicated to all persons responsible for the experimental units. The measurement protocols and crop management schedules will subsequently be collected from all units and prepared as an internal report to function as a reference for projects that wish to use the experimental areas.

Fields days open to farmers and advisors will be held in June every year at all sites, if possible. These field days will be organised in collaboration with the DARCOF secretariat.

Annual reports will be prepared by collecting information from all involved experimental units. At the end of 2002 a review will be made on the use of all experimental units, and on the use and value of the measurements that are collected in the experimental areas in WP2 and WP7, which do not directly involve experimental treatments.

Deliverables

D1. Annual reports (20xx/10)
D2. Report on future status of experimental units (2002/12)
D3. Final report (2005/03)
D4. Field days for farmers and advisors (20xx/06)

Milestones

2002/12: End of external funding of most experimental units
2004/12: End of funding for the CRE and RUG units

WP2: Workshop areas at Jyndevad, Foulum, Årslev, Flakkebjerg and KVL-Taastrup

Workpackage number:	2				
Start date or starting event:	2000/01				
Responsible person:	JEO				
Contributing persons:	JEO	IAR	KTK	HLP	HLJ
Person-months:	2	3	3	1.5	1.5

Objectives
To provide workshop facilities for research projects on organic crop production and studies that are concerned with soil/plant interactions

Description of work
The existing workshop areas will be continued according to their current plans for the period 2000 to 2002. The only exception is the FO2 workshop area that will be closed by the end of 2000, because it has not be sufficiently used during the first phase of DARCOF projects and an initial evaluation of the second phase DARCOF projects does not indicate increase use of this workshop area.

Data and experience from the management of the workshop areas and the measurements in reference areas in each field will be compiled at the end of 2002 and form the basis for one or more newsletters for farmers and advisors.

Deliverables
D1. Contributions to annual reports in 2000 to 2002
D4. Field days for farmers and advisors (20xx/06)
D5. Fact sheets on the results from references areas in the workshop areas (2002/12)

Milestones
2002/12: End of external funding

WP3: Long-term fertilisation experiment at Askov

Workpackage number:	3
Start date or starting event:	2000/01
Responsible person:	BTC
Contributing persons:	BTC
Person-months:	1.5

Objectives

To provide a workshop area with a long history of different fertilisation management for studies on soil fertility related parameters

Description of work

The focus of the experiment is on the interactions between nutrient supply (type and amount of manure), soil properties, and the quality and quantity of crops. The experiment was included in the DARCOF I programme, and the previous research plan is maintained in the next period. The crop rotation is spring cereals undersown with grass/clover, grass/clover ley, winter cereals, and root crop. Equivalent dressings of N, P and K are given in cattle slurry (three levels) and in solid cattle manure + urine (four levels). Unmanured plots and plots given either P or K alone are included. The nutrient contents in the soil have been determined in 1997 and will be reanalysed in 2001 and 2005. Crop development during the growth period is registered and crop yields and N, P and K offtakes are determined at crop harvest.

Deliverables

D1. Contributions to annual reports in 2000 to 2002
D4. Field days for farmers and advisors (20xx/12)

Milestones

2002/12: End of external funding

WP4: Workshop area on grazing intensity and residual effects of pastures

Workpackage number:	4
Start date or starting event:	2000/01
Responsible person:	JE
Contributing persons:	JE
Person-months:	3

Objectives

To determine the importance of pasture age and composition on leaching losses in the grass phase of the crop rotation as well as precrop effects and leaching losses after ploughing of pastures.

Description of work

In the organic farming workshop area at Research Centre Foulum (Burrehøjvej) are four different grassland histories (grazed and cut grass-clover, grazed and cut pure grass). The original grassland histories were established in 1993 and a part was ploughed in 1997 (3 years old). This means that there is now connected plots of cultivated land and older pastures. Each plot is equipped with three ceramic suction cups for collection of soil water leaching from the root zone. Nitrate leaching is estimated from nitrate concentrations in percolation and the drainage volume. In the winter 2000-2001 it is possible in connected plots to compare leaching from cultivated land, 1st and 7th year pasture, and in the winter 2001-2002 is it possible to compare 1st, 2nd and 8th year pasture. The precrop effect from the combinations of pasture use and pasture age can be determined.

Deliverables

D1. Contributions to annual reports in 2000 to 2002
D4. Field days for farmers and advisors (20xx/06)

Milestones

2002/03: End of ley phase in the experiment, i.e. ploughing in of grass
2002/12: End of external funding

WP5: Experiment on nutrient management in organic dairy farming

Workpackage number:	5	
Start date or starting event:	2000/01	
Responsible person:	MA	
Contributing persons:	MA	JE
Person-months:	4	2

Objectives

To estimate the effect of different livestock densities and organic manure types on nitrate leaching and crop production in an organic dairy crop rotation

Description of work

Four treatments, two levels of manure application (70 and 140 kg total-N ha^{-1}) combined with two types of organic manure (cattle slurry and cattle deep litter) are applied to a six field crop rotation. Each of the six fields in the rotation is divided into four blocks with the treatments in plots of 15×18 m. Three ceramic suction cups are installed in each plot. Following one cut of herbage, the grass-clover fields are grazed by cattle. After spring ploughing the 2nd year grass-clover barley/pea/ryegrass is sown in a mixture which is harvested for silage in July/August. A ryegrass catch crop covers the field during winter. Oat undersown with ryegrass is established in the spring and after harvest the following summer, the ryegrass field is left undisturbed until the next spring when fodder beet is sown. The beets are harvested in October-November and in the spring, barley is sown with a mixture of white clover and ryegrass to establish the following grass-clover. Beet top and cereal straw are removed after harvest. The first experimental year with these treatments was 1998. Yield, nitrate leaching and N-balances in the fields and treatments are measured.

Deliverables

D1. Contributions to annual reports in 2000 to 2002
D4. Field days for farmers and advisors (20xx/12)
D6. A refereed paper on nitrate leaching and crop production as affected by livestock density and manure type (2002/12).
D7. A farmers magazine paper on nitrate leaching and crop production in a dairy crop rotation (2002/12)

Milestones

2002/04: End of the field experiment

WP6: Crop rotation experiment

Workpackage number:	6			
Start date or starting event:	2000/01			
Responsible person:	JEO			
Contributing persons:	JEO	MA	IAR	KK
Person-months:	13	13	13	3

Objectives

To explore the possibilities for both short-term and long-term increases in cereal production in organic farming by crop rotational design

To measure the effects of crop rotation, catch crops and manure application on crop production, nutrient leaching and occurrence of weeds, pests and diseases

To provide workshop facilities for research projects on effects of crop rotational design on soil fertility and plant growth

Description of work

The crop rotation experiment described under state-of-the-art is continued, but with the last full experimental year in 2003. The first course of the rotation will be completed by end of 2000. The design of the crop rotation and the measurements will be slightly adjusted for the second rotation based on experiences from the first rotation and on results of and international workshop on "Designing and testing crop rotations for organic farming" held in Denmark in 1999. The present plan for the revised design of the crop rotations is shown in Table 7.

All data from the first course of the crop rotation experiment will be available in June 2001. This will form the basis for a series of refereed journal papers on the effect of crop rotation design on crop production, nutrient flows, weeds, pests and diseases. The analysis of the data will include both effects on individual crops and crop sequences and effects at the crop rotation level using standard statistical methods. The data will also form the basis for a series of fact sheets on these factors directed towards farmers and advisors.

A manual with project guidelines is maintained and revised every year. The amount of registrations during the second course of the rotation will be reduced substantially, because of budget cuts. The experiment will be closed in 2003, one year before completion of the second rotation. Due to the experimental design this means that it will not be possible to make statistical comparisons for some of the measurements (e.g. nitrate leaching). Annual meetings will be held with all participating scientists and technicians twice per year, i.e. in a two-day winter meeting (February) and a one-day summer meeting (June).

Deliverables

D1. Contributions to annual reports in 2000 to 2002
D4. Field days for farmers and advisors (20xx/12)
D8. Papers (4-5) on results of the first complete course of the crop rotation (2002/02)
D9. Fact sheets on results of the first complete course of the crop rotation (2002/04)
D10. Article in a farmers magazine on previous years results (20xx/03)
D11. Articles (ca. 6 per year) on status of crops during each season (20xx)

Milestones
20xx/03: Revised project guidelines
2000/11: First course of the crop rotation experiment is completed
2004/11: Second course of the crop rotation experiment is completed

WP7: The organic experimental station, Rugballegaard

Workpackage number: 7
Start date or starting event: 2000/01
Responsible person: FWO
Contributing persons: FWO
Person-months: 12

Objectives

To provide workshop facilities for studies of the interactions of crop rotations and livestock
To make whole-farm assessments of innovative dairy and pig production systems
To demonstrate and communicate results on organic livestock systems

Description of work

The plans for the three crop rotations at Rugballegård will be reviewed and redesigned in order to better optimise the whole-farm production and nutrient balances. The experience and the data from the previous years will be of considerable value in this respect.

The measurements at the farm level provide a basis for introducing the many visitors to Rugballegaard to the innovative strategies of dairy and pig production systems that are present here, not the least the interaction between the crop/soil and the livestock production.

Deliverables

D1. Contributions to annual reports in 2000 to 2002
D4. Field days for farmers and advisors (20xx/06)

Milestones

2004/12: End of external funding

7. Implementation and time schedule

Table 10. Deliverables list.

Deliverable No	Deliverable title	Delivery date	Meeting[1]	Nature[2]
D1	Annual reports (2000-2004)	20xx/10	G1-G5	Re
D2	Report on future status of experimental units	2002/12		Re
D3	Final report	2005/03		Re
D4	Field days for farmers and advisors	20xx/06		Oral
D5	Fact sheets on the results from references areas in the workshop areas	2002/12		Pop
D6	Paper on nitrate leaching and crop production as affected by livestock density and manure type (NCE)	2002/12		Pu
D7	Article on nitrate leaching and crop production as affected by livestock density and manure type (NCE)	2002/12		Pop
D8	Papers (4-5) on results of the first complete course of the crop rotation experiment (CRE)	2002/02		Pu
D9	Fact sheets on results of the first complete course of the crop rotation experiment (CRE)	2002/04		Pop
D10	Article in a farmers magazine on previous years results (CRE)	20xx/03		Pop
D11	Articles (ca. 6 per year) on status of crops during each season (CRE)	20xx		Pop

[1]**G1-G5**: general meetings to be hold Nov. each year from 2000-2004
[1]**W1-WXX** workpackage meetings
[2]Please indicate the nature of the deliverable using one of the following codes:
Pu= International publications in books and journals
Re= Reports
Pro-in= Proceedings/abstracts at international symposia, conferences etc.
Pro-na= Proceedings/abstracts at national conferences etc.
Pop= Popular papers
Oral= Oral presentations, lectures etc.
Th= Theses
O= Others

Table 11. Time table.

8. Collaborative partners

The experimental units in EXUNIT have all been intensively used during the first phase of DARCOF coordinated projects, and it is envisaged that this use will continue during the second phase. The experimental units have also been used by students, both B.Sc., M.Sc. and Ph.D. students.

The project leader of EXUNIT organised an international workshop on "Designing and Testing Crop Rotations for Organic Farming" in June 1999. The proceedings of this workshop is published by Olesen *et al.* (1999a). Many of the experimental units in EXUNIT were presented at this workshop, which provided valuable information for the continuation of the organic crop rotation research in Europe. It is envisaged that the participants in the workshop will continue their collaboration, e.g. as part of an EU concerted action. Important aspects in such a collaboration are standardisation of measurement protocols and sharing of long-term data.

The EXUNIT project has links to a proposal for EU funding (INORG), which is coordinated by the the project leader of EXUNIT (Jørgen E. Olesen). The INORG proposal aims to apply simulation modelling to datasets from several long-term organic farming trials across Europe. The INORG project will also adapt a simple weed population model to these long-term trial data. The simulation models of crop and nitrogen dynamics will be linked with the weed population dynamics model using a crop/weed density response model. The INORG proposal will use data from the crop rotation experiment (CRE) to calibrate and validate these models. Some additional experimentation in CRE will also be conducted.

For the ASK experimental area soil organic matter quality and the nature of soil P pools have been examined in cooperation with University of Bayreuth (Georg Guggenberger) and Queen Mary and Westfield College, London (E.W. Randall). A comparative review of results from long-term Askov and Rothamsted experiments has been produced with A.E. Johnston, IACR-Rothamsted.

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Title: Experimental units for research in organic farming systems

Acronym: EXUNIT

Appendix

Research group

The research group is comprised of senior scientists and experienced agronomists from both Danish Institute of Agricultural Sciences (DIAS) and The Royal Veterinary and Agricultural University (KVL).

Curriculum vitae for Jørgen E. Olesen

Born on 28 October 1958. M.Sc. in agriculture from the Royal Veterinary and Agricultural Univerisity in Copenhagen, 1983. Senior scientist and head of research unit on Cropping Systems at Department of Crop Physiology and Soil Science.

Work

My research effort has concentrated on developing and applying models, especially in relation to the influence of weather on processes in the soil plant atmosphere continuum. This has included use of simulation models for assessing effects of climate change on crop production, development of a computer system for irrigation scheduling (MARKVAND), relation between weather factors and volatilisation of ammonia, methods for estimating evapotranspiration and modelling water balance from basins, and simulation of interaction between crop management and weeds, pests and diseases in winter wheat. I was project leader for a large interdisciplinary project on integrated crop protection in winter wheat and I have participated in three EU projects on the effect of climate change on agriculture (EPOCH, CLAIRE and CLIVARA). In the CLIVARA project, I developed methods for upscaling model results on effects of climate change to region and country levels. I have also been in change of projects on the use of satellite imagery and GIS for land use assessments. I was the leader of the team developing the soil-plant-atmosphere model in the FASSET whole farm simulation model, including adaptation of the model for organic farming. I am currently involved in a experiment on organic crop rotations for grain production, and I have recently (May 1999) organised an international workshop on Designing and Testing Crop Rotations for Organic Farming.

Other duties

Reviewer for a number of scientific journals, including J. Agric. Sci., Eur. J. Agron., Clim. Res. and Acta Agric. Scand.
External reviewer at the Royal Agricultural and Veterinary University, Copenhagen.
Assistant supervisor for 3 Ph.D. students and 1 M.Sc. student.

Recent relevant publications

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Sommer, S.G. & Olesen, J.E. (in press). Modelling ammonia volatilization from animal slurry applied to cereals. *Atmospheric Environment.*

Curriculum vitae for Bent Tolstrup Christensen

- 9. May 1952: born in Glim near Roskilde, parents farmers
- September 1972: matriculated at University of Copenhagen, biology
- December 1979: cand. scient. degree in biology/ecology (equiv. Ms.)
- ultimo 1980: guest researcher at Merlewood Research Station (UK)
- January 1981: scientist at Askov Experimental Station, The Danish Institute of Plant and Soil Science
- July 1988: appointed Head of Department for Plant Nutrition and Physiology, Askov
- January 1994: Head of Organic Matter Research Group, Research Centre Foulum
- 1995-1997: Co-ordinator of Danish Centre for Root Zone Processes financed by The Danish Environmental Research Programme
- 1995-2000: Head of research programme: Rhizodeposition in Arable Soils - Effect of Climate Change, financed by The Agricultural and Veterinary Research Council

Experience

External censor (B.Sc., MA, Ph.D., Docent) at the Universities of Copenhagen, Odense, Aalborg and Aarhus, The Royal Veterinary and Agricultural University, Swedish University of Agricultural Sciences, and University of Guelph. Member of evaluation committees for assistant and associate professorships and research professor (University of Copenhagen, The Royal Veterinary and Agricultural University), research director (National Environmental Research Institute), and scientist and senior scientist positions (Danish Institute of Agricultural Sciences, Risø National Laboratory). Member of research programme committees on Green Fields, Sustainable Agriculture (Danish Ministry of Food, Agriculture and Fisheries), The Danish Environmental Research Programme (Soil Surface/Upper Soil Layers), The Danish Agricultural and Veterinary Research Council (Microbial Processes in the Rhizosphere), and evaluation panel for the Square Grid Project. Peer reviewer and evaluator of research proposals for Danish, Swedish, UK, USA and Australian research granting bodies. Appointed foreign member of The Royal Swedish Academy of Agriculture and Forestry. Member of Editorial Board for Applied Soil Ecology, Soil Use and Management and Field Crops Research, and referee on 68 papers for 12 different journals.

Author, senior-author and co-author on 121 publications of which 43 are in international, refereed scientific journals and 19 are book chapters or conference proceedings. Most publications relate to decomposition of plant residues, soil organic matter turnover, nitrogen cycling in arable soils, leaching of nitrate and volatilization of ammonia from animal manure.

Recent publications

Christensen, B.T., Meyer, N.I., Nielsen, V. & Søgaard, C. (1996): Biomasse til energi og økologisk jordbrug. Rapport nr. R-002, Institut for Bygninger og Energi, Danmarks Tekniske Universitet, Lyngby.

Christensen, B.T. (1997): Kvælstofomsætning i jord - Hvorfor tager det tid at reducere nitratudvaskningen. JordbrugsForskning 1, nr. 2, september/oktober, 7-11.

Christensen, B.T. & Johnston, A.E. (1997): Soil organic matter and soil quality: Lessons learned from long-term field experiments at Askov and Rothamsted. In E.G. Gregorich & M.R. Carter (Eds.): Soil Quality for Crop Production and Ecosystem Health. Elsevier Science Publ., Amsterdam, 399-430.

Thomsen, I.K. & Christensen, B.T. (1998): Cropping system and residue management effects on nitrate leaching and crop yields. Agriculture, Ecosystems & Environment 68, 73-84.

Thomsen, I.K. & Christensen, B.T. (1999): Nitrogen conserving potential of successive ryegrass catch crops in continuous spring barley. Soil Use and Management 15, 195-200.

Jensen, B., Sørensen, P., Thomsen, I.K., Jensen, E.S. & Christensen, B.T. (1999): Availability of nitrogen in nitrogen-15 labeled ruminant manure components to successively grown crops. Soil Science Society of America, Journal 63, 416-423.

Curriculum vitae for Jørgen Eriksen

1967-82 Date of Birth: 2 February 1967. Grew up on a farm.
1982-85 High school at Lemvig Gymnasium.
1985-86 Basic agricultural traning course at Kongensgaard Landbrugsskole followed by work in practical farming.
1986-91 Agronomy studies at The Royal Veterinarian and Agricultural University.
1991-94 Ph.D. studies at The Royal Veterinarian and Agricultural University and the Danish Institute of Plant and Soil Science.
1994-96 Scientist at Department of Soil Science, Danish Institute of Plant and Soil Science.
1997- Senior Scientist at Department of Plant Physiology and Soil Science, DIAS.

Education
M.Sc.(Agric) from The Royal Veterinarian and Agricultural University January 1991.
Ph.D. in Plant Nutrition from The Royal Veterinarian and Agricultural University December 1994

Studies abroad
February-August 1993: 6 month stay at University of New England, Australia. Collaboration with Assoc. Prof. Graeme Blair and his group on sulphur in soil.

Activities in DARCOF-1
Project leader in programme III.6 Precrop effects and leaching following grass-clover (workshop area)
Project leader in programme V.2 Nutrient balances in organic pig production
Project partner in programme I.2 N-fixation, recirculation og leaching.
Project partner in programme III.9 Nutrient management in an organic dairy crop rotations (workshop area)
Project partner in programe IV.1 Availability and utilization of potassium, phosphorus and sulphur.

New relevant publications

1. Eriksen J. & Søegaard K. (2000) Nitrate leaching following cultivation of contrasting temporary grassland. *Grassland Science in Europe*. In press.
2. Eriksen J. & Askegaard M. (2000) Sulphate leaching in an organic crop rotation on sandy soil in Denmark. *Agriculture, Ecosystems and Environment* 78: 107-114.
3. Eriksen J., Askegaard M. & Kristensen K. (1999) Nitrate leaching in an organic dairy/crop rotation as affected by organic manure type, livestock density and crop. *Soil Use and Management* 15: 176-182.
4. Eriksen J. & Mortensen J. (1999) Soil sulphur status following long-term annual application of animal manure and mineral fertilizers. *Biology and Fertility of Soils* 28: 416-421.
5. Jensen L.S., Mueller T., Eriksen J., Thorup-Kristentsen K. & Magid J. (1999) Simulation of plant production and N fluxes in organic farming systems with the soil-plant-atmosphere model DAISY. In "Designing and testing crop rotations for organic farming" (Eds. Olesen, J.E., Eltun, R., Gooding, M.J., Jensen, E.S. and Köpke, U.) DARCOF Report no. 1.
6. Eriksen J. & Høgh-Jensen H. (1998) Variations in the natural abundance of ^{15}N in ryegrass/white clover shoot material as influenced by cattle grazing. *Plant and Soil* 205: 67-76.

Curriculum vitae for Hanne Lipczak Jakobsen

1996 -	University Farms Manager, KVL i Taastrup
1987-1996	Research assistant at Danish Institute of Agricultural Science, Lyngby *Projects:* Model of forecasting for downy mildew in onions. Leek rust - epidemiology, forecasting and taxonomic description. Influence of leaf diseases on growth of carrots. Epidemiology and forecasting for Sclerotinia sclerotiorum in oil seed rape. Pesticide efficiency testing - including implementation of GLP in efficiency testing procedures. *Ph.D.-course:* Advanced Plant Pathology at KVL *Nordic Research Courses (Ph.D.-level)*: Plant Diseases and Crop Loss Assessment, NLH, Diagnosis of Plant Pathogens, Finland
1985-86	Research assistant at Danish Instutute of Agricultural Science, Aarslev *Project:* Possibilities for reduced pesticide usage in apple orchards.
1985	MS Horticulture from KVL. Thesis on plant pathology.

Curriculum vitae for Kristian Thorup-Kristensen

1987 M.Sc. in agriculture from The Royal Vet. and Agricultural Univ. (KVL)
1995 Ph.D. degree in Plant Nutrition and Soil Fertility

1987 to 1988, Scientist at The Royal Vet. And Agricultural Univ.
1989 to 1997 Scientist at the Danish Inst. Agric. Sci.
Since 1997 Senior Scientist at the Danish Inst. Agric. Sci.
Since 1998 Head of Research group for Vegetable production, Danish Inst. Agric. Sci.

Censor at KVL, Institute of Agricultural Science
Co-supervisor for two PhD students, one at KVL and one at The Sweedish Agricultural University og en ved Sveriges Landbrugs Universitet i Uppsala.

Research interests

The main topics have been N utilization, root growth of vegetables and catch crops and effect of catch crops and green manure and organic crop rotations. The work has focused on growth, and the significance of differences in root growth for N utilization. The research has also been directed at applied aspects of this, how to improve the utilization of catch crops and green maures to design crop rotations with higher NUE and lover losses. The results have been communicated through 13 papers in scientific journals, more than 20 papers in proceedings from workshops etc., and 25 papers in farmers journals etc.

Recent publications

Thorup-Kristensen, K and Van den Boogaard, R. 1998 Temporal and spatial root development of cauliflower (Brassica oleracea L. var. botrytis L.), Plant and Soil 201: 37-47

Thorup-Kristensen, K and Nielsen, N.E. 1998 Modelling and measuring the effect of nitrogen catch crops on nitrogen supply for succeeding crops. Plant and Soil 203: 79-89.

Thorup-Kristensen, K. 1998. Root development of green pea (*Pisum sativum* L.) genotypes, Crop Science 38: 1445-1451.

Thorup-Kristensen, K and Van den Boogaard, R. 1999 Vertical and horizontal development of the root system of carrots following green manure. Plant and Soil 212: 145-153

Thorup-Kristensen, K. (submitted) Are differences in root growth of nitrogen catch crops important for their effect on nitrogen leaching losses? Submitted to Plant and Soil

Thorup-Kristensen, K. (1999) An organic vegetable crop rotation self-sufficient in nitrogen. In: Olesen, J.E., Eltun, R., Gooding, M.J., Jensen, E.S. & Köpke, U. (Eds) Designing and testing crop rotations for organic farming. DARCOF Report no. 1. p 133-140

Curriculum vitae for Frank Willem Oudshoorn

1984: M.Sc. Agriculture, Wageningen (NL)
1984-1985: Academic assistant at the section for alternative agriculture,at the agricultural university, Wageningen,for professor J.D. van Mansvelt.
1987-1998: Farm adviser in Vejle Amts Familielandbrug. The last 5 years mainly occupied with organic agriculture.
1998- : Manager of the organic experimental farm Rugballegård.

The main tasks at the organic experimental station Rugballegård are:

- To manage and develop the organic systems.
- To represent and communicate results and the organic research program to all interested.

- To direct and coordinate the activities

This demands contacts to both research and practical organic agriculture as well as maintenance of all up to date knowledge on organic growing and organic animal husbandry.

Curriculum vitae for Hanne Lindhard Pedersen

M. Sc. Horticulture, KVL. (1987). Scientist at Department of Fruit and Berries (1987). PhD minor in Plant Pathology and Entomology, KVL (1995). Ph.D. in Pomology, KVL (1996). During this period visiting scientist 6 months at Hort+Research in New Zealand. Senior Scientist (1997). Head of research unit Fruit and Berries (1997). Visiting scientist 4 month at Hort+Research in New Zealand (1999-2000).

Hanne Lindhard is supervisor for 2 PhD student and supervisor for 2 Master students.

Recent publications

Lindhard Pedersen H. and Hansen P. 1997. Effect of timing of nitrogen supply on growth, bud, flower and fruit development of young sour cherries (*Prunus cerasus* L.). Scientia Horticulturae, 69, 181-188.

Lindhard Pedersen H. 1997. Alleyway groundcover management impacts on soil, pests and yield components in blackcurrants (Ribes nigrum L.). Biological Agriculture and Horticulture, 14, (2), 159-169.

Lindhard Pedersen H. and Løschenkohl B. 1997. Testing of a warning system against cherry leaf spot (*Blumeriella jaapii*). Gartenbauwissenschaft, 62 (5), 197-201.

Lindhard Pedersen H. 1998. Field resistance of black currant cultivars (*Ribes nigrum* L.) to diseases and pests. Fruit Varieties Journal, 52 (1): 6-10.

Lindhard Pedersen H. 1999. Alternative all'uso degli erbicidi per il controllo delle erbe infestanti nel meleto. (Alternatives to herbicides in controlling weed in apples). Rivista di Frutticoltura e di ortofloricoltura. Vol, LXI, 10, 81-83.

Curriculum vitae for Margrethe Askegaard

Royal Veterinary and Agricultural University, Copenhagen, Denmark, M.Sc. (Agronomy, plant husbandry), 1980.

1993-date Scientist, DIAS, Dept. of Crop Physiology and Soil Science
1983-1993 Advisor, Agricultural Extension Service
1980-1983 Instructor, Agricultural Schools.

Main research activities

Project leader of a project on nutrient management in an organic dairy crop rotation. Participating project leader of a project on organic crop rotations for grain production. Project leader of a project on availability and utilisation of potassium, phosphor and sulphur in the soil-plant system in organic plant production. Ph.D. project on potassium dynamics in organic farming as main objective. Project leader of a project on plant production, nutrient management and crop protection on organic dairy farms. Participant in a project on plant production, nutrient management and crop protection on organic dairy farms.

Recent publications

Askegaard, M.& Eriksen, J. 2000. Potassium leaching and retention in an organic crop rotation on loamy sand (submitted to Soil Use and Management).

Askegaard, M., Rasmussen, I.A. & Olesen, J.E. 1999. Agronomic considerations and dilemmas in the Danish crop rotation experiment. In: Olesen, J.E., Eltun, R., Gooding, M.J., Jensen, E.S. & Köpke, U. (Eds) Designing and testing crop rotations for organic farming. DARCOF Report no. 1, 63-69.

Askegaard, M., Eriksen, J., Søegaard, K. & Holm, S. 1999. Nutrient management and plant production in four organic dairy farming systems In: Olesen, J.E., Eltun, R., Gooding, M.J., Jensen, E.S. & Köpke, U. (Eds) Designing and testing crop rotations for organic farming. DARCOF Report no. 1, 257-265.

Eriksen J. & Askegaard M. 2000. Sulphate leaching in an organic crop rotation determined by the ceramic suction cup technique. Agriculture, Ecosystems & Environment (in press).

Eriksen, J., Askegaard, M. & Kristensen, K. 1999. Nitrate Leaching in an organic dairy/crop rotation as affected by organic manure type, livestock density and crop. Soil Use and Management, 15, 176-182.

Olesen, J.E., Askegaard, M.A. & Rasmussen, I.A. Design of an organic farming crop rotation experiment serving multiple purposes (submitted to Acta Agriculturae Scandinavica, Section B, Soil and Plant Science)

Curriculum vitae for Ilse A. Rasmussen

1985	Master of Science in Agriculture. Thesis: Weed control in organic farming.
1989-	Scientist at the Department of Crop Protection, DIAS
1986-1989	Agricultural advisor for organic farming in Frederiksborg County
1984-1985	Teacher in organic farming at St. Restrup Peoples College

Research profile

Organic farming - crop rotations and weed control. Mechanical weed control and prevention in cereals and oil seed rape. Population dynamics of weeds, weed seed production and soil seed reserve. Weed control in organic farming is the most important part of my work. An important part is the experiment with organic crop rotations for cereal production. I am responsible for the organic research area of 25 ha. at Research Centre Flakkebjerg, including crop rotation, choice of varieties, fertilisation, catch crops, strategies for prevention and control of pests, diseases and weeds. I conduct experiments with prevention and control of weeds in cereals and oil seed rape. My work include weed seed production and the soil seed reserve. My work was earlier concentrated on growing malting barley without the use of pesticides and weed seed production with reduced doses of herbicides.

Recent publications

Andersen, B.; Thrane, U.; Svendsen, A. & Rasmussen, I.A. (1996): Associated field mycobiota on malt barley. Canadian Journal of Botany, 74 (6), 854-858.

Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (1999): Weed control in organic crop rotations for grain production. In: *Proceedings of the 11th EWRS (European Weed Research Society) Symposium 1999, Basel*, p. 98.

Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (1999): Plant protection in organic crop rotation experiments for grain production. In: *Designing and testing crop rotations for Organic farming* (Eds. J.E. Olesen, R. Eltun, M.J. Gooding, E.S. Jensen & U. Köpke). FØJO-report no. 5. Denmark: Researach Centre Foulum (in press).
Rasmussen, I.A.; K. Kristensen & S. Stetter (1995): Growing malting barley without the use of pesticides. In: BCPC Symposium Proceedings no. 63: "Integrated Crop Protection: Towards Sustainability?": 431-438.
Rasmussen, I. A. (1993): Seed production of a mixture of two Polygonum species at normal to very low herbicide doses. In: Brighton Crop Protection Conference - Weeds. I. pp. 281-286.
Rasmussen, I.A. (1993): Seed production of Chenopodium album in spring barley sprayed with different herbicides in normal to very low doses. In: T. Eggers (ed.) Quantitative approaches in weed and herbicide research and their practical application. 2. Braunschweig. (Proceedings of the 8th Symposium of the EWRS) pp. 639-646.