Danish Research Centre for Organic Farming

Annual Status Report 2001 and Application for Continuation in 2002

For research projects financed by grants from
The Directorate for Food, Fisheries and Agro Business
under the Danish Ministry of Food, Agriculture and Fisheries

1. Research program

Research in organic farming 2000-2005 (DARCOF II)

2. Project title and number

IV Experimental units for research in organic farming systems (EXUNIT)

3. Head of project

Senior scientist Jørgen E. Olesen
Danish Institute of Agricultural Sciences
Department of Crop Physiology and Soil Science
Research Centre Foulum
P.O. Box 50, DK-8830 Tjele
Tel. +45 89991659
Fax. +45 89991619
E-mail: JorgenE.Olesen@agrsci.dk

4. Participating institutes

Danmarks JordbrugsForskning
Forskningscenter Foulum
Postboks 50
8830 Tjele
Tlf. 89991900
Fax. 89991919
E-mail: djf@agrsci.dk

KVL
Forsøgsgårdene KVL
Agrovej 10
2630 Taastrup
Tlf. 35283526
Fax. 35283580
E-mail: halj@kvl.dk

Grønt Center
Maribovej 9
4960 Holeby
Tlf. 54607000
Fax. 54606905
E-mail: mail@greencenter.dk

5. Contact persons

Forskningsleder Jørgen E. Olesen, DJF, Afd. for Plantevækst og Jord, Postboks 50, 8830 Tjele, Tlf. 89991659, Fax. 89991619, E-mail: JorgenE.Olesen@agrsci.dk

Driftschef Hanne L. Jacobsen, KVL, Forsøgsgårdene KVL, Agrovej 10, 2630 Taastrup, Tlf. 35283526, Fax. 35283580, E-mail: halj@kvl.dk

Direktør Birgit Hartvig Larsen, Grønt Center, Maribovej 9, 4960 Holeby, Tlf. 54607000, Fax. 54606905, E-mail: mail@greencenter.dk

6. Other project staff

Forskningsleder Jørgen E. Olesen (JEO), Afd. for Plantevækst og Jord, Postboks 50, 8830 Tjele, Tlf. 89991659, Fax. 89991619, E-mail: JorgenE.Olesen@agrsci.dk.

Forsker Margrethe Askegaard (MA), Afd. for Plantevækst og Jord, Postboks 50, 8830 Tjele, Tlf. 89991702, Fax. 89991719, E-mail: Margrethe.Askegaard@agrsci.dk.

Afdelingsforstander Bent T. Christensen (BTC), Afd. for Plantevækst og Jord, Postboks 50, 8830 Tjele, Tlf. 89991709, Fax. 89991719, E-mail: BentT.Christensen@agrsci.dk.

Seniorforsker Jørgen Eriksen (JE), Afd. for Plantevækst og Jord, Postboks 50, 8830 Tjele, Tlf. 89991870, Fax. 89991719, E-mail: Jorgen.Eriksen@agrsci.dk.

Seniorforsker Hanne Lindhard Pedersen (HLP), Afd. for Prydplanter og Vegetabilske Fødevarer, Forskningscenter Årslev, Kirstinebjergvej 10, Postboks 102, 5792, Årslev, Tlf. 63904171, Fax. 63904396, E-mail: Hanne.Lindhard@agrsci.dk.

Driftschef Hanne L. Jacobsen (HLJ), Forsøgsgårdene KVL, Agrovej 10, 2630 Taastrup, Tlf. 35283526, Fax. 35283580, E-mail: halj@kvl.dk

Seniorforsker Kristian Kristensen (KK), Afd. for Jordbrugssystemer, Postboks 50, 8830 Tjele, Tlf. 89991209, Fax. 89991200, E-mail: Kristian.Kristensen@agrsci.dk.

Professor John R. Porter (JRP), KVL, Agroøkologi, Agrovej 10, 2630 Tåstrup, Tlf. 35283377, Fax. 35282175, E-mail: jrp@kvl.dk.

Videnskabelig leder Frank W. Oudshoorn, Rugballegård Forsøgsstation, Postboks 536, 8700 Horsens, Tlf. 76296106, Fax. 76296102, E-mail: Frank.Oudshoorn@agrsci.dk.

Forsker Ilse A. Rasmussen (IAR), Afd. for Plantebeskyttelse, Forskningscenter Flakkebjerg, 4200 Slagelse, Tlf. 58113394, Fax. 58113301, E-mail: IlseA.Rasmussen@agrsci.dk

Lektor Jesper Rasmussen (JR), KVL, Agroøkologi, Agrovej 10, 2630 Tåstrup, Tlf. 35283456, Fax. 35282175, E-mail: jer@kvl.dk.

Forskningsleder Kristian Thorup-Kristensen (KTK), Afd. for Prydplanter og Vegetabilske Fødevarer, Forskningscenter Årslev, Kirstinebjergvej 10, Postboks 102, 5792, Årslev, Tlf. 63904128, Fax. 63904394, E-mail: Kristian.ThorupKristensen@agrsci.dk

7. Start of project: 2000
End of project: 2004

8. Annual report/Application for continuation in 2001

A. Objectives and expected achievements (from application)

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.

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 KVL-Taastrup
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

B. Project summary (from application)

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.

Table 1: Work package list (from application)

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

* Responsible participants are underlined

C. Progress

C.1 Annual description (resume) of main results and conclusions

WP1. Project coordination

Field days has been organised at all experimental units in collaboration with DARCOF. In addition all experimental units have had several visits from farmers, agricultural advisors, researchers and the public general.

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

Jyndevad
The experimental area at Jyndevad is divided into seven fields and the crop rotation is spring barley, grass/clover, grass/clover, grass/clover, spring oat, winter rye and potatoes. Each of these fields is subdivided into five manure treatments. The yields in 2001 are shown in Table 1 for each of the manure treatments.

Table 1. Yields (hkg/ha) in the manure treatments at Jyndevad in 2001. The spring barley was taken as whole crop for silage, and yields here are dry matter.

Manure treatment	Potatoes	Oats	Winter rye	Spring barley
No manure	131	46	20	36
0.8 LU/ha in slurry	258	49	24	77
1.4 LU/ha in slurry	326	51	30	92
0.8 LU/ha in deep litter	233	55	16	50
1.4 LU/ha in deep litter	258	50	26	60

Foulum
Only one experimental area is maintained at Foulum with EXUNIT, a dairy farm rotation. This dairy farm rotation has been managed organically since 1987. Yields are recorded in a reference area, but yields from 2001 are not yet available. An analysis of yields, nutrient balances and soil contents of K and P for the period 1987 to 1998 have shown that the soil contents of P and K are stable. The P and K applied in manure are almost in balance with the nutrients removed by the crops. The yield level was consistently high with cereal yields of about 5 t DM/ha, whole crop cereal yield and yield of first grass cuts of about 8 t DM/ha and fodder beet yields of about 15 t DM/ha.
Årslev - vegetables

The vegetable crop rotation has been continued as in the previous years, including measurements of yields, uptake of N, P, K and S and removal in harvested products, and measurements of soil mineral nitrogen. The yield levels now seem to have stabilised, in the spring barley crops at a lower level than during the first years, but in the vegetable crops at a higher leves. The yield level of spring barley are around 5, 4.5 and 3.5 t/ha after pea, cabbage and leek respectively, quite high considering the well developed undersown clover grass established together with each barley crops. No exhaustion of the soil is thus indicated by the crop yields, nutrient concentrations in the harvested products (N, P and K), or the N_{min} samples of the soil, though the most recent analysis for soil K and P indicated some reduction since the start of the rotation.

Årslev - fruits and berries
The trials planted in the research area is shown in Table 2. Only the black currant trials are financed by EXUNIT. The other trials have alternative funding. The two last apple trials are not established yet, but are planned. They will be planted in early spring 2001 and 2002, respectively.

Table 2. Trials carried out in the fruit and berries research area at Årslev.

Crop	Estab. year	Experiment
Black currants	1997	Susceptibility of sulphur for 3 black currant varieties
	1996	Unsprayed black currant varieties
	1996	Cover crops as fertiliser in 5 varieties
	1996	Black currants on legs
Strawberries	1999	Unsprayed varieties
Mini-kiwi	1996	Unsprayed varieties
Rose hips	2000	Unsprayed clones
	2000	Soil treatment, including irrigation and fertilisation
Apples	1996	Trial to determine the present races of *Ventura inaquealis*
	1994	Cover crops in apple scab resistant varieties
	2002	Early testing of new resistant selections
	2001	Reducing apple scab infection risk using cultural methods

Table 3. Susceptibility of black currant cultivars to sulphur. Scores are indexed 1 to 9 with 1 being no damage.

Variety	Sulphur	Yield (kg/bush)				Scores, July 2000			
		1998	1999	2000	2001	Scorch	Discolor	Leaf-drop	Mildew
Ben Alder	0	0,22	0,54 a	0,43 a	1.1	2.1 a	2.4 d	2.2 b	1.8 a
	2	0,20	0,65 a	0,47 a	1.3	2.0 a	3.2 bc	3.0 a	1.5 a
	4	0,20	0,53 a	0,38 a	1.2	2.0 a	3.8 ab	3.0 a	1.5 a
	6	0,18	0,58 a	0,41 a	1.3	2.0 a	4.0 a	3.1 a	1.4 a
	8	0,18	0,65 a	0,49 a	1.2	2.0 a	3.7 ab	3.3 a	1.4 a
Ben Lomond	0	0,11	0,01 a	0,06 a	0.2	2.2 a	3.2 b	3.0 a	4.0 bc
	2	0,13	0,01 a	0,06 a	0.2	1.9 bc	3.3 ab	3.0 a	4.4 a
	4	0,10	0,01 a	0,07 a	0.2	2.0 abc	3.4 ab	3.1 a	3.8 c
	6	0,10	0,02 a	0,08 a	0.3	2.1 ab	3.3 ab	3.1 a	4.4 a
	8	0,11	0,01 a	0,05 a	0.2	1.8 c	3.9 a	3.2 a	1.8 a
Titania	0	0,50	0,54 a	0,31 b	0.3	2.1 a	2.8 d	2.4 c	1.0 a
	2	0,37	0,62 a	0,39 a	0.5	2.0 a	4.2 c	3.2 b	1.0 a
	4	0,46	0,58 a	0,23 ab	0.2	2.0 a	4.5 b	3.3 b	1.0 a
	6	0,39	0,57 a	0,32 ab	0.3	2.0 a	4.9 a	3.9 a	1.0 a
	8	0,44	0,59 a	0,28 ab	0.3	2.0 a	4.9 a	3.9 a	1.0 a

To control powdery mildew in black currants sulphur is sprayed every 2 weeks from April to before harvest. In the susceptible variety Ben Lomond the sulphur had a small effect on powdery mildew in 1999 but not in 2000. The leaf drop in July was reduced in 1999, whereas the discolouring of the leaves increased with the sulphur concentration in 1999 and 2000. The yield was not effected (Table 3).
The varieties ‘ Ben Loyal’ had the highest yields under unsprayed conditions in 1998-2000 (Table 4).

Ben Loyal is also rather resistant to the 3 main diseases in black currants. ‘Ben Lomond’, ‘Thena’, ‘Otello’ and ‘Phoenix’ had the highest level of mildew.

Table 4. Unsprayed black currant varieties. Yield in kg/bush. The infection rated on a scale 1 to 10 (1 is no infection).

Variety	Yield			Mildew	Leaf spot	White pine blister rust
	1999	2000	2001			
Ben Lomond	0,2 e	0.9 fg	1.6	3.4 b	2.9 ab	1.7 cde
Ben Loyal	3,6 a	8.4 a	7.6	1.0 d	1.0 d	1.4 ef
Ben Nevis	0,2 e	0.8 fg	1.9	2.5 c	2.5 b	1.0 f
Cie 5-32	0,5 e	1.8 ef	1.5	1.0 d	1.8 cd	2.9 a
Cie 5-63	2,1 b	3.2 bc	6.0	1.0 d	1.5 cd	1.9 bcde
Haakon (N7)	1,0 d	2.3 cd	3.2	1.0 d	1.1 d	1.4 ef
Kristin (N8)	1,5 c	4.4 b	1,6	1.0 d	1.0 d	1.4 ef
Otelo	0,2 e	0.7 fg	1.5	3.5 b	3.2 a	2.1 bcd
P-8-5-24	1,8 bc	3.2 cd	2.9	1.0 d	1.0 d	2.4 ab
Phoenix	0,02 e	0.04 g	.	4.0 a	3.2 a	1.6 def
Ben Rua	0,4 e	1.6 ef	0.1	2.9 c	3.0 ab	1.8 bcde
Sunniva	0,3 e	1.5 ef	0.4	1.0 d	1.2 cd	2.9 a
Tenah	0,2 e	1.3 ef	0.9	3.4 d	2.8 ab	2.2 abcd
Tsema	0,3 e	1.4 ef	1.1	2.9 c	1.4 cd	2.3 abc

The best yielding varieties in 2001 are ‘Titania’, ‘Ben Alder’, and ‘Intercontinantal’. Whereas ‘Farleigh’ had a very low yield in 2001, due to late winter frost. ‘Ben Lomond’ is very susceptible to powdery mildew (Table 5). ‘Farleigh’ are susceptible to rust and ‘Titania’ is rather resistant. There were a medium attack of leaf spot in 1999 and 2000. Treatment 1 had tendency towards a higher yield for ‘Titania’ and ‘Ben Alder’ in 2000 and 2001.

Two varieties of black currants are established on leg or as normal deep plantings (Table 6). The idea of legs is that the mechanical herbicide cleaning should be more effective under the scrubs. In 2000 and 2001 the yield were smaller for the plants on legs. The reason was a smaller bush with fewer branches. There was a slightly bigger infection of leaf spot in the bushes on legs in 1999 and 2000, probably because of a more dense structure. The infestation of aphids was smaller on legs in 2000.

Flakkebjerg

The cereal-based crop rotation has been unchanged and remains: spring barley with undersown alfalfa, two years of alfalfa, spring oats, winter wheat with undersown catch crop, spring barley mixed with peas undersown with catch crop, sugar beets. Only spring barley, winter wheat and sugar beets receive manure.

Table 5. Effect of soil cover on yield and disease incidence in black currant. Diseases are scored from 1 to 9 (1 is no disease). The soil treatments are: 1) Clean from April to July then annual cover crop, 2) Clover grass and mulching, 3) Clover grass and slurry, 4) Clover grass.

Variety	Soil	Yield (t/ha)			Mildew	Rust	Leaf spot
	Treatment	1999	2000	2001	July	July	July
Ben Alder	1	2,3a	2,1 a	5.0	1.6 a	1.5 a	3.3 a
	2	2,1a	1,6 a	4.0	1.5 a	1.6 a	3.0 ab
	3	1,9a	1,4 a	3.9	1.4 a	1.7 a	3.0 ab
	4	2,0a	1,7 a	4.4	1.4 a	1.7 a	2.0 b
Ben Lomond	1	0,02a	0,6 a	2.4	3.2 a	1.2 a	3.4 a
	2	0,02a	0,5 a	1.9	3.1 a	1.2 a	3.5 a
	3	0,03a	0,6 a	2.6	2.9 a	1.3 a	3.1 b
	4	0,01a	0,7 a	2.7	3.2 a	1.4 a	3.1 b
Intercontinetal	1	3,2a	2,5 a	5.2	1.0 a	0.0 a	3.1 a
	2	3,6a	2,7 a	4.8	1.0 a	0.0 a	2.6 ab
	3	3,8a	2,2 a	4.3	1.0 a	1.0 a	2.5 b
	4	3,7a	2,0 a	5.7	1.0 a	1.0 a	2.3 b
Farleigh	1	1,7a	3,7 a	0.4	1.0 a	1.6 a	5.0 a
	2	2,1a	3,4 a	0.3	1.0 a	1.8 a	5.3 a
	3	2,1a	3,7 a	0.1	1.0 a	1.9 a	5.1 a
	4	1,4a	3,4 a	0.04	1.0 a	2.1 a	4.8 a
Titania	1	4,0a	4,9 a	6.8	1.0 a	1.0 a	2.1 a
	2	3,4a	4,0 a	5.9	1.0 a	1.0 a	2.3 a
	3	3,9a	3,6 a	5.7	1.0a	1.0 a	2.3 a
	4	3,9a	4,2 a	6.1	1.0 a	1.0 a	2.4 a

Table 6. Black currants on legs. Growth and infections in 2000 were rated on a scale from 1 to 10 (1 is no infection).

Variety	Treat-ment	Yield (t/ha)			Growth	Mildew	Aphids	Rust	Leaf spot
		1999	2000	2001	July	July	July	July	July
Titania	Control	5.50 a	5.7 a	9.6	8.0 a	1.0 a	2.1 a	1.0 a	1.9 a
	Leg	5.81 a	4.7 a	6.6	7.4 b	1.0 a	1.7 b	1.0 a	2.0 a
Ben Lo-mond	Control	0.07 a	1.6 a	4.3	5.4 a	2.6 b	2.1 a	1.8 a	2.4 b
	Leg	0.05 a	1.1 b	1.7	5.1 b	3.3 a	1.7 b	1.5 a	2.9 a

The development of the yields in the cereal crops since 1996 can be seen in table 7. Spring barley has a constant yield around 3.5-4.5 t ha^{-1}, although it was somewhat lower in 2000. After 1997, oats have most years had a good yield above 5-6 t ha^{-1}, but in 2001 this was much lower. The reason is not quite clear. Winter wheat was moved in the rotation from after the pulse crop to after the oats since 1999. This has given a much higher yield of 6-7 tons ha^{-1}. The pulse crop generally has low yields and the pea:barley mixture is not much better than the lupine.

Table 7. Yields in the cereal crops, t ha^{-1} at 85% dry matter.

Crop	1996	1997	1998	1999	2000	2001
Spring barley	3.7	4.6	4.1	4.6	3.0	-
Oats	-	2.8	6.7	5.3	6.1	3.3
Winter wheat	-	3.4	4.1	6.9	5.9	7.2
Pulses*	-	1.7	3.1	3.1	3.4	3.6

the pulse crop was lupine in 1997, 1998 and 1999, pea/barley mixture the other years.

The development of the weed density and biomass can be seen in Table 9. The number of weeds in spring barley has generally been high, but the biomass has only been among the highest the last two years. On the contrary, the oats and winter wheat have had very low weed biomass the last two years, even thought the numbers are not always low. The pulses have generally had high weed biomass. If the weed infestation in each field is regarded over the years (not shown), it is seen that some fields have low infestations and others high – regardless of crop. It seems that the number of weeds in the field is determined by the field potential, but the biomass is determined by the crop and other external factors (weed control, climate etc.)

Table 8. Weed biomass, g m^{-2}.

Crop	1998	1999	2000	2001
Spring barley	37	22	27	51
Oats	84	55	18	17
Winter wheat	76	36	9	16
Pulses*	86	7	155	26

* see note to table 7.

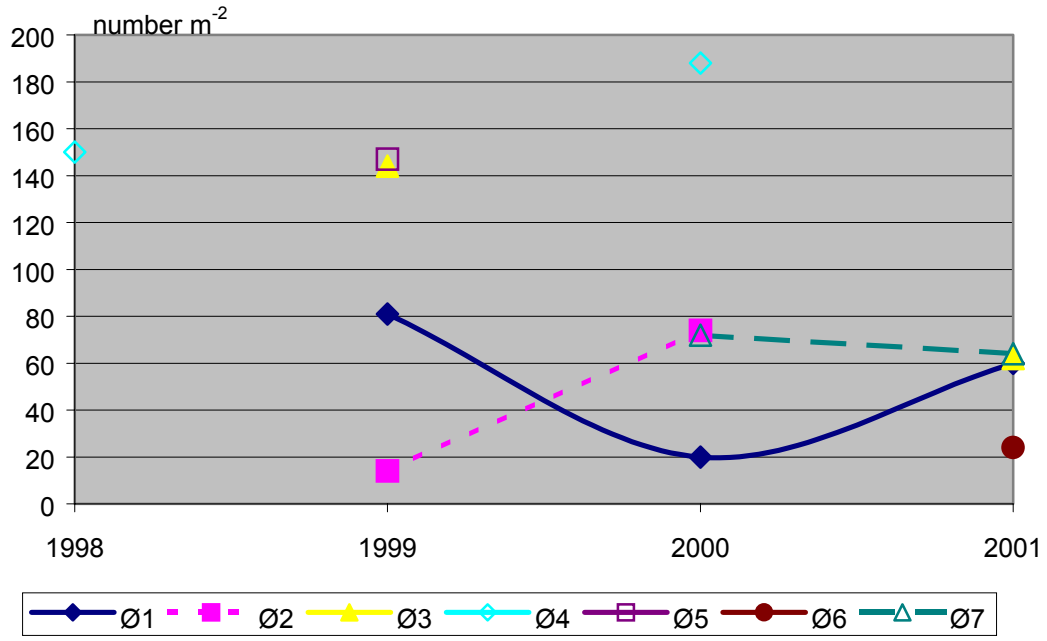

Figure 1. Number of weeds m^{-2} in the different fields**.**

KVL-Taastrup

There are two experimental areas at KVL-Taastrup, the CFE-system and the organic crop rotation. 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. Willow belts were harvested in March 2000. The yields from the belts showed an average growth per ha and per year of 2.6 t for Alnus glutinosa (red alder), 10.9 t for Salix spp. (willows) and 1.1 t for Corylus avellana (hazel). The actual harvested and weighed area of the belts was 0.44 ha. Table 9 shows the yields of the crops in the CFE-system. Some of the belts and selected species of others were not harvested in order to facilitate continous studies of effect on microclima, water balance etc. Next year of harvesteing will be 2003 or 2004. The yields of the organic crop rotation are shown in Table 10. The fodder beets were not harvested in either system at the time of this annual report.

Table 9. Average crop yields in the CFE-system (t/ha).

Year	Barley			Grass-clover	Fodder beets			Oats		
	Grain	Straw	Total	Total DM	Top	Root	Total DM	Grain	Straw	Total
1996	4.2	2.9	7.0	12.5[1]	3.6	8.2	11.8	5.6	5.3	11.0[2]
1997	3.4	6.1	9.5	9.8	3.1	13.5	16.6	5.3	5.8	11.2
1998	4.3	8.1	12.4	10.7	6.3	15.8	22.2	5.2	6.4	11.6
1999	4.0	5.6	9.8	10.4	3.5	14.3	16.6	4.4	4.3	8.7
2000[1]	4.6	5.8	10.4	11.5	4.3	16.2	20.5	5.8	8.9	14.6
2001	4.7	4.1	8.8		-	-	-	6.5	8.3	14.8

[1] Provisional data
[2] In 1996 wheat was grown instead of oats

Table 10. Average crop yield data for the organic crop rotation at KVL-Taastrup.

Crop	2000	2001
Barley undersown with grass-clover	4.2 t/ha in grain	2.93 t/ha in grain
Grass-clover 1st year	11.8 t DM/ha	7.77 t DM/ha[1]
Grass-clover 2nd year	10.3 t DM/ha	7.27 t DM/ha
Winter wheat	6.6 t/ha in grain	5.78 t/ha in grain
Fodder beets – top	4.4 t DM/ha	-
Fodder beets - root	9.3 t DM/ha	-

[1] Provisional data, 3rd cutting not included.

WP3. Askov long-term fertilisation experiment

In 1996 one of the four blocks (B4-field) 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), solid manure + liquid manure (four levels), an unmanured plots. The experiments is grown with a four-course rotation of spring barley, grass/clover, winter wheat and beet roots. For each fertilisation level, similar quantities of N, P and K are given in either cattle slurry (GY) or in solid + liquid cattle manure (FG). At fertilization level 1, the annual mean of the 4-course rotation (winter wheat, root crop, spring barley, grass/clover) is 100 kg total-N, 20 kg total-P and 80 kg K per ha. This corresponds to 17 t slurry (GY) and 14t solid manure + 6 t liquid manure (FG).

The crop grown in the B4-field in 2000 was a grass/clover mixture of lucerne, alsike clover, birdsfoot trefoil, ryegrass, fescue and timothy and has been used in the Askov long-term experiments since 1949. The grass/clover was established in 1999 as an underseed in spring barley. The crop does not receive any fertilisation directly but relies on residual effects of nutrients added to the previous crops in the rotation. In spring 2001, the grass/clover sward was incorporated and followed by a spring wheat crop. Each plot was divided into two subplots. In one subplot the sward was incorporated directly by ploughing followed by seed-bed preparation. In the other subplot, the sward was rotovated before being ploughed under in order to speed up decomposition of crop residues. This activity is part of the FØJO II-4 NIMAB project (WP2). Spring wheat biomass was harvested during growth to examine the N uptake profile. At maturity wheat grain samples from each miniplot was analysed for nutrient contents, and baking quality parameters (NIMAB WP4). Research achieved are reported in the status report of FØJOII-4, NIMAB.

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

The effect of pasture history on cereal crop yield and nitrate leaching after cultivation were determined during 1997-99 at this location. Thus, after determination of nitrate leaching in the winter of 1999-2000 it was possible to make an overall N balance for three years of grassland followed by three years of cereal cropping (Table 11).

Table 11. Nitrogen balance (kg N ha^{-1}) of six grasslands three years before and three years after cultivation. Ryegrass and grass-clover were established in 1993. SE in brackets.

	Ryegrass			Grass-clover		
	cut	grazed low N[1]	grazed high N[1]	cut	grazed low N[1]	grazed high N[1]
Annual input 1994-1996						
Fertilizer	300	300	300	0	0	0
N_2-fixation	0	0	0	300	258	266
Animal manure	0	222	320	0	240	326
Annual output 1994-1996						
Herbage yield	287	240	292	288	271	342
Balance (sum) 1994-1996	39	846	984	36	681	750
Output 1997-2000[2]						
Barley 1997	73 (6)	133 (13)	121 (3)	149 (11)	133 (7)	131 (2)
Leaching 1997-1998	12 (1)	21 (3)	36 (1)	28 (16)	24 (6)	24 (4)
Wheat 1998	74 (13)	111 (2)	112 (2)	116 (11)	127 (11)	112 (4)
Leaching 1998-1999	6 (0.1)	12 (2)	24 (5)	17 (0.1)	23 (8)	13 (5)
Barley 1999	68 (10)	83 (4)	93 (2)	87 (5)	88 (2)	80 (9)
Leaching 1999-2000	5 (1)	9 (1)	9 (1)	12 (2)	14 (2)	8 (2)
Total (sum) 1997-2000	239 (27)	368 (14)	397 (6)	409 (10)	409 (29)	368(18)

[1] Grazed low and high N refers to grazing be diary cow with 140 and 300 g N d^{-1} in supplements.
[2] Unfertilised plots only.

Details about the balance may be found elsewhere (Eriksen & Søegaard, 2000; Eriksen, 2001), but the main conclusions after the first three years are summarised below.

The huge N-pool in grazed grassland mineralized upon cultivation presents a potential environmental hazard. This work showed that when using good management practices (spring ploughing and catch crops) the release of N from three-year-old grasslands gave a considerable residual effect for two years after ploughing with nitrate concentrations in leachates not exceeding the EU Drinking Water Directive upper limit of 50 mg l^{-1}. In the first year the residual effect of grazed grasslands was large enough for supplementary fertilizer to be unnecessary, but in the following years gradually more and more fertilizer N was required to obtain optimal yields. The total leaching loss from a dairy rotation depends on the utilization of the N accumulated in grassland. Leaching losses are minimized by including residual effects in the fertiliser budgets for crops following the ploughing of grasslands.

The history of the grazed grassland (grass-clover or ryegrass, low or high N levels in feed) did not affect residual effects and nitrate leaching. Presumably, huge differences in N-input during the grassland phase of the crop rotation were equalised by substantial but variable N losses during grazing. Possibilities for further improving the utilisation of grassland N following cultivation are limited when the current knowledge has been implemented. If the N use efficiency of dairy farming systems are to be further improved the utilisation of N in the pasture phase must be considered regarding the frequency of pastures in the rotations and the management during grazing.

In 2000-2001 the simultaneous nitrate leaching from newly established swards, swards grazed for 1 and 7 years and swards cut for 7 years was investigated. In the newly established swards nitrate leaching from grass-clover and ryegrass were similar but at increasing sward age nitrate leaching from the fertilized ryegrass increased dramatically compared to a constant low level from the unfertilized grass-clover. Apparently, the clover component of grass-clover was able to equalize differences in soil nitrogen availability in swards of different age. The results of N_2 fixation studies in swards of different age in 2001 will be used in the interpretation of the nitrate leaching data.

WP5. Experiment on nutrient management in organic dairy farming

The objective of the experiment is to estimate the effect of different livestock densities and organic manure types on nitrate leaching and crop production in an organic dairy crop rotation. The manuring plan matching the four treatments is shown in Table 12.

The growing season 2001 passed off relatively unproblematic. We did not observe failure of crops except for N-deficiency in barley caused by the manuring treatments. However, after a high dry matter yield in cut one and a dry summer, the growth of the grass-clover remained retarded. Table 13 shows the yields of the first cut of grass-clover and of the barley/pea mixture. The 2001 yields of grains and fodder beets are not ready yet. In the 1st cut in the 2nd year grass-clover we found a very low content of clover compared with the 1st year grass-clover, probably due to a higher N-level in the soil. In barley/pea, having the 2nd grass-clover as precrop, the yield in treatment 1 (no manure) was similar to the other treatments receiving 60-120 kg total-N ha^{-1}.

Tabel 12. Manuring plan 1998-2002 (kg total N ha^{-1})

		Treatment 1	Treatment 2	Treatment 3	Treatment 4
Crop rotation		Slurry-low	Slurry-high	Deep litter-low	Deep litter-high
Barley	Slurry	50	100		
	Deep litter			50	100
1st yr grass-clover	Slurry	0	0		
	Deep litter			0	0
2nd grass-clover	Slurry	70	140		
	Deep litter			0	0
Barley/pea	Slurry	0	60		
	Deep litter			60	120
Oat	Slurry	75	150		
	Deep litter			75	150
Fodder beet	Slurry	125	250		
	Deep litter			150	300
Average		53	117	56	112

Table 13. Dry matter yields (t/ha) and content of clover and pea (% of DM) in 2001

	Spring-barley		1st yr grass-clover		2nd yr grass-clover		Barley/pea		Oat		Fodder beet	
Treat-ment	Grain	Straw		*Clo-ver%*		*Clo-ver%*		*Pea %*	Grain	Straw	Root	Top
1			5.0	*10*	5.4	*3*	9.7	*22*				
2			4.8	*15*	5.5	*1*	9.8	*6*				
3			4.9	*12*	3.9	*4*	9.5	*17*				
4			5.2	*14*	4.7	*2*	10.2	*16*				

Soil water has been sampled from the installed suction cups at intervals between 1 and 4 weeks depending on the precipitation. Calculation of the nitrate leaching will take place at the end of the experiment in spring 2002.

WP6. Crop rotation experiment

A field experiment is conducted which focuses on different aspects of crop rotations for cereal production in organic farming. 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 14, and the revised crop rotations for 2001-2004 is shown in Table 15. 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 16).

Table 14. 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 Grass-clover Spring wheat Lupin	S. barley:ley Grass-clover Winter wheat Peas/barley	S. barley:ley Grass-clover Winter wheat Beet	Spring oat Winter wheat Winter cereal Peas/barley
With	S. barley:ley Grass-clover S. wheat:Grass Lupin:Grass	S. barley:ley Grass-clover W. wheat:Grass Peas/barley:Grass	S. barley:ley Grass-clover W. wheat:Grass Beet	S. oat:clover W. wheat/clover W. cereal/clover Peas/barley:Grass

Table 15. 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 cereals and clover.

Catch crop	Rotation 1	Rotation 2	Rotation 3	Rotation 4
Without	S. barley:ley Grass-clover S. oat Pea/barley	S. barley:ley Grass-clover Winter cereal Lupin	S. barley:udlæg Grass-clover Winter wheat Beet	Winter wheat S. oat S. barley Lupin
With	S. barley:ley Grass-clover S. oat:gr+ci Pea/barley:gr+ci+cl	S. barley:ley Grass-clover W. cereal:gr+ci Lupin:gr+ci+cl	S. barley:ley Grass-clover W. wheat:gr+ci+cl Beet	W. wheat:clover S. oat/clover S. barley:gr+ci Lupin:grass

gr+ci: grass+chicory
gr+ci+cl: grass+chicory+clover

Table 16. 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

The yields of the individual crops as an average of 1997 to 2000 are shown in Table 17. There is significant yield increase in all cereal crops from manure application. Manure was not applied to the pulse crops. The use of catch crops increased yields in spring cereals.

The average yield of sugar beet was 13.0 and 12.5 t dry matter per ha at Flakkebjerg and Holeby, respectively.

Table 17. Grain and seed yields (t/ha with 15% water) on the four experimental sites for the period 1997 to 2000 as average of plots with and without manure and with and without catch crops.

Crop	No catch crop		Catch crop		No catch crop		Catch crop	
	÷ man	+ man	÷ man	+ man	÷ man	+ man	÷ man	+ man
	Jyndevad (sand)				*Foulum (loamy sand)*			
Spring barley	2.2	3.1	2.8	3.7	3.3	4.5	3.7	5.1
Spring oat					4.1	5.2	4.4	5.5
W. wheat after grass-clover	2.8	3.8	2.7	37	4.4	5.9	4.4	5.9
W. wheat after oat					3.0	5.3	2.9	4.3
Triticale after wheat					2.4	5.1	2.0	3.5
Pea/barley	4.1	3.9	3.7	4.6	4.8	4.6	4.8	4.7
Spring wheat	3.0	3.8	3.0	3.6				
Lupin	2.1	2.5	2.1	2.0				
	Flakkebjerg (sandy loam)				*Holeby (loam)*			
Spring barley	2.4	3.7	2.5	4.0	5.1			
Spring oat	2.8	3.7	3.3	4.6	5.4			
W. wheat after grass-clover	4.4	5.0	4.7	5.0	6.2			
W. wheat after oat	2.9	4.4	2.7	4.6	5.7			
W. wheat after wheat	2.8	4.2	2.2	3.7	5.9			
Pea/barley	3.2	3.5	3.9	3.9	4.0			

The average for the entire rotation is calculated as the total yield of the four experimental years divided by four. This accounts for the fact that the grass-clover field in rotations 1 and 2 does not contribute to the yield. Table 18 shows that manure application increased yields in all cases. The higher effect of manure in rotation 4 compared with the other rotations results from use of higher manure rates in rotation 4. This is caused by higher recommended rates for the winter cereals in rotation 4.

Use of catch crops only affected rotation yields slightly. In rotation 2 there were positive yield effects of catch crops in spring barley only, which gave yield increases for the rotation of ca. 0.1 t/ha. Catch crops in rotation 4 gave yield increases of 0.3 t/ha at Flakkebjerg, but a yield decrease of 0.5 t/ha at Foulum. This difference is mainly caused by the bicropping of wheat and clover that resulted in yield reductions at Foulum, but small yield benefits at Flakkebjerg. The oat crop was much more vigorous at Foulum compared with Flakkebjerg, and this resulted in a weaker stand of white clover and thus less nitrogen available for the winter wheat in the bicropping system.

There were only very small yield differences between rotations 1 and 2 at Jyndevad. Growing winter cereals at this site does thus not increase yields in organic farming systems. The yield at rotation level was higher in rotation 4 compared with rotation 2. The difference was about 0.4 t/ha without manure, and about 0.8 t/ha with manure. The yield benefits from the grass-clover crop could thus not outweigh the yield reductions caused from leaving a quarter of the rotation out of production.

Table 18. Average annual grain yields for the entire rotation for 1997 to 2000 (t/ha with 15% water).

Location	Year	Rotation 2		Rotation 4	
		Without	With	Without	With
Jyndevad	1	2.0	2.7	2.2	2.7
(sand)	2	2.2	2.6	2.2	3.0
Foulum	2	3.1	3.8	3.2	3.9
(loamy sand)	4	3.6	5.0	3.6	4.5
Flakkebjerg	2	2.5	3.1	2.7	3.1
(sandy loam)	4	2.8	3.9	3.1	4.2

The yield of spring barley in rotation 2 was affected by the catch crop of the preceding pea/barley crop (Table 19). The average yield increase for catch crop was 0.8 t/ha at Jyndevad, 0.6 t/ha at Foulum and 0.3 t/ha at Flakkebjerg. The largest yield increases were thus obtained at the sandy soil, which may be related to the higher risk of nitrate leaching on the sandy soil. Leaching of potassium on the sandy soil may also play a role.

There are large differences between years. In 1999 large yield increases were obtained from catch crops at all sites. The average yield increase for catch crop across all sites was thus 1.1 t/ha in 1999, but only 0.2 and 0.3 t/ha in 1998 and 2000, respectively. The climatic conditions in the individual year probably plays a considerable role for the release of nitrogen from the catch crop and for uptake by the crop.

Table 20. Grain yield in spring barley in rotation 2 (t/ha with 15% water).

Location	Year	Without catch crop		With catch crop	
		÷ manure	+ manure	÷ manure	+ manure
Jyndevad	1998	1.4	1.7	1.7	2.3
(sand)	1999	1.3	2.4	2.2	4.0
	2000	2.1	3.8	3.0	4.1
Foulum	1998	4.7	5.6	4.5	6.3
(loamy sand)	1999	1.9	3.7	3.6	4.3
	2000	3.1	4.4	3.0	5.1
Flakkebjerg	1998	2.9	3.3	2.6	3.4
(sandy loam)	1999	1.5	3.3	2.5	4.3
	2000	2.8	4.1	2.9	3.9

Catch crops in the preceding pea/barley gave average yield increases in oats of 0.2 and 0.5 t/ha at Foulum and Flakkebjerg, respectively. This is in particularly caused by positive effects in 1999 and 2001, whereas there was no yield effect of catch crops in 1998.

Table 21. Grain yield in spring oats in rotation 4 (t/ha with 15% water).

Location	Year	Without catch crop		With catch crop	
		÷ manure	+ manure	÷ manure	+ manure
Foulum	1998	5.0	6.1	4.6	6.1
(loamy sand)	1999	4.9	5.8	5.5	5.8
	2000	3.8	5.5	4.7	5.7
Flakkebjerg	1998	3.6	3.8	3.4	4.3
(sandy loam)	1999	2.7	4.8	4.0	5.2
	2000	3.1	3.5	3.4	3.9

Pea/barley was included in both rotation 2 and rotation 4 in the experiment. In rotation 2 the catch crop was ryegrass in winter wheat prior to pea/barley. However, the in rotation 4 the catch crop was white clover, which had been used for bicropping with winter wheat for two years prior to pea/barley.

The catch crop in rotation 2 did not affect total yield of pea/barley. However, in rotation 4 there was an average yield increase for catch crop of 0.5 t/ha at Foulum and 1.3 t/ha at Flakkebjerg. This is probably not only caused by effect of residual nitrogen, but also because catch crops increase the water holding capacity of soils, which will affect the competitiveness of the pea crop in particular.

Table 22. Yield in pea/barley grown for maturity in rotations 2 and 4 with and without catch crops (t/ha with 15% water)

Location	Year	Rotation 2		Rotation 4	
		Without	With	Without	With
Foulum	1998	5.6	5.7	5.5	5.8
(loamy sand)	1999	4.6	4.3	4.1	4.2
	2000	4.8	4.7	4.0	5.1
Flakkebjerg	1998	3.9	3.9	4.0	5.4
(sandy loam)	1999	4.0	3.5	2.9	4.0
	2000	2.9	2.9	2.3	3.6

The leaching of nitrogen in rotation 2 was calculated at an average of the two first seasons (Figure 2). There was a very large nitrate leaching at Jyndevad, which in most crops and in both years exceeded 100 kg N/ha/yr. The nitrate leaching at Foulum was only half as big, and it was further more than halved at Flakkebjerg and Holeby. There were large differences between crops with the largest nitrate leaching after grass-clover and smallest after spring barley.

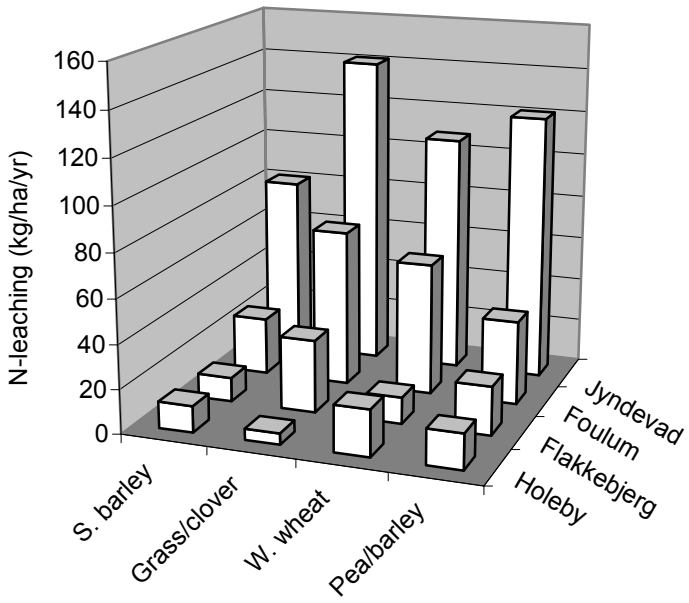

Figure 2. Annual nitrate leaching in rotation 2 with manure and without catch crops.

WP7. The organic experimental farm, Rugballegaard

Field activities

The field activities concerns the basic managing 140 ha of organic grown fodder crops, and the managing of numerous field experiments and trials.The fields are divided in three crop rotation systems, matching the estimated needs of a dairy, a pig and a mixed system, with both cows and pigs (Table 23).

Table 23. 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[3]	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.
[3)] from august 2000 these rates are changed for pigs to 20%

Year 2000 was the last year where the three rotations are carried out in the original design. In august 2000 the EU introduced new common standards for organic animal production. These standards require a larger percentage of organic feed stuffs in the organic husbandry. Also it has become extremely difficult to blend fodder mixtures containing sufficient amounts of protein, both for cattle and pigs. This development in organic agriculture means that other crops and strategies are becoming necessary. Two groups of scientists are at this moment working on the future design. One group is working on the pig rotation and one group on the dairy and the mixed rotation.

Until now the rotations has been as follows:
The dairy rotation:
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

Results of these three systems are shown in Table 24. The estimated nitrogen available in the systems is shown in Table 25. The managing of these three systems makes it possible to carry out experiments that require long-term registration and monitoring rotational consequences in different systems.

From 1999 to 2001 a substantial cereal variety research program was carried out by a breeding firm, in two of the rotations systems. A long term soil experiment with various ploughing and cultivating systems was practised from 1997-2000 i al five crops of the mixed rotation system. Extension of this project where soil compaction is being monitored extends to 2002. The growing of lupines, a new protein crop with potentials in Denmark was started in the pig-rotation, as a substitute for pies Due to the larger demands on self sufficiency i organic feed stuffs, the growing of winter rape seed is started in 2001. The rape seed crop integrated in the dairy rotation.

Stable activities
The dairy herd on the experimental station is at present 60 milking cows with calves and a pig herd of approximately 65 sows, 6 bears, and the production of 1300 fattening pigs a year. All the animals are housed and fed according organic EU standards. The experimental farm has achieved a special exception from the standards, to give the possibility of joining traditional foddered and housed experimental plots in the research scheme. This is only allowed if the research program has special organic interest. Due to the great variety of fodder crops grown in the three rotation systems, a numerous amount of animal feed experiments will and can be carried out during the years of this project. Also the growing of totally new crops like lupines and chicory contribute to research programs.

Table 24. Preliminary crop yields in the systems at Rugballegaard (hkg DM/ha).

System	Crop	1997	1998	1999	2000	2001***
Dairy	Whole crop barley/pea			86		
	Grass-clover	74	62	80	61	
	Oats	34	30			
	Winter wheat		41	38	54	
	Barley	35	30		49	36
	Average cereals	34	35	36	50	
	Average roughage	86	74	81	59	
Pig	Barley	34	30	36	39	31
	Lupines				33	28
	Pea/barley	40	39	42	41	
	Oats	42	42	45	50	32
	Winter wheat	53		44	51	28
	Grass-clover*	62	21	18	46	
	Average cereals	41	40	42	44	
	Average roughage	62	21	19	46	
Mixed	Whole crop	72	63	102	74	
	Grass-clover	54	52	64	68	
	Oats		41	51	51	41
	Winter wheat		43	41	50	40
	Fodder beets/sugar beets	114	115	152	81**	
	Barley/pea	41	20	32	41	36
	Average cereals	43	36	42	51	
	Average roughage	83	83	90	70	

* There was only harvested in 1997, 98 and 99 were only grazed, 2000 was cut and grazed.

** In the year 2000 sugar beets were produced, for sale.

*** In the year 2001 there were several circumstances that has caused lower yields. The winter wheat variety chosen was severely attached by rust (Puccinia), and during the harvest the continuing rainfall caused huge amounts of unharvested waste products (up to 10% of the registered harvest).

Table 25. Nitrogen inputs (kg N/ha) in the three systems at Rugballegaard in average for '97-2000.

	Dairy	Pig	Mixed
Manure spread in the field	108	82	71
Grazing animals	43	30	36
Fixation by legumes	89	30	60
In total	240	142	167

C.2 Fulfilment of tasks and deadlines in individual work packages

WP1. Project coordination	Time schedule according to application	Deviations, if any*
Task		
1. Coordination of project plans and reporting	2000-2004	
2. Planning of field days	2000-2004	
3. Ensure high experimental standards	2000-2004	
Deliverables		
1. Annual reports	200x/10	delivered
2. Report on future status of experimental units	2002/12	
3. Final report	2005/03	
4. Field days for farmers and advisors	200x/06	
Milestones		
1. End of external funding for most units	2002/12	
2. End of external funding for the CRE unit	2003/12	
3. End of external funding for the RUG unit	2004/12	

** Deviations are to be further discussed at C3*

WP2. Workshop areas at experimental stations	Time schedule according to application	Deviations, if any*
Task		
1. Provide workshop facilities	2000-2002	
Deliverables		
1. Annual reports	200x/10	delivered
4. Field days for farmers and advisors	200x/06	delivered
5. Fact sheets on results from workshop areas	2002/12	
Milestones		
1. End of external funding	2002/12	

** Deviations are to be further discussed at C3*

WP3. Long-term fertilisation experiment	Time schedule according to application	Deviations, if any*
Task		
1. Provide workshop facilities	2000-2002	
Deliverables		
1. Annual reports	200x/10	delivered
4. Field days for farmers and advisors	200x/06	delivered
Milestones		
1. End of external funding	2002/12	

** Deviations are to be further discussed at C3*

WP4. Workshop areas on residual effect of pastures	Time schedule according to application	Deviations, if any*
Task		
1. Precrop effect of pastures	2000-2002	
Deliverables		
1. Annual reports	200x/10	delivered
4. Field days for farmers and advisors	200x/06	delivered
Milestones		
1. End of ley phase	2002/03	
2. End of external funding	2002/12	

** Deviations are to be further discussed at C3*

WP5. Nutrient management in dairy farming	Time schedule according to application	Deviations, if any*
Task		
1. Effect of livestock density and manure type	2000-2002	
Deliverables		
1. Annual reports	200x/10	delivered
4. Field days for farmers and advisors	200x/06	delivered
6. Paper on nitrate leaching and crop production	2002/12	
7. Farmers journal article	2002/12	
Milestones		
1. End of field experiment	2002/03	

** Deviations are to be further discussed at C3*

WP6. Crop rotation experiment	Time schedule according to application	Deviations, if any*
Task		
1. Crop rotation effect on production etc.	2000-2004	
2. Provide workshop facilities	2000-2003	
Deliverables		
1. Annual reports	200x/10	delivered
4. Field days for farmers and advisors	200x/06	delivered
8. Reviewed journal papers from first rotation course	2002/02	
9. Fact sheets from first rotation course	2002/04	
10. Article on previous years results	200x/03	delivered
11. Articles on crop status during the seasons	200x	delivered
Milestones		
1. Revised project guidelines	200x/03	fulfilled
2. First course of crop rotation is completed	200x/03	fulfilled
3. End of external funding for experiment	2004/03	

** Deviations are to be further discussed at C3*

WP7. Organic experimental station, Rugballegaard	Time schedule according to application	Deviations, if any*
Task		
1. Provide workshop facilities	2000-2004	
2. Make whole-farm assessments	2000-2004	
3. Demonstration and communication	2000-2004	
Deliverables		
1. Annual reports	200x/10	delivered
4. Field days for farmers and advisors	200x/06	delivered
Milestones		
1. End of external funding	2004/12	

** Deviations are to be further discussed at C3*

C.3 Discussion on the progress, incl. deviations and achievements in the project as a whole and in the individual work packages

There are no deviations from the work plan in terms of major deliverables and milestones. However, in WP6 the publication of results from the first course of the experiment will be extended into 2002.

D. Description of plans and future work in the project as a whole and in the work package (Including plans for publication and communication)

WP1. Project coordination

Field days will be organised at all experimental units in 2001.

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

The workshop areas will be continued according to their current plans. However, during 2002 plans will be made for adjusting the crop rotations at Jyndevad, Foulum, Flakkebjerg, Årslev and Højbakkegaard to more closely match changes in cultivation practice in practical organic farming in Denmark.

The areas for organic research of fruit and berries at Årslev are nearly totally occupied. There is only room for very small trials. To be able to fit in the planned planting of the trial: Early testing of new resistant selections, we have to withdraw additional land in the organic area. The trial to determine the present races of Ventura inaquealis in black currants, established 1996, are going to be pulled out the coming winter, as we have seen results for 4 years now. The work concerning biological control stopped last winter as the project ran out. The trees are pulled out the coming winter.

WP3. Askov long-term fertilisation experiment

According to plans, the crop in 2002 will be beet roots. This crop receives either cattle slurry (three levels) or solid cattle manure (four levels). Roots and tops yields are determined separately and analysed for nutrient contents at harvest.

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

Nitrate leaching will be determined throughout the autumn and winter period by collecting samples of soil water below the root zone weekly or biweekly from grazed (with dairy cows) and cut fields (unfertilized grass/clover and fertilized pure grass). In the winter 2001-2002 it will be possible to compare 1st, 2nd and 8th year pasture allowing for estimates of the effect of increasing N accumulation in grassland on nitrate leaching. In 2002 are then ploughed pastures 1, 2 and 8 years old. As a reference

is used the associated cut grassland. Nitrate leaching is determined before and after ploughing the pastures, and in the following years. The N up-take is determined in spring wheat after ploughing. The precrop effect from the combinations of pasture use and pasture age is determined from the yield of spring wheat compared to the yield of an adjacent area without grassland history, which is used as a nil precrop reference.

WP5. Experiment on nutrient management in organic dairy farming

The experiment will be ended in 2001 (with the last soil water samplings in spring 2002). This may be changed if a new project on the workshop area is initiated. In that case the experiment will be continued, possibly with slightly changed manure treatments. The plans for publication include the following international publications:

Nitrate leaching in an organic dairy/crop rotation as affected by organic manure type, livestock density and crop (2002-3)

Crop production in an organic dairy/crop rotation as affected by organic manure type and livestock density (2002-3)

In addition 1-2 articles in national farmers magazines are planned (2002-3).

WP6. Crop rotation experiment

The crop rotation experiment will be continued in 2002 according to the revised plans.

The publication of results from the first course of the rotation experiment will be completed. This will include a number 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.

WP7. The organic experimental farm, Rugballegaard

It is necessary for the experimental station to organise open days with special topics on the agenda, and not just showing all activities. The range of activities is too big. In the end of 2001 a annual report will be presented on a meeting, summarising the years scientific activities and the observations from the practical cultivation. Furthermore a website is established, where the experimental station and its activities is presented with links to the various researchers and institutes involved. More resources will be used on experimenting and demonstrating and developing new techniques, strategies and crops. This means that the contacts with organic agricultural movements will be expanded.

E. Project publications

1. Articles in internation, scientific journals with peer review

Askegaard, M. & Eriksen, J. 2000. Potassium retention and leaching in an organic crop rotation on loamy sand as affected by contrasting potassium budgets. *Soil Use and Management* **16**, 200-205.

Askegaard M. & Eriksen J. (accepted). Exchangeable potassium in soil as indicator of potassium status in an organic crop rotation on loamy sand. *Soil Use and Management*

Eriksen, J. & Jensen, L.S. (2001). Soil respiration and nitrogen mineralisation in situ following cultivation of temporary pastures. *Biology and Fertility of Soils* **33**, 139-145.

Eriksen, J. (2001). Nitrate leaching and growth of cereal crops following cultivation of contrasting temporary grasslands. *Journal of Agricultural Science, Cambridge* **136**, 271-281.

Eriksen, J., Olesen, J.E. & Askegaard, M. (accepted). Sulphur leaching and sulphur balances of an organic cereal crop rotation on three Danish soils. *European Journal of Agronomy*

Eriksen, J. & Søegaard, K. (2000). Nitrate leaching following cultivation of contrasting temporary grassland. *Grassland Science in Europe* **5**, 577-579.

Føreid, B., Porter, J.R. & Mogensen, V.O. (submitted). Effects of short rotation coppice in strips between crops – 1. Microclimatic effects.

Føreid, B., Porter, J.R. & Mogensen, V.O. (submitted). Effects of short rotation coppice in strips between crops – 2. Crop growth and development

Guggenberger, G., Christensen, B.T. & Rubæk, G.H. (2000). Isolation and characterization of labile organic phosphorus pools in soils from the Askov long-term field experiments. *Journal of Plant Nutrition and Soil Science* **163**, 151-155.

Iversen, C.K., Pedersen, H.L., Olsen, C.E. & Brandt, K. (in press). Relationship between phenolic compounds, disease resistance and cover crop type of 5 black currant (*Ribes nigrum L.*) varieties. *Journal of Biological Agriculture & Horticulture*.

Kuemmel, B. & Hooker, K.J.M. (submitted). Potential pollination bonus of short rotation willow belts grown for energy.

Kuemmel, B. & Porter, J.R. (submitted). CO_2 adaptation costs are independent of stabilisation target.

Langer V. (submitted). Clover/grass ley and short rotation coppice hedges as reservoirs for parasitoids of cereal aphids in organic agriculture.

Munkholm, L.J., Schjønning, P., Debosz, K., Jensen, H.E. & Christensen, B.T. (2002). Soil aggregate strength and bulk soil mechanical behaviour of a humid sandy loam subjected to long-term fertilization treatments. European Journal of Soil Science (in press).

de Neergaard, A., Gorissen, A. & Porter, J.R. (submitted). Carbon and nitrogen dynamics in the early growth of willows.

Olesen, J.E., Askegaard, M. & Rasmussen, I.A. (2000). Design of an organic farming crop rotation experiment. Acta Agriculturae Scandinavica, Section B, Soil and Plant Science 50, 13-21.

Olesen, J.E., Rasmussen, I.A., Askegaard, M. & Kristensen, K. (submitted). Whole-rotation dry matter and nitrogen grain yields from the first course of an organic farming crop rotation experiment. Journal of Agricultural Science, Cambridge.

2. Presentations at congresses, symposiums etc

Callesen, O., Pedersen, H.L. & Daugaard, H. (2000). Research and development needs for organic fruit production. Workshop on Organic Fruit opportunities and challenges. 16-17 October 2000, England.

Christensen, B.T. (2000). Hvad forstås ved begrebet jordfrugtbarhed. Tidsskrift for Landøkonomi 187, 276-279.

Daugaard, H., K. Thorup-Kristensen, L. Petersen, B. Leonhard, H. Lindhard, M. Korsgaard, B. Rasmussen, J. Solvang, O. B. Hansen og J. Jensen 2001. Vurdering af økologisk produktion i gartneri og frugtavl. Rapport til Kirsten Jensen Udvalget. 103 pp.

Eriksen J. & Søegaard K. (2000) Nitrate leaching following cultivation of contrasting temporary grasslands. Preceedings from Eurosoil 2000. University of Reading 4-6 September 2000. British Society of Soil Science. 2 pp.

Lindhard Pedersen H. (2001). Cover crops in Blackcurrants. 8th International Rubus and Ribes Symposium, 9-11 July 2001. Acta Horticulturae.

Olesen, J.E., Askegaard, M. & Rasmussen, I.A. (2000). Udnyttelse af husdyrgødning i sædskifter til økologisk planteavl. FØJO-rapport 7, 75-82.

Olesen, J.E., Askegaard, M. & Rasmussen, I.A. (2000). Crop production during the first course of an organic crop rotation trial in Denmark. Aspects of Applied Biology 62, 187-195.

Olesen, J.E., Rasmussen, I.A. & Askegaard, M. (2000). Crop rotations for grain production. In: T. Alföldi, W. Lockeretz & U. Niggli (Eds.) Proceedings 13th International IFOAM Scientific Conference, 28-31 August 2000, Basel. p. 145.

Pedersen, H.L., Korsgaard, M. & Daugaard, H. (2000). Organic fruit production in Denmark. Gro-

wers Experiences in Denmark. Workshop on Organic Fruit opportunities and challenges. 16-17 October 2000, England.

Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (2000). Weed control in organic crop rotation experiments for grain production. In: T. Alföldi, W. Lockeretz & U. Niggli (Eds.) Proceedings 13th International IFOAM Scientific Conference, 28-31 August 2000, Basel. p. 182.

3. Articles in agricultural journals etc.

Askegaard, M. (2000). Forår uden problemer. Økologisk Jordbrug 217, 8.

Askegaard, M. (2000). Nyt fra sædskifteforsøg. Økologisk Jordbrug 223, 8.

Askegaard, M. (2001). Nyt fra forsøg med økologiske sædskifter. Økologisk Jordbrug 241, 6.

Askegaard, M. (2001). Nyt fra de økologiske sædskifteforsøg. Økologisk Jordbrug 247, 6.

Eriksen, J. (2001). Ompløjning af græsmarker kan give stor udvaskning. Økologisk Jordbrug 242, 6.

Eriksen, J. & Mogensen, J. (2001). Ompløjning af afgræsningsmarker. Forfrugstværdi og N-udvaskning. Grøn Viden Markbrug nr. 237.

Lindhard H. 2001. Gødskning med kvælstof i solbær. Frugt og Bær, 4/2001. S. 94-95.

Lindhard H. 2001. Dækkultur i økologisk solbærdyrkning. Frugt og Bær. 6/2001.

Olesen, J.E. (2000). International forskning i økologiske sædskifter. Økologisk Jordbrug 209, 8.

Olesen, J.E. (2000). Status i sædskifteforsøget. Økologisk Jordbrug 225, 8.

Olesen, J.E. (2000). Synlige forskelle i sædskifteforsøget. Økologisk Jordbrug 219, 8.

Olesen, J.E. (2000). Europæisk forskning i sædskifter til økologisk jordbrug. Forskningsnytt om økologisk jordbrug nr 2, 16-17.

Olesen, J.E. (2001). Sommeren står for døren i sædskifteforsøget. Økologisk Jordbrug 243, 8.

Olesen, J.E. (2001). Gunstige effekter af efterafgrøder i forsøg. Økologisk Jordbrug 245, 8.

Olesen, J.E., Rasmussen, I.K. & Askegaard, M. (2000). Danske forskere tester sædskifter. Økologisk Jordbrug 215, 14.

Olesen, J.E., Rasmussen, I.A. & Askegaard, M. (2000). Økologisk vinterhvede kan lykkes på god jord. Landsbladet Mark nr. 8, 26.

Olesen, J.E., Rasmussen, I.A. & Askegaard, M. (2001). Udbytter i sædskifter til økologisk kornproduktion. Forskningsnytt om økologisk landbruk i Norden 2-2001, 12-13.

Olesen, J.E., Rasmussen, I.A. & Askegaard, M. (2001). Planteavl uden kløvergræs mulig. Økologisk Jordbrug 238, 8.

Olesen, J.E., Rasmussen, I.A. & Askegaard, M. (2001). Fangafgrøder øger udbyttet. Økologisk Jordbrug 238, 9.

Pedersen, H.L. (2000). Nye solbærsorter fra skotland. Frugt og Bær 115.

Rasmussen, I.A. (2000). Nyt fra sædskifteforsøg. Økologisk Jordbrug 215, 8.

Rasmussen, I.A. (2000). Nyt fra sædskifteforsøg. Økologisk Jordbrug 221, 8.

Rasmussen, I.A. (2000). Nyt fra sædskifteforsøg. Økologisk Jordbrug 239, 6.

Rasmussen, I.A. (2001). Nyt fra forsøg med økologiske sædskifter. Økologisk Jordbrug 249, 6.

Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (2001). Nye og bedre sædskifter. Økologisk Jordbrug 238, 9.

4. Other presentations at meetings, field days etc.

Djurhuus, J. & Olesen, J.E. (2000). Characterisation of four sites in Denmark for long-term experiments on crop rotations in organic farming. DIAS report No. 33.

Eriksen, J. (2001). Eftervirkning af kløvergræs. I "Bilag til Efterårskonference 2001" s 64. 2. oktober, Hotel Nyborg Strand.

Eriksen J. & Mogensen J. (2001) Forfrugtsværdi og N-udvaskning efter ompløjning af flerårige græsmarker med forskellige forhistorier. DJF rapport nr. 46 Markbrug. 40 pp.

Field days have been held at all experimental units, and there have also been several interviews on radio concerning the activities. In addition many of the experiments have their own web-site on the internet.

F. Scientific education (ph.d. and post doc.), including visiting scientists and visits abroad

The experimental units have also been used by students, both B.Sc., M.Sc. and Ph.D. students. in addition presentations and discussions have been carried out with many visiting national and international scientists.

The WP3 Askov long-term fertilization experiment had supported two M.Sc. thesis at Aarhus University, Department of Plant Ecology (April and May 2001). Ingrid S. Bleeg: Phenolic acids and flavonoids in organically grown spring barley (*Hordeum vulgare* L.) at different nutrient availability, and Dorthe B.F. Andersen: Infection of pathogenic fungi and contents of N and soluble phenols in leaves of barley (*Hordeum vulgare* L.) grown in the field at different nutrient additions.

The CFE-system and the organic crop rotation at KVL-Taastrup are used as resource tools during the European Common Curriculum (SOCRATES) course in Ecological Agriculture

In the CFE-system at KVL-Taastrup several ongoing PhD projects and other studies have been completed or are nearing completion with studies of the carbon and nitrogen cycling within the CFE system (Andreas de Neergaard), the CFE's economic and energy balances (Bernd Kuemmel) and the effect of the CFE system on the distribution and ecology of predatory and herbivorous insects and their prey (Vibeke Langer and Karsten Dromph). In several of these studies reports are nearing publication in the international press.

As a part of a Ph.D. study done by Chr. B. Henriksen, Agroecology Section, KVL, an experiment entitled "Long term effect of different weed control and soil management methods in fodder beets" will be carried out in the organic crop rotation at KVL-Taastrup.

The following Ph.D. students have been directly involved with the experimental units:

Anders Borgen. Varieties of organically grown cereals and legumes (organic crop rotation at KVL-Taastrup).

Lars Kristensen. Environmentally friendly methods for control of seed born pathogens on cereals (organic crop rotation at KVL-Taastrup).

Torben Sole Madsen. New ploughing techniques in Organic Agriculture.(Department for agricultural engineering).

Martin Nørregaard Hansen. Technology for reduction of N-losses in solid manure (Department for agricultural engineering).

The following M.Sc. students have been directly involved with the experimental units:

Søren S. Simonsen (2000). Influence of catch crops on nitrogen balance and yield in an organic crop rotation (crop rotation experiment at Foulum).

J. Ulnitz (2000). False seed bed in fodder beets (organic crop rotation at KVL-Taastrup).

G. National and international co-operation

The experimental units in EXUNIT will been intensively used by other DARCOF coordinated projects.

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

The crop rotation at Jyndevad has primarily been for experiments on potatoes (Jens Peter Mølgaard) and an experiment on ridge cropping (Chr. B. Henriksen).

The dairy crop rotation at Foulum has primarily been used for the nutrient cycling experiment described in WP5.

DINOG (I.13) subproject 2.1 has investigated N2-fixation in grass-clover at Jyndevad and Foulum.

Several experiments were carried out in the vegetable crop rotation at Årslev. This included seven experiments from DARCOF project I.10, one experiment from DARCOF project I.3 and two projects from a grass-root project concerning varieties for organic farming. The capacity for experiment is thus almost exhausted. In addition a number of samplings and measurements has been carried out to support other DARCOF projects.

The organic fields at Flakkebjerg have again in 2001 been extensively used for experiments by the projects under DARCOF and other projects concerning organic farming.

WP3. Askov long-term fertilization experiment

The spring wheat grown in 2001 in the B4-field is an integral part of the FØJOII-4 NIMAB project.

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

NIMAB (I.4) subproject 1 has investigated the utilization of N in grazed grass-clover fields and subproject 4 has analysed wheat samples for quality aspects.
DINOG (I.13) subproject 2.1 has investigated N2-fixation in grass-clover and subproject 2.3 has looked at spatial variations and quantification of N_2O emission at field scale.
The EU-project “Greenhouse Gas Mitigation for Organic and Conventional Dairy Production” (MIDAIR) has used the experimental unit for N_2O studies.

WP6. Crop rotation experiment

The following additional activities have been carried out in the crop rotation experiment in 2001:

- Experiments with application of potassium in selected plots at Jyndevad (Margrethe Askegaard).
- Development in plant available soil potassium over time using soil samples from plots at Jyndevad (Margrethe Askegaard).
- Samplings and measurements in cereal crops at Foulum to determine C and N turnover (Jørgen E. Olesen, part of the BIOMOD project).
- Subsoil loosening in plots at Foulum and Flakkebjerg (Per Schjønning, part of the ROMAPAC project).
- Topsoil compaction in plots at Foulum and Flakkebjerg (Per Schjønning, part of the ROMAPAC project).

WP7. The organic experimental farm, Rugballegaard

The following projects are carried out in the fields at Rugballegaard

1. In the rotation system of the mixed farm system a research program **“Soil Fertility”** was carried out. The year 2000 was the last year of a 5 year period, where the basic issue of research was the comparison of Non inverting tillage systems with the traditional ploughing. The project is financed by DARCOF. Per Schjønning is the project responsible scientist.
2. The company Eco-Dan has in cooperation with DIAS developed a laser steered computer vision system that can steer hoeing equipment attached behind a tractor by following the rows. The organic experimental station collaborated with the developed on testing the eco-dan machine in a sugar beet crop.

3. Together with the Danish advisory system the experimental station was part of the Eco-demo project. This project demonstates new cultivation techniques for farmers. This year the demonstration plot was in the lupine crop, where two different species were sown, and different weed-strategies were tried out. Michael Tersbøl, Danish Agricultural Advisory Center, is responsible for this project.
4. From 1997-1999 a DARCOF financed project was carried out to investigate the possibility to practice mixed grazing with pregnant sows and heifers. The project was terminated with good results, especially the heifers accounted for this. The sows could uptake about half of their roughage intake as fresh grazed clover-grass, while grazing on the same plot the whole summer. Together with two of the researchers connected to the previous project (Viggo Danielsen and Karin Søgaard) in 2000 the mixed grazing was continued, and further developed. The grazing pasture was divided in three, and a rotation grazing system with sows and heifers was practiced.
5. The Pajbjerg plant breeding company started a field trial to monitor many varities of spring and winter cereals grown in the organic rotation systems. The main objective for this work is to find the species and varieties that are best suitable for organic cultivation. The trial is carried out in the pig rotation system and in the mixed rotation system. Anni Jensen, Pajbjerg Fonden, is reponsible for the project).
6. The Department of Variety Testing carries out field experiments on many different sites in

   Danmark. In 2000, 229 winter cereal parcels and 119 spring cereal parcels were laid out at Rugballegaard to test varieties grown under organic conditions.
7. Together with the Department of Variety Testing and the Danish Advisory system the Organic Experimental Station laid out a field trial with 33 varieties in spring and winter cereals and pies to measure the yields.
8. Together with the Danish Advisory System an experiment with catch crops in Maize for silage was carried out.
9. In 2001 a row soil steaming drilling device is being developed, experiments start in 2002.

The following activities are carried out on animals at Rugballegaard

1. In order prepare to start up a research project in organic milk production dealing with prolonged lactation and grazing habits of milking cows only fed with roughage, compared with part of the herd that is fed with both concentrates and roughage, the organic experimental station held part of the herd without concentrates. This work is done in close contact with the project leader Troels Kristensen.
2. Together with the Department of Agricultural Engineering a new stable for organic pig production is tested.
3. Research program PIGSYS, resource use, environmental impact and economy in organic pig production systems has begun in 2001 (John Hermansen)
4. OrganicPigFeed, pig feeding under organic conditions with emphasis on nutrient utilisation, product quality and health has begun in 2001. (José Fernandez)
5. A large developement project started in 2001, where new housing systems for organic slaughtering pigs, new grazing systems for sows and slaughtering pigs and animal welfare are the main topics. (John Hermansen)

H. Possible elaboration of project and achieved results

The results achieved at the experimental units have been greatly disseminated among organic farmers in Denmark and functioned as inspiration for many other activities.