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Progress Report 2008 and Application for Continuation in 2009

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1. Project title and acronym

Grass-clover in organic dairy farming - options to reduce costs and improve nutrient utilization (OrgGrass)

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2. Project journal number **3304-FOJO-05-19-01**

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3. Project period (month, year)

Start of project: 1-2007
End of project: 12-2011

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7. Midterm description of the project, its results and progress, and application for continuation in 2008

A. Project summary

Table A.1: Work package list (from application)

WP No.	WP title	Responsible scientist	Budget DKK	Start	End	Deliverable No.
1	Productivity and N-leaching in grass-clover crop rotations	J. Eriksen	5.3 mill.	2-2007	6-2011	D1.1-D1.8
2	Grassland N management on coarse sandy soil	E.M. Hansen	1.7 mill.	2-2007	12-2010	D2.1-D2.4
3	Multi species grass-clover with high persistence	K. Søegaard	3.1 mill.	2-2007	6-2011	D3.1-D3.9
4	White clover soil fatigue – an establishment problem	K. Søegaard	0.9 mill.	2-2007	9-2009	D4.1-D4.3
5	Earthworms, macropores and N leaching	M. Holmstrup	1.5 mill.	6-2007	6-2010	D.5.1-D5.3
6	System analysis and economics	T. Kristensen	1.0 mill.	10-2007	6-2011	D6.1-D6.3
7	Project management	J. Eriksen	0.5 mill.	1-2007	12-2011	D7.1-7.7
Total			14 mill.			

Objectives and expected achievements

The main hypothesis is that we through grass-clover ley management on large grass intensive organic dairy farms can achieve cost-efficient feed production and efficient nutrient utilization. The overall objective is to produce results that can form the basis of this development by:

- Determination of grassland residual effects and nitrogen leaching when manipulating the grassland frequency in the crop rotation, grassland utilization and grazing intensity, and nutrient load.
- Investigating nutrient use efficiency of grassland N in high-risk areas regarding nitrate leaching (coarse sandy soil).
- Investigating the use of multi-species mixtures to increase long-term productivity, feed quality, biodiversity and nature value and improve clover establishment.
- Investigating how management practises of grass-clover fields influence the leaching losses of N in the autumn as influenced by earthworms and macropores.
- Optimizing representative whole farm prototypes regarding production, self-sufficiency, farm economics and environmental load.

Midterm results and progress

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

WP1: Productivity and N-leaching in grass-clover crop rotations

Two crop rotations have been established at Foulum. One of the crop rotations represents the situation close to the farm buildings (crop rotation near farm) and the other represents the situation further away from the buildings (crop rotation distant to farm). The crop rotations are shown in the table below.

Table 1.1. The dairy crop rotation at DIAS Foulum. Catch crop in brackets.

	Distant to farm	Near farm
1	Barley/grass-clover	Barley/grass-clover
2	1st yr grass-clover	1st yr grass-clover
3	2nd yr grass-clover	2nd yr grass-clover
4	Barley wholecrop/(Ital. ryegrass)	3rd yr grass-clover
5	Maize/(ryegrass/winter rape)	4th yr grass-clover
6	Lupin/(winter rye)	Barley wholecrop/(Ital. ryegrass)

In each of the crop rotations are made five grassland grazing/manure treatments varying in nutrient load per unit area and grassland management.

Table 1.2: Grassland grazing/manure treatments

Treatment no.	Grazing/manure
1	Grazing regime with manure application (100 kg total-N)
2	Grazing regime without manure application
3	Cutting and grazing regime with manure application (100 kg total-N)
4	Cutting regime with manure application (200 kg total-N)
5	Cutting regime without manure application.

Each combination of crop rotation, crop and grazing/manure treatment is present in duplicate each year. Adjacent to the crop rotations, permanent grassland established in 1993 is used as a reference with the five grassland manure treatments established. The permanent grassland was ploughed-out in spring 2008 similar to grass-clover leys in the two rotation sections.

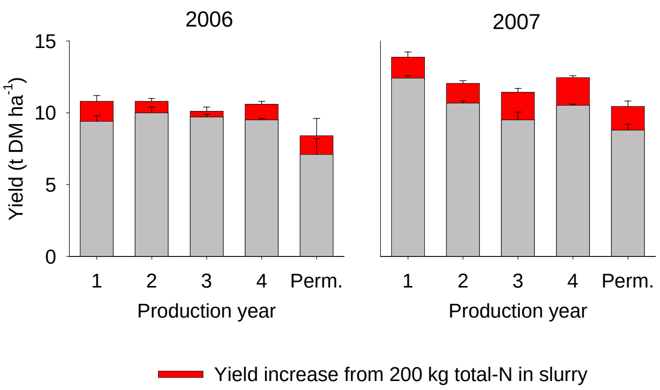

Fig 1.1: Annual grassland yield in two years and yield increase from slurry application. Error bars: SE

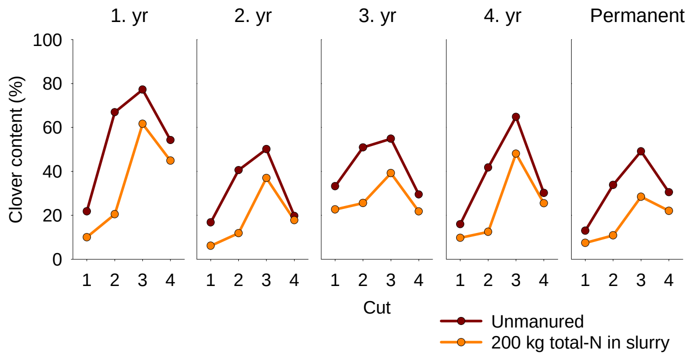

Fig 1.2: Clover content in grasslands as affected by manure application. Average of two years.

Annual grass-clover production in 2006 and 2007 is shown for cut grassland in Fig. 1.1. Within the 1st to 4th year there was little variation in DM yield and the yield increase caused by manure application was modest. The explanation was a compensating increase in clover content in unmanured grassland both years (Fig. 1.2). As an effect of the high clover content in especially 2nd and 3rd cut the N yield in manured and unmanured grasslands were almost identical.

In Fig. 1.3 is shown nitrate leaching from two years of measurement, calculated as annual volume-weighted nitrate-N concentrations for easier comparison between years with different rainfall. The general picture is the same in both years. Nitrate leaching in the crop rotation close to the farm was mainly in the grasslands and generally nitrate leaching was lowest in the first production year. In both crop rotations the barley wholecrop undersown with Italian ryegrass was very efficient in accumulating N following grassland cultivation and therefore leaching losses at this place in the crop rotations were at a very low level. Distant to the farm leaching losses following maize and lupin were both years considerable, despite both crops were followed by a catch crop – in maize was undersown a mixture of ryegrass and winter rape and lupin was followed by rye.

Nitrate losses in grasslands depended on both grazing and manure treatment. In figure 1.3 is shown only the average of all grasslands but the same pattern appeared more or less in all grasslands. Highest nitrate leaching was found following the grazing regime with manure application, but a considerable drop was observed when avoiding the manure application. Also a drop was observed when removing a first cut before start of grazing. In cut grassland manure application did not influence nitrate leaching.

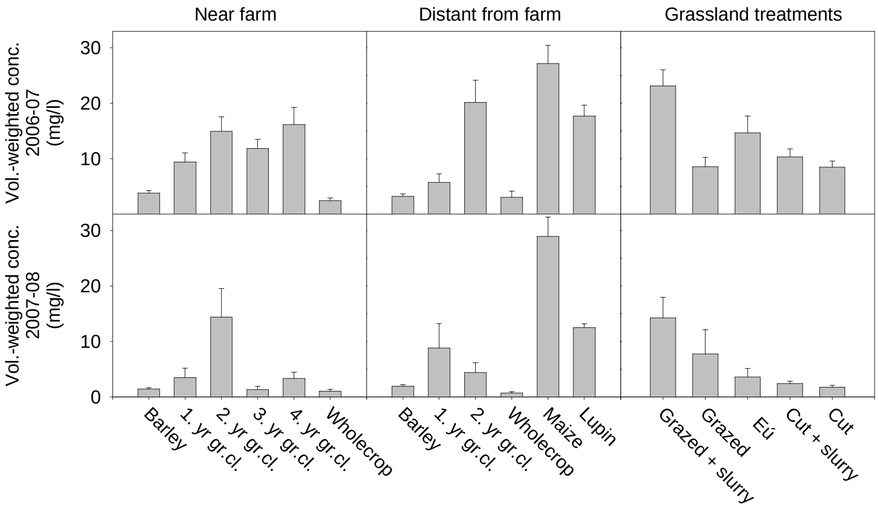

Figure 1.3: Nitrate leaching in two years calculated as annual volume-weighted nitrate concentration. Error bars: ±SE.

WP 2. Grassland N management on coarse sandy soil

In spring 2006 was selected a four year old grass-clover field on a private dairy farm on coarse sandy soil in the southern part of Jutland. An experiment including three grazing treatments was established in the field: 1. grazing only (G), 2. spring cut and grazing (CG) and 3. spring cut, grazing and autumn cut (CGC). The experiment was established as a randomized plot experiment in four replications. Each grazing treatment was established on 16 subplots allowing each treatment to be subdivided into another four treatments with maize in spring 2008. Each subplot was equipped with two suction cups in 80 cm depth i.e. each grazing treatment was equipped with 32 suction cups. Each suction cup was permanently installed with suction and collection tubes taken outside the experimental field in narrow furrows just beneath the sod allowing the cattle to graze without hindrance. Soil water from the suction cups are analysed for nitrate-N in order to calculate nitrate leaching. Ordinarily, the two samples from each subplot are mixed before analysing, except at one date in autumn each year, where all samples were analysed separately. So far soil water samples until February 2008 have been analysed. In the period from 11 April 2006 to 8 February 2008 soil water samples were collected from the suction cups at 36 dates. The whole experiment was irrigated with a total of 123 mm in 2006 and 75 mm in 2007.

In most of the soil water samples (average of two samplers) nitrate concentrations were below 10 ppm, but in some cases very high values were recorded (maximum 478 ppm). Those high values most likely originate from urine patches. On the date of 13 December 2006 and 18 December 2007 all samples were analysed separately. In all cases with high average concentration were seen very different concentrations in the two samples from the same subplot. The most extreme was 382 ppm in one sample and 0.3 ppm in the other. The average nitrate leaching and the variation in nitrate leaching between replications are shown in Table 1.

Table 1. Nitrate leaching from 11 April 2006 to 8 February 2008 in grazing treatments (kg N ha^{-1}). Each replication includes 8 suction cups. In brackets nitrate leaching from 11 April 2006 to 9 March 2007 (last midterm report).

Treatment	Replication				Average
	1	2	3	4	
1. G	28 (24)	203 (188)	35 (27)	280 (101)	137 (85)
2. CG	53 (24)	103 (86)	78 (73)	121 (33)	89 (54)
3. CGC	121 (33)	52 (44)	212 (96)	33 (28)	105 (50)

In treatment G which was permanently grazed there were four subplots with extremely high nitrate leaching (310 – 718 kg N ha^{-1}), in treatment CG which was grazed in summer and autumn were also seen four subplots with high leaching (119 – 381 kg N ha^{-1}) and in CGC which was only grazed in summer, two subplots with very high leaching (352 - 664 kg N ha^{-1}) were seen. In both years urine patches from the summer grazing seems to have "survived" until autumn, where most leaching takes place. This means that in comparison to cutting, even summer-grazing may increase the risk of nitrate leaching on this soil type due to urine patches.

In spring 2008 the grazing treatments were subdivided into treatments with maize (with and without catch crop and manure) and a reference treatment with a barley green crop. Nitrate leaching measurements are continued as planned until spring 2009.

<u>WP3: Multi species grass/clover with high persistence</u>

Three different seed mixtures were established in 2006 and 2007 in the 'Near farm crop rotation' WP 1. In 2008 there were thus two swards with different age. Mixture 1 was a basis mix with perennial ryegrass, white clover and red clover. Mixture 2 was composed of mix 1 together with 7 herbs. Mixture 3 was mix 1 together with festulolium, lucerne and herbs. Sainfoin and chervil were not found in both swards, whereas all other species had a frequency of nearly 100 % in spring measured in 0.25 m^2 areas. The mixtures are examined under different managements; that is the treatments in WP 1 (grazing/cutting and slurry). Effects of many different aspects can be analysed in this project, and only a few will be mentioned here. In table 3.1 the effect of grazing versus cutting on the botanical composition is shown for the three mixtures. The length of the period with grazing and cutting increased from autumn 2007 to autumn 2008. The proportion of legumes (white clover, red clover, lotus and lucerne) increased during the season and was highest in mixture 1 compared with mixture 2 and 3. Lucerne depressed red clover under cutting in mix 3 without affecting the other species. Especially this fact can give some interesting aspect for the future. Under grazing lucerne (a cutting type) has gradually disappeared. Among the herbs chicory had the highest competitiveness and the proportion was highest under grazing. Plantain was established very well in 2006, but has decreased over time. The proportion has been highest under cutting. Caraway competed best under grazing and great burnet had generally a low competitiveness. The herbs depressed especially the proportion of grass and white clover.

Table 3.1. Botanical composition (% of herbage dry matter) measured by hand separation in mixture 1, 2 and 3 after different management. Until the measuring period, the swards have either been grazed continuously by heifers or cut. Results are from plots without slurry application. Mean of two replicates.

Without slurry	2007 (Harvest year 1) Cut 3						2008 (Harvest year 2) Cut 1						2008 (Harvest year 2) Cut 3					
Management	Grazing			Cutting			Grazing			Cutting			Grazing			Cutting		
Mix	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Grass[1)]	21	10	12	15	2	4	74	68	51	52	28	31	39	34	30	6	3	5
White clover	46	15	15	34	14	14	24	21	24	30	26	26	35	30	26	10	10	6
Red clover	33	40	32	51	55	22	2	4	4	18	27	17	24	17	20	84	70	22
Chicory		18	16		5	6		2	4		4	1		10	8		5	6
Plantain		14	11		18	22		3	6		11	11		4	6		8	6
Caraway		2	1		1	2		2	10		4	2		3	4		0	1
Burnet		0	0		0	0		0	2		0	0		0	0		0	0
Lotus		1	3		4	5		0	0		1	1		1	3		3	0
Lucerne			10			25			0			11			1			54
Unsown sp.	1	0	0	0	0	1	1	1	0	0	0	0	3	0	0	0	0	0

[1)]: perennial ryegrass and festulolium.

There was a great difference in feeding value between the species (Table 3.2). The content of crude protein in the non-leguminous herbs was like the content in grass. The composition of the cell wall differed very much. Plantain was characterised by having the highest content of cell wall even that it was lower than for grass. The lignin content in plantain was extremely high, as it was higher than in Lucerne, and the content of hemicellulose was the highest among the herbs. Caraway seems to have a very high feeding value. Low content of cell wall as white clover, very low content of lignin and a very high digestibility of organic matter. The high content of crude ash in caraway indicates a high mineral content.

Table 3.2. The feeding value of the single species. Samples from mix 3. Mean of cut 1 and 3 in 2007.

	IVOMD[1)]	Cell wall	Hemi-cellulose[2)]	Cellulose[2)]	Lignin[2)]	Crude protein	Crude ash
Grass	77.8	47.9	19.2	26.3	2.4	13.7	8.7
White clover	77.7	26.6	3.3	19.3	4.0	23.2	10.9
Red clover	74.7	30.6	7.4	20.0	3.2	20.5	8.6
Chicory	73.2	32.6	5.1	23.9	3.6	12.1	11.4
Plantain	63.0	42.6	9.0	27.3	6.1	10.6	8.9

Caraway	82.4	25.8	2.3	20.7	2.8	13.0	13.1
Burnet	59.9	30.0	5.2	20.1	4.4		8.1
Lotus	68.1	30.8	4.6	20.4	5.8	21.9	8.1
Lucerne	67.8	36.0	7.3	23.1	5.6	21.8	10.2

1): In vitro organic matter digestibility
2): Cell wall composition calculated from fibre analyses (van Soest method). Cell wall (NDF), hemicellulose (NDF-ADF), cellulose (ADF-ADL) and lignin (ADL).

The annual dry matter yield under cutting in 2007 was nearly the same in the mixtures; 13,700 kg DM/ha. However, the yield of net energy for lactation was higher in mix 1 (97,000 MJ NEL/ha) than the two other mixtures (86,000 MJ NEL/ha). The main reason for this is the lower feeding value of the main herbs chicory and plantain (Table 3.2).

The mixtures were also established on six farms in 200 m^2 plots with two replicates in spring 2006. Generally the white clover was well established, and the herbs were therefore exposed to a high competition from the beginning. The mixtures are only grazed by dairy cows on the farms and not cut. The herbs constituted on average 18 % of dry matter in August 2008 on the farms compared with 38 % in the plots at Foulum. The proportion has decreased during the season of 2008. On farms chicory and plantain were too the predominant herb species. On farms the cows' selectivity was measured in 25 x 0.25 m^2 areas per plot. The cows avoided the plantain, especially the flowers, and in the last part of the season they also avoided the chicory. The sward structure of the mixtures was the same, which indicates that the cows are grazing the mixtures in the same way.

Nitrogen transfer between species using tracer methodology (Ph.D. study)

Experiment	Site	Field Work	Measurements/Analyses
Experiment 1: Transfer and deposition of nitrogen between different plants in multi-species mixtures	Foulumgaard	Cylinders were installed in the established multi-species grassland on the 15th of April 2008; ^{15}N leaf-labelling was done 3 times starting on the 6th of May 2008; above ground plant tissue was harvested 3 times starting on the 26th May 2008 (4th harvest in mid of October 2008); additionally, ammoniumsulphate enriched with ^{15}N was added on a 1x1m plot to measure N_2 fixation of the legumes in the mixture; plant tissue within the 1m^2 plot was harvested	Dry matter yield was measured on each species (9 in total) for each harvest in each cylinder (Fig 1) as well as for the N_2 fixation plots; Plant samples are being prepared for the ^{15}N analyses
Experiment 2: Effective rooting depth of different plants in multi-species mixtures	Højbakkegaard	Different mixtures and monocultures of grassland plant species were established directly at Højbakkegaard in Taastrup Sept 2007. Two N supply levels were initiated and 3 harvests were done starting on the 4th of June 2008; ^{15}N placement in different depths will be done in the growing season of 2009 when all crops are well established.	In order to establish a baseline for two N supply levels, dry matter yield was measured for each species of the mixtures and for each monoculture plot
Experiment 3: Temporal difference in macro- and micromineral content of different plant species over the season and over a three year period after sward establishment.	Foulumgaard	Plant samples for macro – and micronutrient analyses were taken 3 times in 2008 at the same day as experiment 1 (4th harvest in mid of October 2008);	Macro- and micronutrient analyses by Inductively Coupled Plasma Spectroscopy (ICP-OES) were done on plant samples from 2007 for the 1st and 3rd cut (Fig 2); Plant samples from 2008 are being prepared for ICP-OES analyses

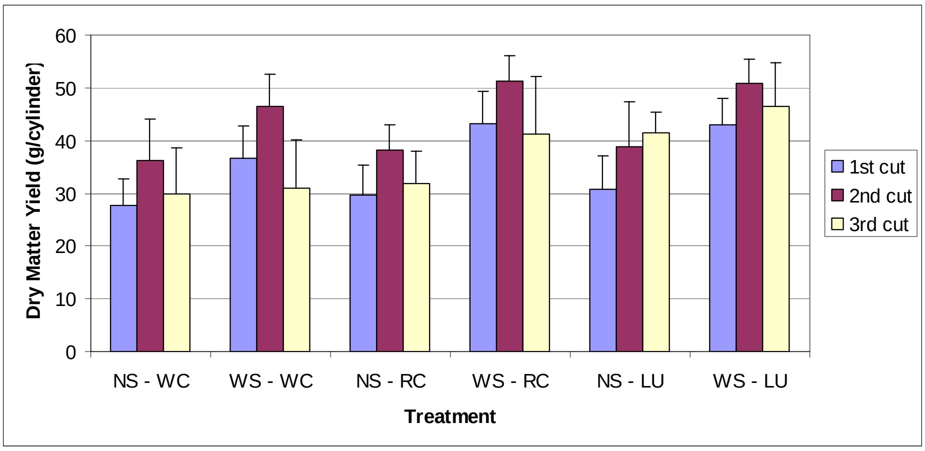

Fig 1. Dry matter yield with standard deviation (n=8; for WS - LU n=9) for cylinders labeled with white clover (WC;*Trifolium repens*); red clover (RC; *Trifolium pretense*) and Lucerne (LU; *Medicago sativa*), respectively and managed with (WS) or without (NS) slurry

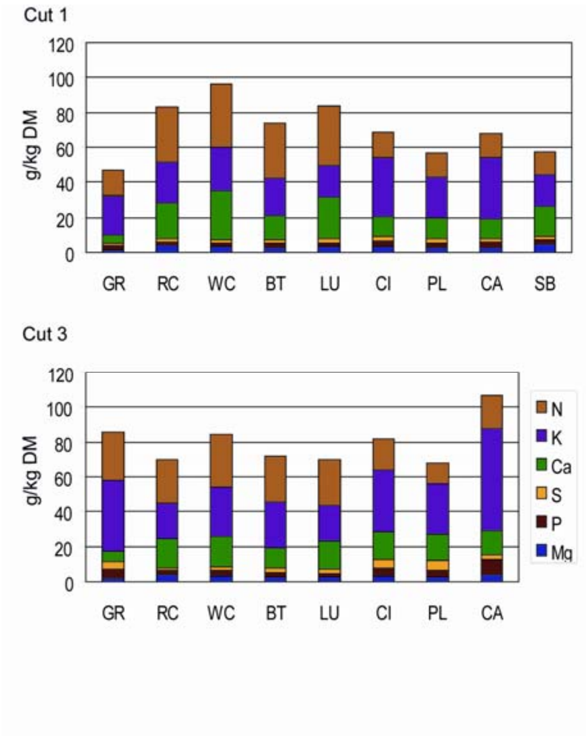

Fig 2. Concentration of macronutrients (N=Nitrogen; K=Potassium, Ca= Calcium, S= Sulphur, P=Phosphorous, Mg=Magnesium) in nine grassland plant species at the first and third harvest in 2007, respectively (GR= perennial ryegrass (*Lolium perenne*) and festulium, RC=Red clover (*Trifolium pratense*), WC= White clover (*Trifolium repens*), BT= Birdsfoot trefoil (*Lotus corniculatus*), LU= Lucerne (*Medicago sativa*), CI= Chicory (*Cichorium intybus*), PL= Plantain (*Plantago lanceolata*), CA= Caraway (*Carum carvi*), SB= Salad Burnet (*Sanguisorba minor*); (n=2).

WP4: White clover soil fatigue – an establishment problem

In spring 2007 five different soils were collected. No. 1 was a reference soil from Foulumgård from a field without clover in the crop rotation for at least 20 years. The other four soils were from grass/clover fields, where clover soil fatigue could be expected. No. 2 and 3 were from Foulumgård and no. 4 and 5 from two organic dairy farms. The experiment was carried out in pots (31 l containers), in total 135 pots. Different species (white clover, red clover, lucerne, Italian ryegrass and none) were established in spring barley. The average barley yield and the yield of the undersown species are shown in table 4.1. The yield of barley was low in soil 1 because of low soil fertility. This caused good growing conditions for the undersown crop.
In 2007 there was a distinct white clover fatigue especially in soil 5. The white clover plants stopped growing, became yellow/red/brown and disappeared. In soil 5 there was also a low production of red clover and lucerne. Italian ryegrass, however, yielded well on all soil types, and the yield was not related to the yield of the cover crop. This indicates, that the great decrease in legume yield from soil 1 to the other soils is not simply a result of low barley yield and by that a high penetration of light to the undersown crop.

Table 4.1. Dry matter yield (kg DM/ha) 26 July 2007. Mean of two pots.

	Barley	White clover	Red clover	Lucerne	Italian ryegrass
1 (reference)	2,682	2,217	3,148	1,891	1,359
2	9,383	783	546	251	1,439
3	9,250	139	485	199	1,075
4	7,983	145	400	331	954
5	9,057	0	86	63	2,066

Samples are taken of soil and newly germinated plants to examine the number of nematods. In roots grown in soil where clover soil fatigue could be expected many plant parasitic nematodes were found. In 2008 the pot experiment has continued. Half of the pots were undersown with white clover, which means that there has only been one year without white clover. The other half was sown with the same crop as in 2007. In 2009 all pots will be sown with white clover and there will be two and one years, respectively, without white clover. In spring 2008 there was a very bad establishment of white clover and to a small extent also of red clover. The clovers were sown again with a better but not satisfactory germination. Yield is determined, but due to the bad establishment no samples for nematodes was taken. In stead nematodes will be analysed more detailed in 2009.

WP5: Earthworms, macropores and N leaching

The experimental work will be carried out in October and November 2008 in the organic dairy crop rotation experiment at Foulum (WP1). In each treatment will be applied potassium bromide in aqueous solution evenly to a 2-m^2 area to model nitrate originating from urine deposited during autumn grazing. This is followed by irrigation to simulate potential nitrate leaching during natural rainfall. A 1-m^2 plot will be excavated in successive layers to (1) determine the presence of earthworms (identified to species and individually weighed), (2) quantify the size and distribution of macropores (primarily earthworm burrows), and (3) determine the movement of bromide in the soil profile. These excavations will include the plowing layer, the plow pan and deeper soil layers down to a depth of 1.5 m. As a result of these investigations we will be able to quantify the potential leaching of nitrate-N under various grassland management strategies. It can then be determined if this is correlated with the density of earthworms and earthworm burrows. Our primary investigations will be carried out in systems grazed by cattle because the highest potential of N-losses (via urine) is found here. However, we will include grass-clover without grazing for comparison in order to assess the effects of cattle trampling on earthworms and macropore flow.

WP6: System analysis and economics

Prototyping has been made for a scenario with 100 ha, equal between near and distant rotation, and a herd of 133 LSU (85 dairy producing 8500 kg energy corrected milk and 93 heifers with an annual live weight gain of 250 kg). Focus has been on N flow in order to establish a balance between N ab animal and N applied to the different fields and on the feed supply (net energy in terms of SFU and N) from the two crop rotations.

The expected production in each crop within the two rotations is based on productivity results from earlier years corrected with the shown utilization and input of manure.

Table 6.1. Crop rotation, input of manure N and expected net production from the field near farm

Crop	Utilization	Kg N brutto manure[1)]	Net production, SFU	Net production, kg DM
Barley with	Silage	100	2270	2853
grass clover	Grazing	0	3395	3654
Grass-clover	Grazing	0	5978	6165
Grass-clover	Grazing	50	5978	6165
Grass-clover	Grazing/silage	70	5483	5674
Grass-clover	Grazing/silage	85	5483	5674
Barley with	Silage	0	2270	2853
ryegrass	Grazing	0	3395	3654
	Average	51	5709	6115

[1)] Kg N after correction for input of straw, N deposited during grazing and N emission from stable and storage.

Table 6.2. Crop rotation, input of manure N and expected net production from the field distant farm

Crop	Utilization	Kg N brutto manure[1)]	Net production, SFU	Net production, kg DM
Barley with	Cereals+straw	135	4305+432	3862+1890
Grass clover	Silage	0	377	513
Grass-clover	Silage	170	6665	7945
Grass-clover	Silage	170	6665	7945
Barley with	Cereals+straw	0	4305+432	3862+1890
grass	None	0		
Maize	Silage	305	6709	8148
Lupin with	Cereals	0	3000	2179
ryegrass	None	0		
	Average	130	5337	5742

[1)] Kg N after correction for input of straw, N deposited during grazing and N emission from stable and storage.

Besides the shown amounts of N from applied manure there will be 5300 kg N deposited during grazing and an estimated fixation of 12500 kg N (Estimation based on crop type, DM net production, expected % legumes and N applied). This gives a total input of 270 kg brutto N per ha in average of the 100 ha.

The total net production from 100 ha (50 ha near and 50 ha distant) can be calculated to 552.000 SFU and 18000 kg N; equal to an efficiency of N at 66%. 224.000 SFU are utilised as pasture all in the near farm rotation. This leaves 74.800 SFU as silage in the near farm rotation of which half is from barley harvested at heading and the other half from 16.7 ha of 1. cut in grass-clover.

Table 6.3. Annual feed budget – 50 ha near and 50 ha distant to farm, 85 dairy cows and 93 heifers.

Crop type	Feed item	Dairy cows SFU	Heifers SFU	Herd total SFU, 1000	N, kg
Clover grass[1)]	Pasture	1400	700	224	7344
	Silage	1840	730	184	7288
Maize	Silage	660		56	870
Barley	Cereal	850		72	1112
	Straw	30	30	6	163
Lupin	Cereal	290		25	1216
	Milk		25	2	53
Imported	Barley	970	220	103	1603
	Concentrates	370		31	829
	Total	6410	1705	703	20478

1) Included silage from barley (harvested at heading) in the near farm rotation.

The above feed budget meets the demand for the cows and heifer based on ad libitum feeding of roughage supplemented with barley, lupins and concentrate. Twelve percent of the N demand is imported in barley and concentrates (19% crude protein in DM) and 19% of the energy (SFU) and 15% the drymatter is imported. For all type of crops and feed items, expect straw there is an annual balance between production (Table 6.1 and 6.2) and the calculated feed intake. The surplus of straw (8 ton) is used as bedding together with an import of 106 ton straw (3,6 kg pr cow and heifer daily). In terms of N the import with straw is 600 kg N or 4% of the total N production ab animal.

The amount of N applied to the fields is estimated to 9050 kg (table 6.1 and 6.2). The difference to the intake of 20478 kg N (table 6.3) is due to N in products (4400 kg), N deposited during grazing (5300 kg), emission from stable and storage (2700 kg N) and addition of N from straw used as bedding.

C.2 Fulfilment of deliverables and milestones

Deliverables list (from application)

Workpackage 1						
Delive-rable No	**Deliverable title**	**Lead scien-tist**	**Delivery date**	**Allocated scientific person moths**	**Type of de-liver-able**	**Fulfilled (ok) or devia-tions (d)***
D1.1	Refereed scientific paper on grassland productivity as affected by crop rotation, grassland management and nutrient load	MA	Jun 2011	9	S	
D1.2	Refereed scientific paper on nitrogen leaching as affected by crop rotation, grassland management and nutrient load	JE	Jun 2011	9	S	
D.1.3	Refereed scientific paper on residual effects as affected by crop rotation, grassland management and nutrient load	JE	Dec 2010	9	S	
D1.5	Paper for farmer journals on the optimizing of mixed crop rotations on organic dairy farms.	MA	Dec 2010	2	P	
D1.6	Popular paper on nitrogen leaching losses from grassland systems	JE	Oct 2010	2	P	
D1.7	Popular paper on crop productivity in mixed farming systems	JE	Mar 2011	2	P	
D1.8	Data for system analysis and economic modelling (WP6)	MA	Jan 2010	7	O	

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 1			
Mileston No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or devia-tions (d)***
M1.1	Crop rotation experiment fully established	Apr 2007	ok
M1.2	Productivity of grassland systems evaluated	Jun 2011	
M1.3	Environmental impact of grassland systems evaluated	Dec 2010	

** Deviations are to be further discussed in D*

(The nature of the deliverables must be indicated by S = publication in scientific journal with peer review; P = publication in journals without peer review; R = reports; C = presentation at meetings and congresses or O = other types of deliverables, e.g., prototypes, models, websites, etc.).

Deliverables list (from application)

Workpackage 2						
Delive-rable No	**Deliverable title**	**Lead scien-tist**	**Delivery date**	**Allocated scientific person moths**	**Type of de-liver-able**	**Fulfilled (ok) or devia-tions (d)***
D2.1	Refereed scientific paper on production and nitrate leaching in the grazed grassland experiment	EMH	Dec 2009	5	S	
D2.2	Popular paper on production and nitrate leaching in the grazed grassland experiment	EMH	Dec 2009	1.5	P	
D2.3	Refereed scientific paper on production and nitrate leaching in the maize experiment	EMH	Dec 2010	5	S	
D2.4	Popular paper on production and nitrate leaching in the maize experiment	EMH	Dec 2010	0.5	P	

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 2			
Mileston No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or devia-tions (d)***
M2.1	Establishment of the grazed grassland experiment	May 2007	ok
M2.2	Establishment of the maize experiment	May 2008	ok
M2.3	Evaluation of production and nitrate leaching in the grazed grassland experiment	Sep 2010	
M2.4	Evaluation of production and nitrate leaching in the maize experiment	Sep 2010	

** Deviations are to be further discussed in D*

Deliverables list (from application)

Workpackage 3						
Delive-rable No	**Deliverable title**	**Lead scien-tist**	**Delivery date**	**Allocated scientific person moths**	**Type of de-liver-able**	**Fulfilled (ok) or devia-tions (d)***
D3.1	Refereed scientific paper on herbs in grasslands as affected by age and management	KS	Jun 2011	5.5	S	

D3.2	Popular paper on herbs in grasslands as affected by age and management	KS	Jun 2011	0.5	P	
D3.3	Refereed scientific paper on grassland persistence as affected by species and management	KS	Jun 2011	4.5	S	
D3.4	Popular paper on grassland persistence as affected by species and management	KS	Jun 2011	0.5	P	
D3.5	Refereed scientific publication on nitrogen transfer between species using tracer methodology	HHJ	Jul 2009	8	S	
D3.6	Refereed scientific publication on rhizodeposition of carbon and nitrogen in mixtures including herbs	HHJ	Dec 2009	8	S	
D3.7	Refereed scientific publication on competition, effective rooting depth and nutrient uptake efficiency of intercropped ryegrass, lucerne, chicory, and great burnet.	HHJ	Dec 2009	10	S	
D3.8	Refereed scientific paper on herbage quality of intercropped ryegrass, Lucerne, chicory, and great burnet over three growth seasons.	HHJ	Dec 2009	10	S	

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 3			
Mileston No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or deviations (d)***
M3.1	Contracts with organic farmers on establishing herbs and registrations in their pastures	Dec 2007	ok
M3.2	Discussions of results from farms with farmers and advisors	Dec 2009	
M3.3	PhD study initiated	Oct 2007	ok
M3.4	Mezotrons inserted in established field trials (WP3.3) with multiple grassland species at clayey loam and coarse sandy soils	Feb 2007	ok
M3.5	Description of transfer and nutrient dynamics in multiple grassland species	Oct 2008	In Prep.
M3.6	Field trails established to investigate nutrient uptake efficiency in multiple species grassland mixtures and tracers positioned	May 2008	ok
M3.7	Description of nutrient uptake efficiency by intercropped multiple grassland species	Dec 2009	
M3.8	Analysis of samples from 3 growth seasons on-farm multiple grassland mixtures for macro- and microelement completed	Jun 2009	
M3.9	Finalisation of PhD study	Oct 2010	

Deliverables list (from application)

Workpackage 4						
Deliverable No	**Deliverable title**	**Lead scientist**	**Delivery date**	**Allocated scientific person moths**	**Type of deliverable**	**Fulfilled (ok) or deviations (d)***
D4.1	Refereed scientific paper on white clover soil fatigue	KS	Jun 2009	4.2	S	
D4.2	Popular paper and information on Internet concerning clover soil fatigue	KS	Jun 2009	0.5	P	
D4.3	Popular paper on optimizing crop rotation	KS	Jun 2009	0.5	P	

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 4			
Mileston No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or devia-tions (d)***
M4.1	Select the plant species used in the experiment, and point out soils on organic dairy farms for the experiment	Mar 2007	ok
M4.2	Evaluate necessity of changes in methods after the first experimental year	Jan 2008	ok

** Deviations are to be further discussed in D*

Deliverables list (from application)

Workpackage 5						
Delive-rable No	**Deliverable title**	**Lead scien-tist**	**Delivery date**	**Allocated scientific person moths**	**Type of de-liver-able**	**Fulfilled (ok) or devia-tions (d)***
D5.1	Refereed scientific paper on potential nitrate loss via preferential flow through macropores	ML	Dec 2009	5	S	
D5.2	Refereed scientific paper the influence of earthworms on leaching of N	PHK	Jun 2010	4.5	S	
D5.3	Refereed scientific paper on the influence of cattle trampling on macropores and leaching of N	ML	Jun 2010	4	S	

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 5			
Mileston No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or devia-tions (d)***
M5.1	First assessment of leaching through macropores in the field	Nov 2008	
M5.2	Assessment of earthworm density and biomass in field experiment	Jun 2009	

** Deviations are to be further discussed in D*

Deliverables list (from application)

Workpackage 6						
Delive-rable No	**Deliverable title**	**Lead scien-tist**	**Delivery date**	**Allocated scientific person moths**	**Type of de-liver-able**	**Fulfilled (ok) or devia-tions (d)***
D6.1	Prototyping of different strategies in a farm perspective	TK	Feb 2007	2.5	O	ok
D6.2	Ø-PLAN Dairy. A whole farm model	NT	Nov 2010	6	R	
D6.3	Refereed scientific paper on farm productivity and economic return in relation to grassland management and crop rotation on organic dairy farms	TK	Nov 2011	7.5	S	

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 6			
Mileston No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or devia-tions (d)***
M6.1	Ø-PLAN extended and tested by expert panel	Apr 2010	
M6.2	Scenarios for modelling defined	May 2011	

** Deviations are to be further discussed in D*

Deliverables list (from application)

Workpackage 7						
Delive-rable No	**Deliverable title**	**Lead scien-tist**	**Delivery date**	**Allocated scientific person moths**	**Type of de-liver-able**	**Fulfilled (ok) or devia-tions (d)***
D7.1-D7.4	Annual reports	JE	Oct 07-10	1	R	ok
D7.5	Project web site	JE	Jun 2007	1.5	O	ok
D7.6	Workshop publication	JE	Feb 2010	1.5	R	
D7.7	Final report	JE	Apr 2011	1	R	

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 7			
Mileston No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or devia-tions (d)***
M7.1	Fulfilment of overall project objectives	Dec 2011	

** Deviations are to be further discussed in D*

D. Description of deviations and subsequent adjustments of plans

In WP5 plans have been adjusted so this workpackage has its main workload in 2008 instead of 2007. The main reason being that it will be possible to use grassland plots in WP1 that have been subject to the manure treatments for a longer period.

Project publications and other products

Products from Organic Eprints archive

Eriksen, J ; Askegaard, M and Søegaard, K (2008) Productivity and N-leaching in organic dairy grass-arable crop rotations. Paper presented at EGF 2008, Uppsala, 9-12 June 2008; Published in *Grassland Science in Europe* 13, page pp. 556-558.

Eriksen, J ; Askegaard, M ; Søegaard, K and Hansen, E M (2008) Planteproduktion og miljø på store økologiske kvægbrug. Paper presented at Plantekongres 2008, Herning Kongres Center, 8-9 januar; Published in *Sammendrag af indlæg*, page pp. 333-334.

Eriksen, J (2007) Projekt om økonomisk og miljøvenligt kløvergræs på store økologiske kvægbrug. In *Landbrugsavisen 2. sektion Agro*, No 22, page 24.

Eriksen, J (2007) Udnyt græsmarkens kvælstof. In *Økologisk Jordbrug*, No 377, page 8.

Eriksen, J. (2007) Udnyt græsmarkens kvælstof. In *Økologisk Jordbrug*, Volume 377, page 8.

Rasmussen, J ; Eriksen, J ; Jensen, E S and Høgh-Jensen, H (2008) In field N transfer, build-up, and leaching in ryegrass-clover mixtures. Paper presented at EGF 2008, Uppsala, 9-12 June 2008; Published in *Grassland Science in Europe* 13, page pp. 559-561.

Søegaard, Karen; Eriksen, Jørgen and Askegaard, Margrethe (2008) Herbs in grasslands - effect of slurry and grazing/cutting on species composition and nutritive value. Paper presented at General Meeting of the European Grassland Federation, Uppsala, Sweden, 9-12 June 2008; Published in Hopkins, A.; Gustafsson, T.; Bertilsson, J.; Dalin, G.; Nilsdotter-Linde, N. and Spörnly, E., Eds. *Grassland Science in Europe* 13, page pp. 200-202.

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

Pirhofer-Walzl K, Søegaard K, Eriksen J and Høgh-Jensen H (2008) Processes behind the use of multi-species mixtures in organic grassland. Poster at 22nd General Meeting of the European Grassland Federation "Biodiversity and Animal Feed. Future Challenges for Grassland Production" in Uppsala, Sweden, 9-12 June 2008.

June 21, 2007, M. Askegaard presented the Orggrass project in the experimental field at Foulum to 190 staff members at University of Aarhus.

September 2, 2007, K. Søegaard presented the Orggrass project at a meeting in the European Grassland Federation working group on 'Grassland resowing and grass-arable rotations' in Ghent.

Field day (Emnedag vedr. græsmarker i økologiske kvægbrugssædskifter herunder anvendelse af urter) at Foulum 22 May for the farmers, on which farms the project has activities, their advisers and other collaborators. In total 23 participants. Arranged together with ECOVIT (ICROFS-III project).

Spring 2008, the WP1 field experiment was used as case in the course 'The cultivated soil – interaction with crop production and environment' for Biology students at Aarhus University.

Scientific education

PhD student, Karin Pirhofer, is directly employed by the project from November 2007 and is enrolled at LIFE, University of Copenhagen.

From July 2007 to June 2010, Post Doc Jim Rasmussen is associated to the project via a grant from the Danish Agency for Science Technology and Innovation for the project 'Sources and characteristics of DON leaching perennial grass-clover mixtures in Northern Europe'.

G. National and international cooperation

Within the DARCOF III programme:

- 'The effect of cropping systems on production and the environment' (CROPSYS) addresses to some extent similar aspects of organic crop production but in arable systems without grazing animals. The research is coordinated through overlap in project staff (M. Askegaard).
- 'Integrated supply of vitamins and minerals and non-antibitic health control in organic dairy herds (ECOVIT)' has on pastures on dairy farms included measurements of mineral content in the plant species and selection by the dairy cows. In present application the botanical composition and the biodiversity dynamic will be measured in the same pastures (WP3 task 2 seed mixture 2). The research is coordinated through overlap in project staff (K. Søegaard and T. Kristensen).
- 'Organic milk of high quality – development of production concepts based on grazing of the dairy cows and gentle treatment of the milk during handling and processing' (ORMILKQUAL) addresses aspects of pasture grazing relevant for milk quality. The research is coordinated through overlap in project staff (T. Kristensen, K. Søegaard and J. Eriksen).

In the post doc project by Jim Rasmussen field experimentation has been carried out on Iceland and in Germany on leaching of dissolved organic N leaching. Contacts: Dean of the Faculty of Land and Animal Resources, Dr. Áslaug Helgadottir, Agricultural University of Iceland, Reykjavik and Professor Dr. Friedhelm Taube, Christian-Albrechts-University, Kiel.

Contacts are made with Professor Dr. Bodil Frankow-Lindberg, Swedish University of Agricultural Sciences, who has a field trial in Swalof with herbs in grassland, which may be used for some of the field trials in WP3.

On September 4-5, 2008 a meeting was held with a group of researcher from Institute of Crop Science and Plant Breeding - Grass and Forage Science/ Organic Agriculture - University of Kiel with presentation of results from Orggrass WP 1, 2, 3 and 6 and the field experiment at Kiel, Reykjavik and Foulum.

Critical reflection on the project

Since the original proposal was submitted in March 2005, the number of cows per organic farm has continued to increase. The part of conventional cows that are kept indoors is also increasing and therefore cows on grass are more and more associated with organic farming. Thus, the research questions of our project are certainly becoming increasingly relevant. Particularly, it is important to demonstrate for conventional farmers how grazing is possible for large herds, since this appears to be a major barrier for conversion to organic farming.

The association of a post doc working on characterisation of leaching of dissolved organic N is a great benefit to the project. One reason is that loss of organic N has been neglected until now and especially in grassland it may be of some importance. Also, it gives us the upportunity to maintain the expertise in the area that was build by the post doc during a Ph.D. study in the DARCOF II project Nitgrass.

8. Budget

A. Account for any change in budgets

In WP5 the main workload has been scheduled to 2008 and man-month has been transferred from 2007.

B. Budget for the whole project (1.000 DKK)

Total consumption of funds from DARCOF and expected consumption this year and coming years

Year:	Original budget	Consump-tion 2005/2006	Consump-tion 2007	Expected consump-tion 2008	2009	2010	2011	Total
Man-months								
Scientific personnel	21.25	0	21.0	35.4	37.9	30.4	14.2	138.9
Technical personnel	25.8	0	14.2	22.9	16.6	3.8	1.6	59.1

Year:	Original budget	Consump-tion 2005/2006	Consump-tion 2007	Expected consump-tion 2008	2009	2010	2011	Total
Salaries								
Scientific personnel	1,037	0	877	1,582	1,723	1,323	758	6,263
Technical personnel	782	0	385	694	544	130	56	1,808
Other operational costs	511	0	423	562	437	112	31	1,566
Equipment	5	0	5					5
Others (please specify)	566	0	715	757	521	23		2,015
Direct costs	2,901	0	2,405	3,595	3,224	1,621	845	11,690
Indirect costs (20% of direct costs)	536	0	481	719	645	319	168	2,333
Total	3,481	0	2,886	4,314	3,869	1,916	1,013	13,999

Comments:

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project Jørgen Eriksen	Department of Agroecol- ogy and Environment, Faculty of Agricultural Sciences, University of Aarhus	1 October 2008	

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

Department of Agroecology and Environment, University of Aarhus

Year:	Original budget	Consump-tion 2007	Expected consumption 2008	2009	2010	2011	Total
Man-months	133,	29	34	36,90	21,	11,	134,
Scientific per-sonnel	83,	16	17	21,30	18,	10,	83,
Technical per-sonnel	49,	13	16	15,60	3,	1,	50,

Year:	Original budget	Consumption 2007	Expected consumption 2008	2009	2010	2011	Total
Salaries	6.042	1.113	1.459	1.645	1.125	615	5.957
Scientific personnel	4.449	755	963	1.128	995	559	4.400
Technical personnel	1.593	358	496	517	130	56	1.557
Other opera-tional	1.168	383	444	329	26	23	1.205
Equip-ment	5	5	0	0	0	0	5
Others (please specify)	1.875	702	732	490	0	0	1.924
Direct costs	9.091	2.203	2.635	2.464	1.151	638	9.091
Indirect costs (20% of	1.818	441	527	493	230	127	1.818
Total	10.909	2.644	3.162	2.957	1.381	765	10.909

Comments:

DMU/AU Department of Terrestrial Ecology

Year:	Original budget	Consumption 2005/2006	Consumption 2007	Expected consumption 2008	2009	2010	2011	Total
Man-months	13.5	0	0.27	9.3	2.8	0.4	0.7	13.5
Scientific personnel	8	0	0.2	3.7	2.8	0.4	0.7	7.9
Technical personnel	5.5	0	0.06	5.5	0.0	0.0	0.0	5.6

Year:	Original budget	Consumption 2005/2006	Consumption 2007	Expected consumption 2008	2009	2010	2011	Total
Salaries	625		11.5	347.2	148.0	19.1	40.1	566.0
Scientific personnel	397		9.5	175.2	148.0	19.1	40.1	391.9
Technical personnel	169		2.0	172.0	0.0	0.0	0.0	174.0
Other operational costs	59		1	40	12	3	3	59.0
Equipment								
Others (please specify)								
Direct costs	625							
Indirect costs (20% of direct costs)	125		2.5	77.4	32.0	4.4	8.6	125.0
Total	750		15.0	464.7	192.0	26.5	51.7	750.0

Comments:

Institute of Integrated Pest Management, University of Aarhus

Year:2007	Original budget	Consump-tion 2005/2006	Consump-tion 2007	Expected consump-tion 2008	2009	2010	Total
Man-months							
Scientific personnel	0.8		0.8	0.8	0.8		2.4
Technical personnel	1.0		1.0	1.0	1.0		3.0

Year:2007	Original budget	Consump-tion 2005/2006	Consump-tion 2007	Expected consump-tion 2008	2009	2010	Total
Salaries							
Scientific personnel	33.6		33.6	34.6	35.7		103.9
Technical personnel	25.0		25.0	25.7	26.5		77.2
Other operational costs	20.0		20.0	20.6	21.2		61.8
Equipment							
Others (please specify)	13.0		13.0	13.4	13.8		40.2
Direct costs	91.6		91.6	94.4	97.2		283.2
Indirect costs (20% of direct costs)	18.3		18.3	18.9	19.5		56.7
Total	109.9		109.9	113.2	116.6		339.7

Comments:

Institute of Food and Resource Economics, University of Copenhagen

Year:	Original budget 2007	Consump-tion 2007	Expected consump-tion 2008	2009	2010	2011	Total
Man-months Scientific personnel Technical personnel	1,5	1,5 1,5	1	1	2	3,	9

Year:	Original budget 2007	Consump-tion 2007	Expected consump-tion 2008	2009	2010	2011	Total
Salaries Scientific personnel Technical personnel	60.500	60.500	41.500	42.800	88.100	158.900	391.800
Other operational costs	5.000	5.000	5.000	5.000	5.000	5.000	25.000
Equipment							
Others (please specify)							
Direct costs	65.500	65.500	46.500	47.800	93.100	163.900	416.800
Indirect costs (20% of direct costs)	13.100	13.100	9.300	9.600	18.600	32.800	83.400
Total	78.600	78.600	55.800	57.400	111.700	196.700	500.200

Comments:

Department of Agricultural and Ecology, University of Copenhagen

Year:	Original budget	Consump-tion 2007	Expected consump-tion 2008	2009	2010	Total
Man-months	36	2	12	12	10	36
Scientific personnel	36	2	12	12	10	36
Technical personnel						

Year:	Original budget	Consumption 2007	Expected consumption 2008	2009	2010	Total
Salaries Scientific personnel Technical personnel	984.000	18.111	368.000	368.000	220.889	984.000
Other op-erational costs	215.000	14.254	52.631	70.000	78.115	215.000
Equipment	0					0
Others (please specify)	51.000	0	11.204	17.000	22.796	51.000
Direct costs	1,250.000	32,365	431.835	455.000	354.407	1,250.000
Indirect costs (20% of	250.000	6.473	86.367	91.000	66.160	250.000
Total	1.500.000	38.838	518.202	546.000	369.960	1.500.000

Comments:

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

Institute of Integrated Pest Management, University of Aarhus

Year:	Original budget	Consump-tion 2005/2006	Consump-tion 2007	Expected consump-tion 2008	2009	2010	Total
Man-months							
Scientific personnel	0.4		0.4	0.4	0.4		1.2
Technical personnel	0.5		0.5	0.5	0.5		1.5

Year:2007	Original budget	Consump-tion 2005/2006	Consump-tion 2007	Expected consump-tion 2008	2009	2010	Total
Salaries							
Scientific personnel	16.8		16.8	17.3	17.8		51.9
Technical personnel	12.5		12.5	12.9	13.3		38.7
Other operational costs							
Equipment							
Others (please specify)							
Direct costs	29.3		29.3	30.2	31.1		90.6
Indirect costs (20% of direct costs)	5.9		5.9	6.0	6.2		18.1
Total	35.2		35.2	36.2	37.3		108.7

Comments:

Department of Agroecology and Environment, University of Aarhus

Year:	Original budget	Consumption 2007	Expected consumption 2008	2009	2010	2011	Total
Man-months	0	0	0	0	0	0	0
Scientific personnel	0	0	0	0	0	0	0
Technical personnel	0	0	0	0	0	0	0

Year:	Original budget	Consumption 2007	Expected consumption 2008	2009	2010	2011	Total
Salaries	0	0	0	0	0	0	0
Scientific per-	0	0	0	0	0	0	0
Technical personnel	0	0	0	0	0	0	0
Other operational	0	0	0	0	0	0	0
Equipment	0	0	0	0	0	0	0
Others (please specify)	594	280	314	0	0	0	594
Direct costs	594	280	314	0	0	0	594
Indirect costs (20% of	1.419	473	408		347	192	1.420
Total	2.013	753	721	0	347	192	2.013

Comments:

Department of Agriculture and Ecology, University of Copenhagen

Year:	Original budget	Consump-tion 2007	Expected consump-tion 2008	2009	2010	Total
Man-months Scientific personnel Technical personnel	5					

Year:	Original budget	Consump-tion 2007	Expected consump-tion 2008	2009	2010	Total
Salaries Scientific personnel Technical personnel	180	45	45	45,	45	180,000
Other operational costs						
Equipment						
Others (please specify)						
Direct costs	180	45	45	45,	45	180,000
Indirect costs (20% of direct costs)	36	9	9	9,	9	36,000
Total	216	54	54	54,	54	216,000

Comments: