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1. Project title and acronym

High Quality Seed – Maintaining Integrity in Organic Farming (SEED)

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2. Project journal number

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3. Project period (month, year)

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End of project: January 2010

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*Lars Bødker is no longer working in this area of research, and the activities he was involved with and in charge of, has been taken care of by Bent J. Nielsen.

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

A. Project summary

The axiom of organic farming that only organic seed is to be used often contradicts with insufficient accessibility of high quality seed. Despite recent achievements, organic seed supply for spring wheat, spring triticale, field pea, beets, maize, white clover and a number of vegetable species is insufficient. This may be due to inadequate production and/or processing, poor quality or lack of seed in varieties with recognised agronomic traits for production in Denmark and needs further investigation. Genes of cultivated plants spread in time and space through pollen and seed dispersal, as well as through handling during transport and processing. To maintain the integrity of organic farming, the availability of organically produced GM-free seed of varieties adapted to organic production systems is of the utmost importance. Therefore, in order to elucidate the potential of recently developed knowledge-based technology for organic seed production in Denmark, it is proposed to undertake a multidisciplinary research approach for the production of high quality organic seed production.

One of the organic farming principles is to enhance diversity at all levels including bio-diversity at the field level and genetic diversity at the crop level. Growing species mixtures has the potential of increasing yield as well as increasing the yield stability. However, it is not yet quantified how production in species mixtures affects seed quality.

Near infrared spectroscopy technologies (NIRS/NITS) are fast and reliable calibrated methods used in determining seed quality. This technique has further been used for discrimination between kernels of different species and varieties. Kernel size and shape parameters contain information relevant for end-use quality. Automated Image Analysis has therefore become a promising analytical tool for the cereal industry.

Grain legumes have an important role in supplying high quality protein feed for monogastric animals and ruminants. The organic grain legume protein production in Denmark is challenged due to severe problems in seed production; soil borne root rot diseases in peas, seed borne anthracnose and grey mould in lupines and *Ascochyta* blight in faba beans.

Common bunt (*Tilletia tritici*) is a potential serious seed borne disease in organic wheat and triticale. Seed health analysis have shown that *T. tritici* occurs relative commonly on organic seed and there is a need for identifying resistant varieties that can be used in integrated production systems.

Our hypothesis is that elucidating the potential of recently developed knowledge-based technologies on the exploitation of genetic diversity, the production in crop mixtures, the improvement of seed quality by utilising new integrated methods in seed technology will improve the supply of high quality organic seed for organic farming to remain independent and viable.

Due to the logistic nature of seed production, seed movements across borders and the future introduction of GM-crops in European farming systems, the project aims at establishing a platform for international scientific collaboration in order to maintain the integrity in organic farming – by the production of high quality, GMO-free seed.

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

WP No.	WP title	Responsible scientist	Budget DKK	Start	End	Deliverable No.
1	Project management and network administration	BB	0,668	01/2006	12/2009	D1.1; D1.2; D1.3; D1.4; D1.5
2	Exploitation of genetic resources for enhanced seed quality and yield	LB	1,709	01/2006	12/2009	D2.1; D2.2; D2.3
3	Enhancing yield and seed quality in variety and species mixtures of cereals and grain legumes	BJ	2,437	01/2006	12/2009	D3.1; D3.2; D3.3; D3.4; D3.5; D3.6
4	Developing strategies for the production of high quality, GMO free organic seed	RBJ	2,186	01/2006	12/2009	D4.1; D4.2; D4.3; D4.4; D4.5
Total			7,000			

B. Objectives and expected achievements

The objective is to maintain the integrity in organic farming – by the production of high quality, GMO-free seed of varieties and species of specific value in organic farming.

This goal is achieved by the
• identification and development of improved species/varieties with specific value in organic farming
• improvement of seed quality and seed yield by production in crop mixtures
• development of strategies to restrict gene flow in out-breeding species of important seed crops.

C. Midterm results and progress

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

WP No.: 1 Project management and network administration

Task 1. Organising workshops where preliminary results are presented
The preliminary results of clover seed production (WP 4) trials have been presented to breeders and seed production advisers each year, and results on seed yield in the gene flow experiment has been included from 2008.

There have not been organised workshops for cereal and legume breeders (WP2 and WP3) due to the fact that all of the three growing seasons have been dry and almost no diseases have been seen in the field. This issue has been discussed during the project meetings each year.
Instead the preliminary results have been presented to the cereal industry during the DanSeed symposium 2008 and 2009 (www.Danseed.dk) and Cerealienetværkets Årsmøde 2007 (www.cernet.dk)

Task 2. Planning communication and publication
During project meetings plans for communication and publication have been discussed.
Again the fact that disease pressure during crop production has been very low has affected the relevance of organising field days and other communication from the diversity trial of WP3.
Trials and yield results of WP4 (clover seed production) has been communicated each year.

Task 3. Organising network meetings
During the activities in the networks of DanSeed and Cerealienetværket the project partners meet with farmers, breeders, advisers and regulatory bodies at least once a year and often more frequently. In addition project partners have been collaborating with breeders and advisers on specific issues (WP2).

Task 4. International activities
In March 2006 a NJF-seminar on 'Aspects of growing transgenic crops' was organised by Birte Boelt and held in Denmark (GBI-Flakkebjerg). The seminar had 23 participants from Finland, Norway, Sweden and Denmark.
http://www.njf.nu/site/seminarRedirect.asp?intSeminarID=379&p=1293

During 2006 a NJF-seminar on Herbage Seed was organised by Birte Boelt and held in Denmark including a session on organic seed production. The seminar was attended by scientists, advisers and seed growers from the Scandinavian countries and the seminar had a total of 93 participants.
http://www.njf.nu/site/seminarRedirect.asp?intSeminarID=395&p=1293

In 2007 the International Herbage Seed Conference was organised in Norway including a post-conference tour in Denmark. Birte Boelt was coorganiser of the conference in Norway and organiser of a post conference tour in Denmark. The conference had close to 100 participants and included a session on geneflow. Following the post-conference tour in Denmark a meeting was held to discuss areas of collaboration with AgResearch, New Zealand. However, activities in New Zealand are scarce due to lack of funding in this area.
http://cropandsoil.oregonstate.edu/ihsg/conference2007/welcome.php

In April 2010 a workshop between seed scientists from New Zealand, Oregon and Denmark will be held in connection with the 7th International Herbage Seed Conference in Texas http://ihsg.org/subsites/conference2010/welcome.php. Birte Boelt is presenting results from SEED and chairing the workshop.

Participation (Hanne Østergaard & Birte Boelt) in the 3rd Co-existence conference in Sevilla Spain autumn 2007.

In 2008 Participation in the BEETLE workshop arranged by the EU Commission (DG Environment) and the German Federal Office of Consumer Protection and Food Safety (BVL). The workshop was assessing potential long term effects of GMO on the environment, animal and human health.

Participation in the Seminar on Specified Trait Seed Testing (Birte Boelt) organised by International Seed Testing Association (ISTA) in Bologne, Italy June 2008.

There is a joint membership among DJF and Risø with The European Consortium for Organic plant breeding (ECO-PB), and Hanne Østergaard was board member until 2009.

Task 5. Project web administration
Project website is available including information on each work package and activities. A photo archive has been included on the webpage.

WP No.: 2. Exploitation of genetic resources for enhanced seed quality and yield
Task 1. Prevalence and severity of seed borne infections of *Ascochyta fabae* in faba bean
Transmission of *A. fabae* from infected seed to new seeds has been estimated in field trials 2007 and 2008 at AU, Flakkebjerg. In trial A three different mixtures of healthy and diseased seeds with *A.* have been sown in field trials to estimate the yield and seed infections of *A. fabae* in the harvested seed. In

trial B, different seed lots of the same variety (Columbo) with different levels of seed vitality and seed infections of primarily *A. fabae* have been sown in field plots to estimate the variation in yield due to difference in seed vitality and seed infections. Despite the use of infected seeds only little infection could be observed in the field in both years.

Task 2. **Threshold values for seed borne infections of *Coletotrichum lupini* in lupine**
At the project start, infected seed lots of varieties varying in resistance was available and further multiplication of susceptible and resistant lines were performed in 2006 (the lines Boruta, Teo Prima, Tanjil Polonez Rose, Illyarie, Eranti, Sonet Kalya, Boral, Lae8 and Danja). Due to the dry conditions in 2006, Anthracnose development in the field was insignificant. Three lines were multiplied in Chile for production of infected seeds during winter 2006-2007. In 2007 the first field trial with variable infection level was carried out. Seeds with 0%, 2,5%, 5% and 7,5% anthracnose infection of the resistant Lav8-5, the susceptible Prima and the highly susceptible Eranti were evaluated in a 4 replicate block experiment. Due to the dry and warm spring the initial transmittance from seed to plant did not occur and anthracnose symptoms were not observed later in the season. The plots were harvested in September 2007 and seeds analysed for infection of *Coletotrichum lupini.* at The Danish Plant Directorate using their standard test on 400 seeds from each seed plot. There was agreement between the low incidence of anthracnose in both susceptible and resistant genotypes in field and the laboratory seed tests showing no anthracnose on harvested seeds. These low attacks are also in agreement with the test of commercial seed lots of lupin from that year, which also showed no occurrence. The harvested seeds from the anthracnose threshold value trials were mend to be used for the experiment in 2008 with different infection levels, however, due to the insignificant infection a special program was established in corporation with Henrik Jørskov Hansen, The Danish Plant Directorate to provide infected seeds for field trials in 2008. Anthracnose mycelium were multiplied on Potato Glucose Agar, incubated for app. 2 weeks at 23 ºC. 30 seeds were placed in each petri dish on the top of the mycelium for 5 hours during which the seeds swelled and mycelium established seed infection. 2000 seed were infected from each of the varieties Lae1, Polonez, being high susceptible to anthracnose and non-branching and branching respectively and Lae8, and Bora being tolerant and non branching and branching respectively. Seeds lots with infection levels in each variety of 0, 1, 2,5, 5 and 10% of the 4 varieties were produced. Symptoms resembling anthracnose attack were observed on young plants, however, classical symptoms did not develop and later in the growing season no symptoms were observed at all. We ascribe the avoidance of attack in field to the dry period from April to June. The harvested seeds are being cleaned and prepared for analysis for anthracnose infection at The Danish Plant Directorate. The “disappointing” level of anthracnose symptoms in field is in agreement with level observed in commercial seed multiplication crops where no anthracnose observations has been reported. The 2 years of trials has not resulted in significant field attack and transmittance from seed to canopy and again to harvested seeds despite high infection level in sown seeds despite using both resistant and highly susceptible varieties. This is an argument for higher anthracnose threshold values in lupin seeds. Howewer, historic data form year 2002 to 2007 on the proportion of commercial lupin seed crops being discarded due to occurrence of anthracnose have been 0%, 9%, 0%, 42%, 0%, 0%. The 0 occurrence in 2006 and 2007 is in accordance with our trial results, however, the highly variable results underline the variability and dependency on weather conditions of the disease, and the potential high risk of infection.

Task 3. Screening for resistance to common bunt (*Tilletia tritici*)
Screening for resistance to common bunt (*Tilletia tritici*) have been performed at AU, Flakkebjerg 2007-2009 with new varieties of wheat and of triticale using artificial inoculation in field experiments with different isolates of *T. tritici*. Wheat varieties (winter types) which in previous trials had shown some resistance where tested again on two different test isolates of *T. tritici.* All new Danish varieties of wheat and triticale have been tested 2007-2009, however in the last test 2009 the conditions for establishment was not good due to combination of very wet weather and soil conditions. Therefore only results from 2007-2008 will be used in the analysis.

The results of the testing showed that most of the Danish winter wheat varieties are susceptible to attack of common bunt (fig 1). Only two varieties (Penta and 702-1102C) were highly resistant against common bunt on the same levels as the standard variety Stava (table 1). A group of seven varieties showed some resistant to common bunt (1-16% attack) and a group of 14 varieties were moderate resistant (16-30 % attack in field trials) while the rest of the varieties were susceptible to bunt (table 1).

Table 1. Percent attack of common bunt (*Tilletia tritici*) in Danish varieties of winter wheat and winter triticale. Only the varieties showing the lowest attack are shown out of total 74 winter wheat varieties tested. Field trials with artificial inoculation 2007-2008. AU, Flakkebjerg

	Winter wheat	% bunt	
1	Stava	0,2	*)
2	702-1102C	0,4	*)
3	Penta	0,4	
4	Samurai	1,3	*)
5	Bill	6,1	*)
6	Minotor	8,9	*)
7	Pagaj	10,5	
8	LEU60115	13,3	
9	MH 05.20	15,7	
10	Hereward	15,8	*)
11	CM 2713	18,1	
12	Torrild	19,4	*)
13	Gallant	19,9	
14	7249.13	20,4	
15	Tambor	20,6	*)
16	Skagen	21,9	*)
17	CPBT W04-117	22,1	
18	CM 1970 2601	22,4	
19	Tommi	23,6	*)
20	Complet	24,8	
21	CPB-T W136	24,8	
22	7249.12	26,8	
23	SWW C503	29,9	
24	F 6118	30,1	
25	Globus	32,9	
26	CE 0412	34,6	
27	Position	34,9	
28	Gosmer	35,1	
29	LEU60124	35,6	
30	CPBT W05-41	38,8	

*) tested 2007-2008

	Winter triticale	% bunt	
1	Algalo	0,0	*)
2	Cyclus	0,0	
3	Dinaro	0,0	*)
4	Gringo	0,0	
5	Kaprys	0,0	*)
6	Korpus	0,0	
7	Lamberto	0,0	*)
8	LP 9841.37	0,0	*)
9	Mungis	0,0	*)
10	Nugget	0,0	
11	S 2686	0,0	
12	SJ 010926180	0,0	*)
13	SW Valentino	0,0	*)
14	TIW 623	0,0	
15	Versus	0,0	*)
16	Tremplin	0,3	
17	Ti 410	0,4	
18	Trigold	0,4	*)
19	Cando	0,5	*)
20	PAJ 904-033	0,5	
21	SW Talentro	0,7	*)
22	CHD 734/00	1,0	
23	NORD 00754/10	1,0	
24	Tritikon	1,3	*)
25	Triskell	1,5	*)
26	HE115-01	1,7	*)
27	HE Ti 318	1,8	
28	Kortego	1,9	*)
29	Trigantus	7,9	*)
30	Triamant	9,5	
31	He Ti 301	14,4	
	Herzog, Wheat reference	55,7	*)
	Dominator, Rye reference	0,0	*)

*) tested 2007-2008

In total 31 winter triticale varieties were tested and in contrast to wheat most of the varieties were resistant to common bunt (table 1). Out of 31 varieties tested, 15 varieties were highly resistant (zero attack) and 13 varieties had a high level of resistance (< 2% attack). Only three varieties were susceptible to some degree (8-14% attack). The level of attack in triticale varieties (even the most susceptible) is in general lower than in wheat.

The resistance tests were also performed in spring wheat and spring triticale varieties. In total 22 spring wheat varieties were tested 2007-2009 and the results show that most of the spring wheat varieties are susceptible to common bunt (table 1). The spring wheat varieties Dragon and Leguan showed some resistance in the test while five varieties were moderately attacked (table 2). The lines 707-4001 and 707-4002 are crossing materials from Pajbjerg (see task 5).

In spring triticale the varieties are generally resistant to common bunt. Out of 9 tested varieties 4 varieties were highly resistant (zero attack in three years trials with different isolates, table 2) and four varieties showed low level of attack (< 1% attack). Only one variety (Dublet) was moderately attacked.

Table 2. Percent attack of common bunt (*Tilletia tritici*) in spring wheat and spring triticale varieties. Field trials with artificial inoculation (6 different isolates 2007-2009), AU, Flakkebjerg 2007 and 2008

	Spring wheat	% Bunt	
1	707-4001 B	0,0	
2	707-4001 C	0,2	
3	707-4001 A	0,4	*)
4	Dragon	1,2	
5	Leguan	3,6	**)
6	Trappe	7,4	*)
7	SW 45456	8,0	
8	707-4002 C	8,1	
9	Vinjett	8,1	**)
10	Alora	8,9	*)
11	707-4002 A	10,1	
12	707-4002 B	10,6	
13	Terice	13,5	
14	Samuno	14,1	*)
15	Zircon	15,2	
16	Sensas	23,7	
17	Amaretto	26,9	
18	Safrani	29,1	
19	KWS SCIROCCO	31,5	
20	Tybalt	31,9	
21	SW Kungsjet	32,4	
22	Taifun	35,0	

*) tested 2007-2008, **) tested 2007-2009

	Spring triticale	% Bunt	
1	Granador	0,0	****)
2	Legalo	0,0	****)
3	Noé	0,0	***)
4	Somtri	0,0	***)
5	Logo	0,2	****)
6	Nilex	0,2	****)
7	Trado	0,5	**)
8	He 104-03	0,8	****)
9	Dublet	4,0	****)
	Vinjett, spring wheat reference	8,2	***)
	Taifun,spring wheat reference	35,0	*)

*) 2007, **) 2007-2008, ***) 2008-2009, ****) 2007-2009

Task 4. Virulence survey

To determine which major resistance genes that are effective against common bunt, a set of wheat lines with different *Bt* genes have been inoculated with different bunt isolates. In 2008 10 different populations have been tested on the differential lines with the different resistance genes. The different populations of *T. tritici* have been sampled from Danish seed producers during the last years and the results from the virulence test shows that many genes still are effective against common bunt (fig 1).

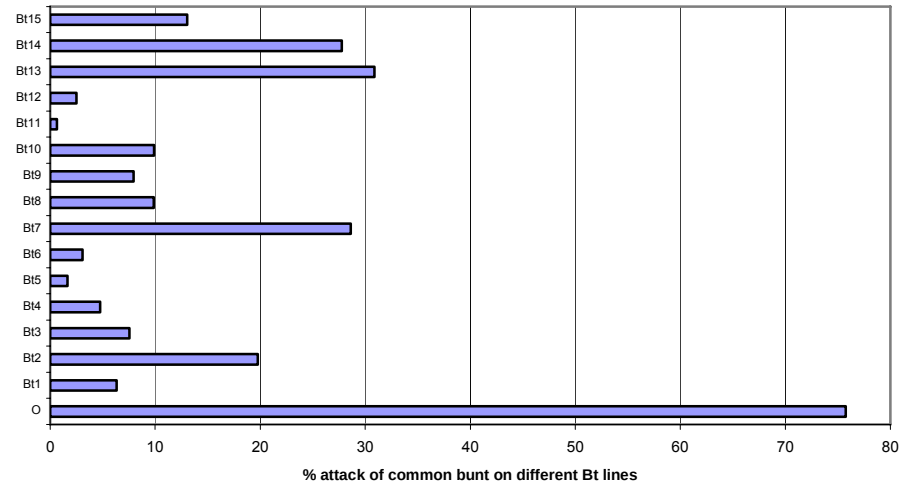

Fig. 1. Attack of common bunt (*Tilletia tritici*) on differential lines with 15 different resistance (bt) genes. Mean of 10 different populations collected from Danish Seed producers. AU, Flakkebjerg 2008.

Task 5. Contribute to the development of new varieties

Breeders at Nordic Seed (Pajbjergfonden) have carried out back crossings of effective genes for bunt

resistance into spring wheat varieties with a good general resistance to other major diseases. Six sub-lines from two lines (7007-4001 A,B,C and 707-4002 A,B,C) have been tested at AU, Flakkebjerg using artificial inoculation in field experiments with two different isolates of *T. tritici*. The results clearly shows a distribution between resistant crossing material (7007-400**1** A,B,C) and susceptible crossing materials (707-400**2** A,B,C, table 2). The lines are now F9 and in the first step of multiplication.

WP No.: 3. Enhancing yield and seed quality in variety and species mixtures of cereals and grain legumes

Task. 1. Disease development during the growing season and in seeds

In 2006-2008 diversification trials have been carried out at two locations, AU, Flakkebjerg and KU, Højbakkegård. The objective is to elucidate the potentials for improved seed quality by increased genetic diversity of cereals and grain legumes and as well as to get information about general and specific combining abilities at species level. The disease development in the cereals and grain legumes in pure stand and in mixtures has been scored during the growing seasons.

In 2006 the summer was hot and dry (July) and disease development in the trial was only moderate and late with approximately 10 % attack of net blotch *(D. teres* and *D. avenae*) in barley and oat. In barley and triticale late attack of rust was observed. There were no differences in leaf attack between the treatments. In legumes there was only significant attack in faba bean (chocolate spot). In the trial at KU, Højbakkegård there was less attack of chocolate spot in the cereal/faba bean intercrop while at AU, Flakkebjerg the opposite was observed.

In 2007 spring and early summer was dry and relatively hot. Conditions for disease development were not favourable and the transmission of diseases from seeds to plant and development of diseases in general on the leaves was late. There were no significant differences in development of seed borne diseases in the crop between infected and healthy seed lots (table 3). There was a slight reduction in attack of net blotch in the cereals/legumes mixtures compared to pure stand of barley or oat.

Table 3. Percent attack of different leaf diseases in diversification trial at AU, Flakkebjerg 2007.

Flakkebjerg, 2007		Seed	Cereals			Pea		Faba bean		Lupin
			net blotch	Septoria	Rust	Ascochyta	Botrytis	Choclate spot	Rust	Antrachnose
		% infection	26-06-2007	26-06-2007	19-07-2007	26-06-2007	26-06-2007	19-07-2007	19-07-2007	26-06-2007
	Name		17	20	60	21	23	68	69	27
1	Pea	5				0,8	1,6			
2	Pea (infected)	44				1,1	2,0			
3	Faba bean (Healthy)	0						11,3	12,5	
4	Faba bean (infected)	5						13,5	11,3	
5	Lupin (healthy)	0								0,0
6	Lupin (infected)	0								0,0
7	Spring wheat			4,0	5,0					
8	Spring wheat - pea (healthy)			4,5	1,8	0,4	1,0			
9	Spring wheat - faba bean (healthy)			3,0	2,5			9,3	3,8	
10	Spring wheat - lupin (healthy)			4,0	2,0					0,0
11	Oat		10,0		5,4					
12	Oat -pea (healthy)		6,3		5,9	0,5	0,8			
13	Oat - faba bean (healthy)		5,8		11,3			5,0	8,3	
14	Oat - lupin (healthy)		8,3		11,3					0,0
15	Spring barley		13,5							
16	Spring barley - pea (healthy)		9,5			0,4	0,8			
17	Spring barley - faba bean (healthy)		10,8					4,1	4,9	
18	Spring barley - lupin (healthy)		9,3							0,0
19	Spring triticale			4,0	5,5					
20	Spring triticale - pea (healthy)			3,5	2,4	0,5	1,0			
21	Spring triticale - pea (infected)			4,5	1,9	1,3	1,3			
22	Spring triticale - faba bean (healthy)			5,0	5,8			11,0	3,8	
23	Spring triticale - faba bean (infected)			4,5	4,0			9,5	7,8	
24	Spring triticale - lupin (healthy)			4,0	2,8					0,0
25	Spring triticale-lupin (infected)			5,0	4,0					0,0

Varieties: Pea: Attika; Faba bean: Colombo; Lupin: Viol; Spring wheat: Vinjett; Oat: Freddy; Spring barley: Smilla; Spring triticale: Nilex

Net blotch: *Drechslera teres and D. avenae* ; Choclate spot: *Botrytis fabae*

The seed lots of pea, faba bean and lupin have been analysed for seed borne diseases before sowing and after harvest in the combinations with spring triticale (table 4, same treatments as in table 3). There were severe infections of Ascochyta in the pea in both pure stand and mixtures where both healthy and infected seeds have been used probably from the light leaf infections seen in June in the

crop (table 3). In faba been there was more Ascochyta in the plots where infected seed have been used and a reduction could be observed when mixing infected faba been with spring triticale (table 4). The seed lots of lupin were collected as infected but later analysis showed that no infection occurred.

In 2008 the spring and early summer was very dry with very unfavourable conditions for spread and multiplication of seed borne diseases to the canopy. Only light infections were seen but severe attacks of aphids occurred in all plots with severe reductions in yield especially in faba been and lupin. Aphids attack resulted in crop failure in 2008 for faba bean, and an estimated yield reduction of 20-50% in pea and lupin, pea being most severely affected. In Faba bean 0-5 g/m^2 was harvested in both sole crops and mixtures and plants wilted and dyed before maturity. Due to the devastating effect of aphids on the legume crops the effects of mixing cereals with legumes is highly reduced, effects in the field could not be evaluated. It is considered whether the data from 2008 should be excluded from the overall analysis.

Table 4. Example of percent infected seed in diversification trial at AU, Flakkebjerg and KU, Højbakkegård, 2007. Seed lots of pea, faba bean and lupin have been used in the different combinations with spring triticale.

2007		Pathogen	Seed	Harvest	
				Flakkebjerg	Højbakkegård
1	Pea (healthy)	Ascochyta spp.	<5	78,8	69,5
2	Pea (infected)	Ascochyta spp.	44	71,8	64,0
20	Spring triticale - pea (healthy)	Ascochyta spp.		73,5	73,5
21	Spring triticale - pea (infected)	Ascochyta spp.		75,5	84,5
3	Faba bean (Healthy)	Ascochyta fabae	0	1,5	1,5
4	Faba bean (infected)	Ascochyta fabae	5	5,0	14,8
22	Spring triticale - faba bean (healthy)	Ascochyta fabae		0,5	0,8
23	Spring triticale - faba bean (infected)	Ascochyta fabae		1,3	6,0
5	Lupin (healthy)	Collletotrichum	0	0,0	0,0
6	Lupin (infected)	Collletotrichum	0	0,0	0,0
24	Spring triticale - lupin (healthy)	Collletotrichum		0,0	0,0
25	Spring triticale-lupin (infected)	Collletotrichum		0,0	0,0

Task 2. Crop development yields and general and specific combining abilities

Crop development has been recorded during the growing seasons including emergence and plant stands, phenological development stages, plant height during vegetative growth and canopy development. Intercropped and cereal sole crops were applied 50 kg N/ha of organic manure (Binadan). Measurement of canopy development has been performed with leaf area index (LAI) by Licor 2000 and normalized difference vegetation index (NDVI) by remote sensing. Weed infestations have been registered during the growing season and at harvest. The plots have been combine harvested, mixtures separated and component yield measured.

The spring 2006 was cold and wet. As a consequence the establishment of the field trials was postponed to start of May and not as planned in start of April at both Flakkebjerg and Højbakkegård. The wet conditions made it difficult to control the weed mechanically. The late time of sowing and problems with weeds have influenced the yields negatively, and reduced the attack of plant diseases. The 2007 trials were established mid April. The spring and early summer was dry and relatively hot. Crop establishment and weed control was good. However, due to the dry conditions disease development was delayed and newer reached significant levels despite the period from mid summer to harvest was wet. In 2008 the trials were sown at 22 April in good conditions and due to the dry and sunny spring and early summer conditions were good for mechanical weed control, however, crop growth were restricted by drought before the rain started in June. Disease development was delayed and as in year 2007 never reached significant levels. Aphids, however, had nearly optimal conditions for early establishment and multiplication in the dry sunny weather and already in June aphids significantly damaged the grain legumes and were present on all cereal plants (Figure 2, table 7). The attack resulted in wilting faba bean and faba bean crop failure in all treatment combinations. Pea and lupin yields were significantly reduced. There was no indication of less aphid attack in crop mixtures compared to the respective sole crops (table 7). After harvest each year, the seeds have been cleaned and species mixtures separated in fractions representing individual crop species and quality and seed analysis performed, however the severe aphid infestations in year 2008 restricted the amount and quality of seeds

available for quality and disease analyses.

Fig. 2. Aphid attack on pea (upper left) lupin (upper right) and faba bean (lower) on June 26 2008 in the Diversity trial at Højbakkegaard. In Faba bean the attack caused plant wilting and crop failure in all plots and in Pea and Lupin significant yield losses were observed. No differences in aphid attack were observed between sole crops and crop mixtures.

The yield level in the cereal crops in 2006 was 2-3,5 t/ha and intercropping with pulses reduced cereal yield up to 35%. Intercropping with cereals had a much larger effect on the pulses with reduction in yield up to 80%. In faba bean intercropping with wheat, oat, barley or triticale influence the total yield negatively in the 2006 trials. Intercropping with lupin did not show the same effect. The combining ability of lupine with cereals seems to be better in this experiment. In 2007 the yields were generally higher especially in the grain legume, wheat and oat, whereas yields were comparable between years for barley and triticale. The most remarkable differences in crop combining ability between years were the increases suppression of cereal yields by pea at Flakkebjerg where pea dominated the mixtures and reduced the cereal yield from 70% to 85% when compared to cereal sole crop yield. This results in a significantly reduced total yields in the mixtures compared with the cereal sole crop yields. Lupins were highly suppressed by all cereal species at both Flakkebjerg and Højbakke in 2007 with yield reduction upto 90% in mixtures compared to sole crop lupin. In 2006 the lupins were much less depressed. Total grain yield in 2007 in mixtures between cereals on the one side and faba bean or lupin on the other were comparable to the respective cereal sole crop yields and significantly higher than the respective faba bean or lupin sole crop yields. Thus where lupin had a better combining ability with cereal in 2006 than pea, this was the case for both lupin and faba bean in 2007. In year 2008 the crop yields of the fababean were near 0 and pea and the yield of lupin and peas decimated due to attack of aphids. Therefore it has little meaning discussing the combining ability and the effect of one crop to other crops in this specific year as it is overshaded by the aphid attacks. It can be concluded from 2008 that faba bean, pea and lupin, in descending order, were severely damaged by aphids, and there were no difference in aphid attack between sole cropping and intercropping. The general conclusion is that in “normal” years the yield of legume cereal mixtures are higher and less variable than sole crop legume yield and as an extra benefit growing these mixtures can eliminate the risqué of total crop failure as seen with the faba bean and partly peas in this experiment but also in farmers field in 2008. Growing mixtures will also decrease the weed infestations and diseases development of some diseases in some years compared to legume sole crops.

Table 7. Number of Aphids per plant.
June 30 in diversity trials 2008

Crop combination	KU, Højbakkegård		
	Cereal % plant infected	Legume % plant Infected	Aphids / legume plant
Pea		100	152
Pea-infected		100	141
Faba		100	898
Faba-infected		100	905
Lupine		100	64
Lupine-infected		100	63
Wheat	100		
½Wheat + ½Pea	100	100	151
½Wheat + ½Faba	100	100	760
½Wheat + ½Lupin	100	100	41
Oat	100		
½Oat + ½Pea	100	100	120
½Oat + ½ Faba	100	100	749
½Oat + ½ Lupin	100	100	57
Barley	100		
½Barley + ½Pea	100	100	172
½Barley + ½Faba	100	100	762
½Barley + ½Lupin	100	100	34
Triticale	100		
½Triticale +½Pea	100	100	148
½Triticale +½Pea-infected	100	100	89
½Triticale + ½Faba	100	100	741
½Triticale + ½Faba-infected	100	100	736
½Triticale + ½Lupin	100	100	53
½Triticale + ½Lupin-infected	100	100	47

Task 3. Grain quality for human and animal nutrition
Samples of cereal and grain legumes from the field trials carried out in 2006, 2007 and 2008 at Flakkebjerg and Højbakkegård have been processed by appropriate cleaning and grading techniques and analyzed for:

- Seed size distributions and shape parameters using standard methods
- Gross chemical composition using NIRS (Near-Infrared Reflectance Spectroscopy, the analyses include seed protein, starch and gluten for wheat; protein and starch for barley and triticale; protein for oat.)
- Gross composition of seed C, S and N (protein) for those grain legumes where no NIRS calibrations have been developed yet
- Feed value in form of FEsv (Feed unit / kg dry matter, for piglets) and FEso (Feed unit / kg dry matter, for sows) have been analysed chemically for wheat and triticale in order to determine nutritional values for non-ruminant animals.
- Germination rate and vitality on cereal seed samples

Selected results of the quality assessment of intercropping cereals and pulses on grain quality of are presented in the following text.

The protein content of wheat was increased significantly when intercropped with pulses in the diversity trials (table 8). The same was observed for the gluten content. Intercropping wheat with peas or faba

beans influences the protein and gluten content significantly more than intercropped with lupine. The effect of intercropping with faba beans are ranked between the effect of intercropping with peas and lupines. No effect on physical grain characteristics as test weight (kg/hl), grading (>2.8 mm) or thousand kernel weight (TKW) of wheat was observed due to intercropping with pulses

Table 8. Wheat quality parameters in diversity trials

	Protein (%)	Gluten (%)	Test weight (kg/hl)	> 2.8 mm (%)	TKW (g)
Wheat	11.5	21.0	76.7	38.5	38.5
½Wheat + ½Pea	12.8	24.0	76.5	35.7	38.5
½Wheat + ½Faba	12.4	22.7	76.0	34.8	38.6
½Wheat + ½Lupin	12.0	22.0	76.2	36.2	39.0
Significance	***	***	ns	ns	ns
$LSD_{p<0.05}$	0.4	1.0	0.6	2.7	0.8

Barley protein content is likewise influenced positively by intercropping with pulses in the three year diversity trials performed at Højbakkegård and Flakkebjerg (table 9). Intercropping with pea particularly increases barley protein content significantly more than faba bean with influence stronger than lupine. The physical grain characteristics of barley measured by grading (>2.8 mm) and thousand kernel weight (TKW) are also significantly increased by intercropping with pulses, particularly intercropping with lupine have a positive effect. The effect of intercropping on the grading is illustrated in figure 3. This knowledge combined with the fact that the protein content in barley intercropped with lupine is relatively low, may lead to the recommendation that this combination is preferable if malting is the intended use of the intercropped barley.

Table 9. Barley quality parameters in diversity trials

	Protein (%)	Test weight (kg/hl)	> 2.8 mm (%)	TKW (g)
Barley	10.1	64.6	26.9	41.3
½Barley + ½Pea	11.5	65.5	35.3	43.5
½Barley + ½Faba	11.0	64.0	34.4	42.1
½Barley + ½Lupin	10.8	64.6	41.9	43.9
Significance	***	ns	***	***
$LSD_{p<0.05}$	0.4	1.1	5.0	1.3

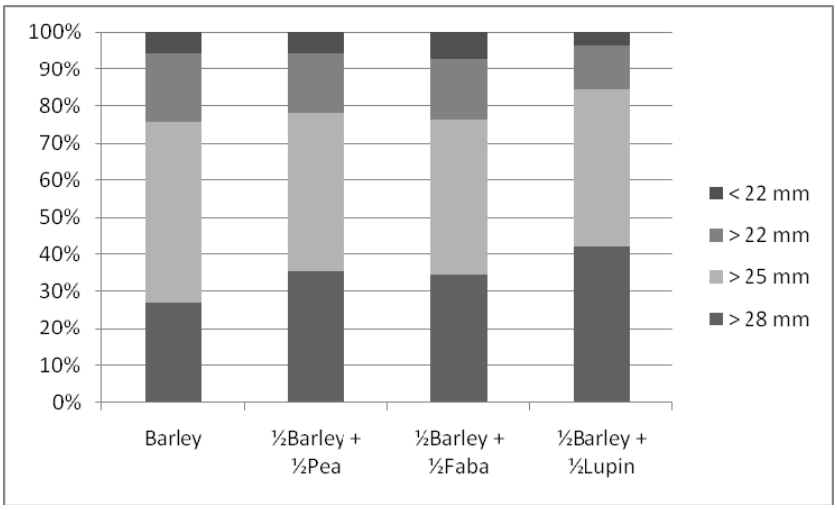

Figure 3. Barley grading influenced by intercropping

The protein content of triticale grain protein is increased significantly when intercropped with pea and faba bean and lupine (table 10). The effect of peas is strongest whereas the effect of faba beans and lupines are on the same level. The physical grain characteristics of triticale measured by grading (>2.8 mm) and thousand kernel weight (TKW) are influenced by the intercropped pulses. The triticale kernels are bigger when intercropped by lupine than when intercropped by peas or faba beans.
Another goal of the trials was to measure the effect on grain quality due to the use of pulses infected by seed born diseases. No effect was detected in this experiment due infected or non-infected seeds of the pulses

Table 10. Tritical quality parameters in diversity trials

	Protein (%)	Test weight (kg/hl)	> 2.8 mm (%)	TKW (g)
Triticale	13.9	70,3	56.7	41.2
½Triticale +½Pea	14.9	69,8	55.7	40.9
½Triticale +½Pea-infected	14.9	69,8	53.1	40.3
½Triticale + ½Faba	14.5	70,3	55.7	41.6
½Triticale + ½Faba-infected	14.6	70,0	54.4	41.0
½Triticale + ½Lupin	14.5	70,7	58.2	42.5
½Triticale + ½Lupin-infected	14.3	70,6	57.6	41.9
Significance	***	*	***	***
$LSD_{p<0.05}$	0,3	0.7	2.1	0.8

The feed value reportet as FEsv (Feed unit / kg dry matter, for piglets) and FEso (Feed unit / kg dry matter, for sows) of wheat for sows and piglets were significantly influenced by year but there were none or only weak significant effect revealed due to intercropping by pulses (table 11, 12 and 13).

Table 11. Wheat feed value parameters in diversity trials

	Crude ashes (%)	Crude fat (%)	Crude protein (%)	EFOS (%)	EFOSi (%)	FEso	FEsv
Wheat	1.57	2.22	11.1	90.8	87.2	116.2	118.3
½Wheat + ½Pea	1.65	2.20	12.2	90.2	87.4	115.8	118.0

½Wheat + ½Faba	1.63	2.20	11.8	90.5	87.1	115.9	117.9
½Wheat + ½Lupin	1.65	2.18	11.4	90.8	87.5	116.3	118.4
Significance	*	ns	***	*	ns	ns	ns
$LSD_{p<0.05}$	0.06	0.05	0.4	0.5	0.6	0.8	0.9

EFOS: Enzyme-digestible organic matter
FEsv: Feed unit / kg dry matter, for piglets
FEso: Feed unit / kg dry matter, for sows

Table 12. Barley feed value parameters in diversity trials

	Crude ashes (%)	Crude fat (%)	Crude protein (%)	EFOS (%)	EFOSi (%)	FEso	FEsv
Barley	2.11	2.41	8.6	83.5	76.6	105.2	104.3
½Barley + ½Pea	2.19	2.39	9.7	84.0	76.9	105.4	104.4
½Barley + ½Faba	2.10	2.39	9.4	83.6	76.5	105.1	104.1
½Barley + ½Lupin	2.08	2.41	8.9	83.9	76.9	105.6	104.8
Significance	*	ns	***	ns	ns	ns	ns
$LSD_{p<0.05}$	0.08	0.05	0.3	0.4	0.5	0.8	0.9

EFOS: Enzyme-digestible organic matter
FEsv: Feed unit / kg dry matter, for piglets
FEso: Feed unit / kg dry matter, for sows

Table 13. Triticale feed value parameters in diversity trials

	Crude ashes (%)	Crude fat (%)	Crude protein (%)	EFOS (%)	EFOSi (%)	FEso	FEsv
Triticale	1.73	1.63	12.2	91.3	87.6	114.9	117.1
½Triticale +½Pea	1.74	1.58	13.1	90.8	87.1	113.8	115.8
½Triticale + ½Faba	1.69	1.6	12.8	91.1	87.5	114.5	116.6
½Triticale + ½Lupin	1.73	1.62	12.7	91.1	87.6	114.7	116.8
Significance	Ns	ns	***	ns	ns	*	*
$LSD_{p<0.05}$	0,10	0,06	0,3	0,4	0,5	0,7	0,8

EFOS: Enzyme-digestible organic matter
FEsv: Feed unit / kg dry matter, for piglets
FEso: Feed unit / kg dry matter, for sows

The germination rate and vitality of the spring cereals were tested across years, locations and intercropped pulses in order to test if there were any positive or negative effect of intercropping. No significant effects were found on any of the cereals germination rate or vitality due to intercropping.

WP3, Task 4: Meta analysis of mixture effects of selected characteristics of species mixtures
Meta-analysis is a statistical approach in which previously published results can be combined in one statistical analysis, thus utilizing information from many different experiments to test hypotheses and potentially determine the relative importance of various experimental conditions. The SEED project has put a small effort (about 3 man months) into collecting data on effects on grain yield of intercropping of cereals and grain legumes and performing meta-analyses to extract combined estimates of these effects. In developing this methodology, SEED has taken advantage of the PhD project at Risø DTU (2006-2009) where meta-analysis has been developed for analysing effects on grain yield of variety mixtures inferred from field trial data (e.g. as published in Kiær et al 2009) and the internship stu-

dent from Ensai, France, with supervisors H Østergård,Risø-DTU, B. Jørnsgård, KU-Life and I Skovgaard, KU-Life (Chastaing 2009). The meta analysis of species mixtures at first retrieved the published information on grain yields in cereals-grain legume intercrops (20 papers with relevant information) of which only 10 papers had enough information about experimental variation to be included; in total this corresponds to 80 measures of intercropping effects. Traditionally, intercropping effects are described by LER-values (Land Equivalent Ratios). An LER value above 1 indicates that the land is used more efficiently with respect to grain yield by growing the species mixture rather than growing the crops as sole crops. The meta-analysis showed that there may be a potential publication bias in the published results because according to some standard assumptions on variation between experiments, more values below 1 than actually reported should have been found. The LER measure is in many ways not optimal for statistical analysis. Therefore two new variables were calculated to describe the effect of intercropping being an effect of 1) selection of the strongest competitor plus an effect 2) of resource use complementarity of the two species. In conclusion, in the included studies, both effects were present and which of the two dominating depended on the growing conditions. Different methods taking into account that some studies had several intercropping results as well as the insufficient data on statistical variation was discussed. This kind of problems was also dealt with in the paper on variety mixtures (Kiær et al).

WP No.: 4 Developing strategies for the production of high quality, GMO free organic seed

Task 1. Producing white clover seed in crop mixtures with grass species
A field experiment was established in the spring of 2006, 2007 and 2008 with white clover/grass species undersown in a cover crop of spring barley. In the spring of the following seed production year two strategies have been evaluated in the mixed cropped plots and compared to white clover in pure stand. These strategies were simulated grazing and a silage cut. Results from the three experimental years are shown in Fig. 4.

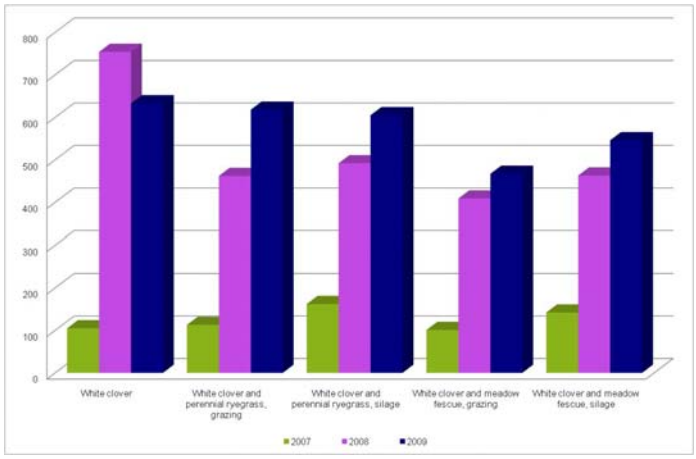

Fig. 4. Seed yield in white clover in 2007-09 as affected by mixed cropping with perennial ryegrass and meadow fescue in simulated grazing or a silage cut.

Seed yield in white clover was in general negatively affected by mixed cropping with grasses, however, the strategies of simulated grazing or a silage cut provided in average 4,5 ton ha^{-1} dry matter of forage and hence provided an alternative use in years where white clover seed yield was low.

Task 2. Developing a decision support system to minimise yield reduction in white clover due to weevils
2007: A glasshouse trial to investigate the influence of the clover cyst nematode on germinating and small clover plants with reference to investigate the 'clover-sickness' problem was carried out. The results show that there were no significant differences between the separate treatments neither after germination and nor later on in the growing process. Therefore, it can be concluded that the clover cyst nematode cannot be the reason for the phenomenon 'clover sickness'. However, from another project we found many free-living nematodes (*Pratylenchus penetrans*) in the clover roots. It is quite conceivable that they are the reason for 'clover sickness.

2008: Two students from KU-Life Sciences (Nanna K. Ytting og Henrik B. Topbjerg) were doing their graduate thesis on the biology of weevil pests in organic white clover. Their work has been a weighty supplement to our knowledge of the biology. They graduated in December 2008.
Master thesis: Weevil Pests in organic White Clover Seed Production (*Trifolium repens*). The effect of late defoliation on *Apion fulvipes* and *Hypera meles*. University of Copenhagen.

2009: A laboratory method to test the efficacy of natural pyrethrum on the clover weevils was carried out. The commercial product AquaPy® was used in different concentrations. The result shows a significant effect. The LD_{50}-value was 0.4 of a normal dose, which is 12.5 litres/ha equal to about 400 g ai/ha.

To determine which meteorological factors are important for colonizing white clover fields from the clover seed weevil (*Apion fulvipes*) 4-5 white clover fields were monitored in 2006-2009, 1-2 times a week from mid April to colonization time. In addition also results from 2004 and 2005 are included. The results shows that migration takes place if more there is at least 6-7 hours in succession with average temperatures more than 18 °C and wind velocity not more than 4.0 m/s. Heavy rain will stop migration.
From present research in combination with earlier research (Hansen, L. M. & Boelt, B. (2008). Thresholds of economic damage by clover seed weevil (*Apion fulvipes* Geoff.) and lesser clover leaf weevil (*Hypera nigrirostris* Fab.) on white clover (*Trifolium repens* L.) seed crops, Grass and Forage Science, vol. 63, nr. 4, s. 433-437) a decision support system is constructed and available at the Internet . Furthermore a manuscript has been prepared for publication (Hansen, L. M. in prep.)

"Clover sickness" is not caused by the clover cyst nematode. Migration of the clover seed weevil takes place when the temperature have exceeded 18 ºC for more than 6 continuous hours
Graduation of two students

Task 3. Collection of base-line information on the prevalence of white clover in organic farming systems and the surrounding natural habitats
In the first year of the project, three organic farms with clover seed production and clover-grass pastures were visited to determine the distribution of white clover in and outside fields. White clover was found outside the cultivated areas, but in frequencies much lower than within fields or pastures. It was judged that the seed set of clover in semi-cultivated places would be rather low, as management of field borders is often accomplished, and seed set controlled. Therefore it was decided to focus on the frequency of clover at the cultivated land including clover-grass fields in rotation and permanent pastures.

In 2008 more farms were surveyed for the presence of white clover especially on these farms where white clover was found for both seed production and as part of the clover-grass fields. Flower heads in the clover-grass fields were counted at two times during the season to quantify pollen and seed dispersal. However, relatively few farms were found that had both types of field, and therefore the field survey has to be repeated in 2009.

In 2009 it was concluded from additional surveys that environmental parameters affect the prevalence of white clover in organic farming systems to a high degree. Parameters like grazing pressure, age of the field, yearly variation in climate, soil quality etc. will all influence abundance, and demand a large and controlled experiment before any general trends in abundance can be revealed. However, where white clover is found for seed production or as part of clover-grass fields, the frequency is generally high, which was also confirmed from interviews with the farmers.

In 2006, the genetic diversity was analyzed in clover grass fields by collecting 25 plants x 5 m2 in each field (125 plants/field). AFLP analysis of plants from three fields showed that the genetic diversity of the white clover was highest in recently established clover-grass and least in old fields. The results support the hypothesis that pronounced vegetative propagation in white clover gave rise to large clones that were most abundant in the older fields suppressing establishment of plants from sexual reproduction. If this is a general trend, then seeds with transgenic paternity (from pollination by GM plants in neighboring fields) are most likely to establish in young fields. However, grazing patterns and trampling are also supposed to influence sexual reproduction and establishment by affecting number of flower heads and creating open patches for seedling establishment. Frequency of flowering head

was counted in the visited clover-grass fields. These data are published together with results on gene flow experiments (task 4).

Task 4. To develop management methods and recommendations for reduction of gene flow in white clover and perennial ryegrass for seed production

White clover, *Trifolium repens*
In 2006 and 2007 we have performed molecular analysis of the three white clover varieties, Klondike, Milo and Rivendel that are sown out in a larger field experiment at AU, DJF, Flakkebjerg. AFLP primer combinations have been selected that will allow us to detect gene flow between different plots (and treatments) in this experiment.
In 2008 the experiments at Flakkebjerg was pollinated from beehives near the field plots. Seed have been harvested and cleaned, and the seed output from the 48 different plots with white clover was very satisfying. The molecular analysis of the offspring will be performed from October 2008 – May 2009.
During 2009 AFLP fragment analysis with two primer combinations was performed on a large part of the plots from the field experiment. The AFLP analysis revealed very polymorphic marker profiles (> 150 markers per primer). Assignment test are presently being applied to the data in order to reveal extent of gene flow between plots. Results are submitted in a manuscript (medio 2010) together with the data on propagation mode in clover grass fields.
In 2007 a master study has been carried out in the frame of WP 4. The title of the master thesis was "Gene flow in white clover, *Trifolium repens* - modeling inter-field dispersal and experiments on gene flow in small populations":

- Modelling, using a mathematical model, which specifically account for gene flow between fields caused by pollinators. The model - the Portion-dilution-model - is based on three observable parameters, E = the fraction of pollinators that arrive in a recipient field from an extrinsic pollen donor source, ψ = the paternity shadow and b = mean number of flower heads a pollinator visits in one foraging bout. The model (Cresswell et al., Oikos 98, 375-384) has previously been applied to oilseed rape and red clover, and we now use it on white clover, where the honey bee (*Apis mellifera*) is the predominant pollinator. The foraging behavior of *Apis* has required some changes in the original model. The paternity shadow has been determined in an experiment, where we used a pollen donor with red leaf marker.
- Experimental results on gene flow between small populations of white clover. In an 11 experimental plots with different genotypes (propagation plots at DLF-Trifolium, St. Heddinge), DNA markers (AFLP) were determined in maternal plants and their offspring. Using assignment test (AFLPop and STRUCTURE) we determine to what extent outcrossing takes place within plots and from other plots at different distances from the recipient. Pollinator behavior has also been observed and frequency of selfing estimated.
- The master student, Christina Løjtnant, KU, defended her master thesis in 18. December 2007. The results from the master project were compiled in a manuscript (Løjtnant et al., in prep), however it has been necessary to revise the manuscript and to add results from a new paternity shadow experiment. The manuscript has just been submitted again to "Environmental Modeling & Assessment". Two scenarios of the gene flow were modelled. In a scenario where fields where assumed to be adjacent to each other, the gene flow level would normally be within the range of 0.005% to 0.49% (5% and 95% percentile), and the most frequent gene flow level would be about 0.13%. In a scenario where white clover fields are relatively well separated the gene flow is expected to be in the range of 0.0004% to 0.08%, and the mean value would be 0.02%. This means that for both scenarios the gene flow between white clover fields would only rarely exceed the threshold limit of 0,9% GM admixture of set by the EU for food and feed. Our results show, that no extra mitigation measures seems to be necessary for coexistence between GM and NON-GM white clover for feed. However, the threshold in seed for seed production is still to be decided. The gene flow levels found in this study may pose a problem for Danish organic farmers if they do not accept GM admixture above 0.1% (the uncertainty of the qPCR method used to estimate the GM contents).

Task 5. Establishing a common procedure and set-up for the studying of gene flow in seed crops between international partners
During the 6th International Herbage Seed Conference in Norway/Denmark June 2007 areas of common collaboration were discussed between scientists from IGER-Aberystwyth, UK; AgResearch, NZ

and AU, DK. Already now the red-leaf morphotype of white clover has been used for pollination trials (collaboration RISØ and AU). Especially the area of pollination seems to be of common interest especially between New Zealand and Denmark. However, in each country resources for activities related to the use of GM-crops are very limited, and activities are quite restricted.
In April 2010 the 7th International Herbage Seed Conference will be held in Texas, and a workshop between researchers from New Zealand, Oregon and Denmark is planned. Birte Boelt will be chairing a workshop on coexistence.

C.1.1 Brief overview of most important results of the whole project and suggested relevant dissemination target groups

WP No.	Results / outcome	Planned/suggested dissemination method	Target groups
1	The clover seed weevil is an economic important pest in organic white clover seed production and during the project information on the lifecycle of the weevil has been collected.	A video showing the life cycle of the clover seed weevil has been produced and introduced via the faculty homepage. Since the launce in May 2009 the video has been shown more than 1500 times mostly in Denmark but also in Sweden, Norway and Germany with approximately 50 visits per country.	Organic clover seed growers, advisors and students.
2	Common bunt (Tilletia tritici) is a potential serious seed borne disease in organic wheat and triticale. The results of the project have shown that in spring- and winter wheat there is a potential for breeding for resistance against the disease. Currently only a few varieties have been identified that posses some resistance but a systematic breeding programme could introduce new varieties with complete or acceptable level of resistance The test programme in the project showed that the level of resistance in the triticale varieties (both spring and winter types) was very high. The resistance to common bunt has perspectives not only for organic production but also for integrated conventional production	Results have been made available to farmers in the variety list (results from the general variety testing, Sortsinfo) Publication about results of the screening of Danish varieties will be published in international journal	Organic farmers,advisors and breeders Conventional system regarding resistance in triticale and use in low input seed treatment IPM programmes National authorities regarding recommended thresholds in triticale
	The level of anthracnose symptoms in lupins in the field trials was very low and there was no transmittance from seed to canopy and again to harvested seeds despite high infection level in sown seeds. This is in agreement with the low level observed in commercial seed multiplication and could be an argument for higher anthracnose threshold values in lupin seeds. Moreover, the highly variable results underline the variability and dependency on weather	White paper (recommendations) to national authorities regarding the need for revising thresholds in lupins	National authorities regarding thresholds

	conditions of the disease, and the potential high risk of infection.		
3	The general conclusions in the diversity trial are that in “normal” years the yield of legume cereal mixtures are higher and less variable than sole crop legume yield and as an extra benefit growing these mixtures can eliminate the risqué of total crop failure as seen with the faba bean and partly peas in 2008. Growing mixtures will also decrease the weed infestations and diseases development of some seed borne and canopy diseases in some years compared to legume sole crops. The diversity trials have revealed that pea is a significantly better than faba beans and lupine in order to increase the protein content of the intercropped spring cereals wheat, barley and triticale. It appears that the better competitor the legume is the higher is the protein content in the cereal. (asymmetric competition for light and Nitrogen) From the review Meta-analysis report it is confirmed that there is a general benefit of growing legume cereal species mixtures.	Publications	Organic farmers
4	Modelling shows low levels of gene flow via pollen between white clover fields whatever isolation distance, whereas results on seed yield in flowerheads in pastures show a large potential for gene flow via volunteers.	Homepage and international and national meeting on co-existence	Regulators, politicians, breeders

Main conclusions and perspectives

There is a growing interest in grain legumes and the need for grain legumes in organic farming is accentuated by the phase-out of conventional animal manure in organic farming (in the period 2015 to 2021 by 10 kg N per year). Organic production of grain legumes, however, is still very challenging, and results are often disappointing, due to eg. aphids, soil and seed borne diseases, drought sensitivity and weed problems, which were also experienced in the present SEED experiments.

Until year 2006 data on diseases and frequencies of seed lot failure due to seed borne diseases were recorded by Landscentret. This gave a valuable overview of the problems in organic seed production. This compilation of existing information from seed companies and official seed testing authorities was abandoned in 2007 and no overview exists after 2006.

Cereals also requires special attention in organic farming, illustrated by the general crop failure of the new and promising spring triticale for organic farming in 2009. Common bunt is also a significant threat in organic farming and as revealed in the SEED experiments resistance to this disease exists among triticale varieties; however, as there is no breeding/selection for this resistance, the existence of resistance will not benefit the organic farmers.

Since 2008 there has been a growing interest in the production of Farm Saved Seed. In the organic production system seed borne diseases in legumes and common bunt in cereals the incidence of

these diseases may be increased by the use of Farm Saved Seed.

Intercropping cereals with pulses, particularly pea, has increased the protein content. This key parameter in seed quality is important when the seed of the cereals are used for feed. However the extensive analysis of feed value of the cereals has not shown any overall improvement in feed value by intercropping with pulses. For human consumption seed quality of wheat for bread use will benefit of intercropping as the increased protein and gluten content is of great importance to secure high quality.

There is a significant difference in the conditions for breeding and seed production systems for organic and conventional farming. One year of severe problem with for example rust in triticale, anthracnose in lupin or aphids in faba bean can decimate seed production and make farmers deselect the crop in the future due to one year of crop failure and shortage of seed. In conventional farming these single events would have been dealt with by seed and crop fungicide treatment. Consequently resistance breeding is much less important for conventional than organic farming. However, despite the growing need for legumes and cereal varieties for organic farming, no grain legume breeding in general or organic cereal breeding is carried out in Denmark. This might be one of the most important limitations for future development of and integrity in organic farming.

White clover is an important crop for forage production and green manure, however, organic seed production is very challenging. The results in SEED verify that pests are the main factor reducing seed yields, however, by mixed cropping with grasses biomass for forage can be produced as a supplement to the seed production. White clover plants are found very frequently in almost any organic farm. This highlights the difficulties in managing coexistence between organic and GM farming. Results from SEED indicate that geneflow through pollen will not restrict organic forage production of white clover, but results indicate that geneflow through seed/volunteers may to a large extent contribute to admixture between GM- and non-GM white clover when seed production and pasture are combined in the crop rotation.

C.2 Fulfilment of deliverables and milestones

(To be completed for each work package)

Deliverables list (from application)

Workpackage 1						
Deliverable No	**Deliverable title**	**Lead scientist**	**Delivery date**	**Allocated scientific person moths**	**Type of deliverable**	**Fulfilled (ok) or deviations (d)***
D1.1	Meetings in the project group – at a minimum twice a year	BB	2006-09		O/C	Partly full filled
D1.2	Yearly communication plans	BB	01/2006 - 01/2009		O	Partly full filled
D1.3	Yearly workshops	BB	2006-09		R/C	OK
D1.4	International workshop	BB	2007		R/C	OK
D1.5	Project web-site established	BB	06/2006		O	OK

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 1			
Milestone No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or deviations (d)***
M1.1	Project website open	05/2006	OK
M1.2	International workshop is held	07/2007	OK

** 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						
Deliverable No	**Deliverable title**	**Lead scientist**	**Delivery date**	**Allocated scientific person moths**	**Type of deliverable**	**Fulfilled (ok) or deviations (d)***
D2.1	Manuscript on influence of seed vitality and seed infections with *A. fabae* in faba bean has been submitted	BJO	05/2009		(P/O)	Left out
D2.2	Manuscript on threshold values of *C. lupini* in lupin in Denmark has been submitted	BJO	05/2009		(P/O) R/O	ICROFS nyt 11/2010
D2.3	Manuscript on resistance to common bunt (*Tilletia tritici*) in Danish wheat and triticale varieties and *T. tritici* virulence survey in Denmark has been submitted	BJN	05/2009		(P/O) S	11/2010

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 2			
Milestone No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or deviations (d)***
M2.1	Infected seed and haulm with *A. fabae* have been produced and collected	09/2006	OK
M2.2	First year field trials on host resistance against *A. fabea* in faba bean are completed	12/2007	OK
M2.3	Second year field trials on thresholds and host resistance against *A. fabea* in faba bean are completed	12/2008	OK
M2.4	Infected seeds have been multiplied and first year field trial on variety resistance and thresholds against *Coletotrichum lupini* in lupin is completed	09/2006	OK
M2.5	Second year field trials on thresholds and host resistance against *Coletotrichum lupini* in lupin are completed	12/2007	OK
M2.6	Third year field trials on thresholds and host resistance against *Coletotrichum lupini* in lupin are completed	12/2008	OK
M2.7	Wheat differential lines with specific Bt genes propagated and seeds with *T. tritici* have been collected	10/2006	OK
M2.8	First year field trials on host resistance against *T. tritici* are completed	12/2006	OK
M2.9	Second year field trials on host resistance against *T. tritici* and first virulence survey are completed	12/2007	OK
M2.10	Third year field trials on host resistance against *T. tritici* and second virulence survey are completed	12/2008	OK

** 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	ICROFS nyt. Disease development, and seed quality in pure stands and mixtures of cereals and grain legumes	BJO	12/2007		R/P	ICROFS nyt 10/2010
D3.2	Paper on disease development and seed infection in pure stands and species mixtures of cereals and grain legumes	BJO/ BJN	12/2009		(R/P) S	11/2010
D3.3	Paper on grain quality for human and animal nutrition in pure stands and mixtures of cereals and grain legumes	JRJ	06/2009		(R/P) S	11/2010 D3.3 and D3.4 com-bined
D3.4	Paper on crop development and general and specific combining ability in species mixtures.	BJO/ JRJ	08/2009		(R/P) S	
D3.5	ICROFS nyt. Yield and quality of pure stands and mixtures of cereals and grain legumes	JRJ	12/2007		R/P	ICROFS nyt 11/2010
D3.6	Manuscript on meta analysis of mixture effects of selected characteristics of species mixtures as part of PhD thesis	BJO/ HØ	12/2008		P	OK

** Deviations are to be further discussed in D*

Milestones list (from application)

Workpackage 3			
Mileston No	**Milestone title**	**Delivery date**	**Fulfilled (ok) or devia-tions (d)***
M3.1	Production of seed lots infected with *A. fabea* in faba bean, *C. lupini* in lupin and *A. pisi* in pea	12/2006	OK
M3.2	Field experiment with species and crop mixtures (diversification trial) conducted first year at two locations	08/2006	OK
M3.3	Harvested seeds from 1st year diversification trial are cleaned and separated. The seed of cereals and grain legumes are tested for seed borne diseases. Physical seed characteristics and quality parameters are analysed	12/2006	OK
M3.4	Field experiment with species and crop mixtures conducted second year at two locations	08/2007	OK
M3.5	Harvested seeds from second year diversification trial are cleaned and separated. The seed of cereals and grain legumes are tested for seed borne diseases. Physical seed characteristics and quality parameters are analysed	12/2007	OK
M3.6	Harvested seeds from third year diversification trial are cleaned and separated	08/2008	OK
M3.7	Harvested seeds from third year of field trials with sole crops and species mixtures cleaned and separated. The seeds of cereals and grain legumes are tested for seed borne diseases. Physical seed characteristics and quality parameters are analysed	12/2008	OK
M3.8	Principles for including data in the meta analysis	9/2006	OK

** Deviations are to be further discussed in D*

Deliverables list (from application)

Workpackage 4						
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)***
D4.1	Yearly reports on white clover seed and clover-grass forage yield in mixed crop production	BB	12/2007 12/2008 12/2009		R/P	OK
D4.2	Decision support system to minimise yield reduction due to pests produced, report and publication written and data available on the internet	LMH	12/2009		R/S/O	OK
D4.3	Report on the frequency and distribution of white clover and clover-grass on or-ganic farms	RBJ	12/2006		S/C	OK
D4.4	Guidelines to reduce gene flow in white clover and clover-grass	BB + RBJ	11/2009		P/S/C	OK
D4.5	Report on the use of morphological markers to analyse gene flow in white clover	RBJ + BB	01/2009		R	Partly fulfilled (publica-tion in progress)

** 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	Seed yields in white clover and forage yields are registered in three consecutive years of field experimentation	08/2007, 08/2008, 08/2009	OK
M4.2	Validation of data for decision support system	12/2008	OK
M4.3	Quantification of white clover and clover-grass on organic farms com-pleted	12/2006	OK
M4.4	Field plots established for pest analysis and gene flow investigations	12/2006	OK
M4.5	Molecular analysis of gene flow between clover-grass fields and white clover in pure stand plots finalised	03/2008	Partly fulfilled
M4.6	Data for the recommendation of guidelines to reduce gene flow ana-lysed	09/2009	OK

** Deviations are to be further discussed in D*

D. Description of deviations and subsequent adjustments of plans

WP2
D2.1. The experiments dealing with influence of seed vitality were left out before granting of the SEED project due to budget reduction from 14 to 7 mill dkk. Deliverable 2.1 should have been left out in that stage.
D2.2. Due to unfavorable weather conditons and only low level of multiplication of seed borne disease the quality of the data does not give basis for proper scientific publication. Instead manuscript on influence of seed infections with A. fabae in faba bean and threshold values of C. lupini in lupin in Denmark will be published in November 2010 together with discussions of thresholds and perspectives for organic production in ICROF news.
D2.3. Manuscript on resistance to common bunt (Tilletia tritici) in Danish wheat and triticale varieties and T. tritici virulence survey in Denmark is under preparation and will be submitted for publication November 2010

WP3
D3.1. "Disease development, and seed quality in pure stands and mixtures of cereals and grain legumes" will be published in ICROFS news November 2010.
D3.3 and D3.4. The deliverables will be combined to one manuscript and submitted for publication November 2010.
D3.5. "Yield and quality of pure stands and mixtures of cereals and grain legumes" (D3.5) will be published in ICROFS news November 2010.
D3.6. is considered fulfilled as a report on meta-analysis of intercropping has been produced and this will be rewritten into a scientific paper in the coming months. Further a paper on meta analysis of variety mixtures has been published as part of the PhD thesis by Lars P. Kiær (co-funding from Risø-DTU).

WP4
D4.5: The last manuscript on gene flow in field trials is delayed, as the job of running and scoring gels has turned out to be much more demanding than previously anticipated. Molecular markers have been scored and assignment test are now performed on the data sets (publication can be submitted medio 2010).

E. Project publications and other products (for the *whole project period*)

1. Products from Organic Eprints archive

Number of items at this level: **18**.

D

Daniel, Marie (2006) **Effect of intercropping on disease severity in organic farming.** **

F

Fernandez-Aparicio, M.; Jørnsgård, B. and Rubiales, D. (2006) Effects of crop mixtures on pest of faba bean under organic agritultural conditions. International workshop on Faba bean breeding and agronomy, Cordoba Spain, 25-27 October 2006. In: Andalucia, Junta de (Ed.) International Workshop on faba bean breeding and agronomy, Viceconsejeria. Servicio de Publicaciones y Divulgacion, pp. 140-142. **

H

Hansen, Lars Monrad and Søegaard, Karen (2009) Kløvertræthed - er nematoder årsagen? In: ICROFSnyt, 2009.

J

Jørgensen, Johannes Ravn (2009) Brug af ny teknologi til kvalitetsbestemmelse af frø. DanSeed Symposium 2009, Skælskør. [Completed,]

Jørgensen, Johannes Ravn (2008) Ny metode til bestemmelse af korns foderværdi hurtigt og billigt. Sammendrag af indlæg Plantekongres 2008.

Jørgensen, Johannes Ravn (2007) Eksisterende og mulige nye kvalitetsmål ved dyrkning og handel med korn. Plantekongres 2007, Herning. In: Sammendrag af indlæg Plantekongres.

Jørgensen, Johannes Ravn and Gislum, René (2009) Prediction of cereal feed value by near infrared spectroscopy. NJF seminar 413, Agricultural applications of NIRS and NIT.

Jørgensen, Johannes Ravn and Gislum, René (2009) Prediction of cereal feed value using spectroscopy and chemometrics. 30th Nordic Cereal Congress , Copenhagen, 15-17th of June 2009 . In: 30th Nordic Cereal Congress 15-17th of June 2009 Programme and Book of Abstracts, University of Copenhagen. Faculty of Life Sciences.

Jørgensen, Johannes Ravn and Gislum, René (2009) Prediction of Enzyme Digestibility of Organic Matter (EDOM) using Spectroscopy and Chemometrics. International Conference on Near Infrared Spectroscopy. NIR-2009: Breaking the Dawn, Bangkok, Thailand. In: Haruthaithanasan, Vichai (Ed.) Abstract Book. NIR-2009 Breaking the Dawn.

Jørgensen, R.B.; Løjtnant, C.; Andersen, N.S. and Andersen, B.A. (2007) Co-existence with GM crops: grasses, clover and fodder beet. XXVIIth EUCARPIA Fodder Crop and Amenity Grass Section meeting, Copenhagen, Denmark, August 19-23 2007. [Unpublished,] **

K

Kiær, Lars; Skovgaard, Ib and Østergård, Hanne (2007) Yield of spring barley mixtures as a function of varietal and environmental characteristics. Varietal characteristics of cerealsin different growing systems with special emphasis on below ground traits, Velence, Hungary, 29-31 May, 2007. **

Kiær, Lars; Skovgaard, Ib and Østergård, Hanne (2006) Meta-analysis is a powerful tool to summarize variety mixture effects - exemplified by grain yield and weed suppression of spring barley. COST SUSVAR workshop, La Besse, France, 12-15 June 2006. In: Østergård, H. and Fontaine, L. (Eds.) Cereal crop diversity: Implicatons for production and products, ITAB, Paris, France, pp. 49-52. **

Kiær, Lars P.; Skovgaard, Ib and Østergård, Hanne (2009) Grain yield increase in cereal variety mixtures: A meta-analysis of field trials. Field Crops Research, 114 (3).

L

Løjtnant, Christina L.; Damgaard, Christian F. and Jørgensen, Rikke B. (2007) Modelling pollen dispersal - relevant to co-existence in white clover (Trifolium repens). 6th International Herbage Seed Conference AND GMCC 2007, Norway AND Seville, Spain, 17-20 June 2007 AND 20-21 November 2007. [Unpublished,] *

N

Nielsen, Bent J. (2009) Resistens mod stinkbrand (Tilletia tritici) i hvede og triticale. Resultater af markforsøg 2009. [Resistance against common bunt (Tilletia tritici) in wheat and triticale. Results of field trials 2009.] Sortsforsøg 2009. Korn, bælgsæd og olieplanter.

Nielsen, Bent J. (2008) Resistens mod stinkbrand (Tilletia tritici) i hvede og triticale. [Resultater af markforsøg 2008Resistance against common bunt (Tilletia tritici) in winter and spring types of wheat and triticale. Result of field trials 2008.] Sortsforsøg 2008. Korn, bælgsæd og olieplanter.

Nielsen, Bent J. (2007) Resistens mod stinkbrand (Tilletia tritici) i hvede og triticale. Resultater af markforsøg 2007. [Resistance against common bunt (Tilletia tritici) in winter and spring types of wheat and triticale. Results of field trials 2007.] Sortsforsøg 2007.

Nielsen, Bent J. (2006) Resistens mod stinkbrand (Tilletia tritici) i hvede og triticale. Resultater af markforsøg 2006. [Resistance against common bunt (Tilletia tritici) in winter and spring types of wheat and triticale. Results of field trials 2006.] Sortsforsøg 2006.

This list was generated on **Thu May 27 12:50:34 2010 CEST**.

Hansen, L. M. & Søegaard, K. (2009). Kløvertræthed: Er nematoder årsagen - hvilke?, *Økologisk Jordbrug,* nr. 431, s. 16.

Chastaing Gaëlle (2009) Meta-analysis on grain yield effects of cereals-legume intercropping – Student report with supervisors (H Østergård, B. Jørnsgård, I Skovgaard). Manuscript as basis for peer-reviewed paper.

Løjtnant CL, Boelt B, Clausen SC, Damgaard CF, Kryger P, Philipp M, Jørgensen RB. Modelling pollen flow between fields of white clover with honeybees as pollen vectors. Submitted to “Environmental Modeling & Assessment”.

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

Boelt, B. 2007 *Co-existence with GM crops: grasses, clover and fodder beet*. 27th SYMPOSIUM ON IMPROVEMENT OF FODDER CROPS AND AMENITY GRASSES, Copenhagen 19-23 August, 2007

Jørgensen, R.B. 2009 a presentation was given on a debate forum arranged by Økologisk Forum on "GMO and or-ganic farming – like fire and water?".
Jørgensen, R.B. 2010 a presentation was given at Økologisk Landsforenings meeting in Svendborg (5-6 marts) on the possible coexistence between GM crops and organic agriculture

Boelt, B. 2006. Frøavl 2005. Foreløbig opgørelse af frøavlsforsøg. Markfrø 2005. 32pp.
Boelt, B. 2006. Frøavl 2006. Foreløbig opgørelse af frøavlsforsøg. Markfrø 2006. 31pp.
Boelt, B. 2007. Frøavl 2007. Foreløbig opgørelse af frøavlsforsøg. Markfrø 2007. 42pp.
Boelt, B. 2008. Frøavl 2008. Foreløbig opgørelse af frøavlsforsøg. Markfrø 2008. 48pp.
Boelt, B. 2009. Frøavl 2009. Foreløbig opgørelse af frøavlsforsøg. Markfrø 2009. 49pp.

Field days:
** Boelt, B. 14 June 2005 Herbage seed. 54 participants.
** Boelt, B. 20 June 2006 Herbage seed. 38 participants.
** Boelt, B. 04 June 2007 Herbage seed. 54 participants.
** Boelt, B. 12 June 2008 Herbage seed. App. 60 participants.
** Jørgensen, J.R. 23 June 2008 Polish scientists. 29 participants
** Boelt, B. 08 June 2009 Herbage seed. 63 participants.

3. Publication overview, total numbers

Publication overview, total numbers		No. actually delivered	No. originally planned
Scientific Manuscripts directly related to the project activity	*Published or in press*	1	3
Scientific Manuscripts directly related to the project activity	*Submitted*	1	
Scientific Manuscripts partially related to the project activity			
Oral Presentations in international fora		3	
Oral Presentations in national fora		13	
Poster Presentations in international meetings		1	
PhD program		2	0
M.Sc. Theses		3	0

F. Scientific education

Marie Daniels has as a part of her master studies studied the disease development in the diversity trials and published the above-mentioned report.

PhD student Lars Kiær is associated to the project without being funded (task 3.4)

All years, teaching (Birte Boelt) at the bachelor course "Organic Agriculture" and the master course "Plant Production and Protection" at KU-Life on "Co-existence and organic seed"

All years, teaching (Johannes Ravn Jørgensen) at the bachelor course "Organic Agriculture" and the master course "Plant Production and Protection" at KU-Life on "Intercropping and seed quality"

All years, teaching (Bent J. Nielsen) at the bachelor course "Organic Agriculture" and the master course "Plant Production and Protection" at KU-Life on "Healthy seed"

PhD on meta analysis has been going on in parallel with this project and contributed with the methodology for applying meta analysis for field trials. A French internship student has contributed with the statistical analysis as Second Year's Training project.

Master student Christina Løjtnant, KU and Risø. Master exam passed 18 Dec. 2007.

SOAR PhD: Naja Steen Andersen, KU-Life and Risø. Thesis on co-existence between GM and NON-GM oilseed rape is submitted September 2008. Passed 7. November 2008.
All years, teaching (Rikke Bagger Jørgensen) at "Fagets Videnskabsteori" at KU-Life on GM plants and
co-existence"
All years, teaching (Rikke Bagger Jørgensen) at the course "Invasion Biology" at KU on GM plants and
co-existence".

G. National and international cooperation

Mirela Cordea, University of Cluch, Rumania has been working as guest researcher at KU, Højbakkegård summer 2007 and has participated in the experimental work.

Intercropping has been discussed in connection with COST 860 SUSVAR Visions workshop in 2008 among the potential methods for future cereal crop production. (Hanne Østergård)

An Eucarpia section for Organic and low-input agriculture has been initiated November 2007, and Hanne Østergård was vice-chair.

SEED has been participating as ICROF representative in eco-pb (European Cooperation in Organic Plant Breeding). Hanne Østergård was member of the Board.

Contribution to COST 860 SUSVAR network: poster for workshop (proceedings under preparation)

Participating in the application EU-project: KBBE-2007-1-4-04, GMO cost-effective and crop-specific co-existence measures, Call: FP7-KBBE-2007-:1. Project leader was part of the EU-application: *Best practices in crop and seed production. Implementing cost-effective coexistence scenarios through modelling and decision-support systems*

The work on meta analysis of mixture effects has been part of the networking activities in the SUSVAR COST Action 860 with H. Østergård as Action leader.

Senior Scientist Christian Damgaard, DMU, Aarhus University

Senior Scientist Per Kryger, DJF, Aarhus University

Participating in the project STEPKO funded by Bundesamt für Naturschutz (BfN) on introduction of GM plants into the environment.

Participating in the European Academy on GM plants and animals for production of pharmaceuticals.

H. Critical reflection on the project

The 3 years of field trials have been performed in years providing very unfavourable conditions for spread and multiplication of seed borne diseases to the canopy. This have from a scientific point of view been disappointing as the study of spread and multiplication of seed borne diseases to the canopy is one of the main goals of the project. The diversity trial at Research Centre Flakkebjerg was irrigated during the growing season of 2008 in order to facilitate the development of diseased to the canopy, but still hardly any attack was seen although the plants originated from infected seed.

The project has had to very different parts and this has made the interaction difficult. It has been interesting to draw the parallels between analyses of variety mixture effects and effects of intercropping on grain yield.

Overall the budget-cut from the applied for 14 mio. DKK to the approved 7 mio. DKK had very drastic consequences. Although research areas were left out, it was hard to fulfil all tasks with the reduced budget. The general impression was that resources were too small to attain what was planned.