Midterm Status Report 2003 and Application for Continuation in 2004

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The Directorate for Food, Fisheries and Agro Business
under the Danish Ministry of Food, Agriculture and Fisheries

1. Research program

Research in organic farming 2000-2005 (DARCOF II)

2. Project title and number

I.6 Cultivation in ridges and mixed cropping - new approaches to organic row crop production (CARMINA)

3. Head of project

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6. Project period (month, year)

Start of project: 09 2000
End of project: 06 2004

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7. Midterm description of the project, its results and progress, and application for continuation in 2004

A. Project summary

The aim of the project is to increase the efficacy of row crop production by improving nutrient cycling and growth conditions at the field level and strengthening prophylactic measures against plant pathogens. Ridge tillage and catch crops will manipulate nutrient cycling and growth conditions. Mixed cropping and catch crops will manipulate pathogens and pests. There will be focus on potato but other row crops will be considered too. Crop yield, nitrogen uptake and nitrogen leaching will be used as key success indicators in relation to nutrient cycling and growth conditions. Reduction of late blight (*Phytophtora infestans*) and *Rhizoctonia* stem canker in potato will be used along with tuber yield and quality as key success indicators in relation to prophylactic measures. Ridges will be established in autumn and it will be tested to what extent residual nitrogen and nitrogen from different combinations of organic manures and crop residues can be protected against leaching in winter. Furthermore catch crops and subsoiling will be integrated into the ridge tillage system and an evaluation of the ridge tillage system for organic row crop production will be performed. Interactions between catch crops and *Rhizoctonia* stem canker will be assessed based on the assumption that catch crop holds the possibility to reduce attack. For mixed cropping two types of mixtures will be used: Mixtures of potato varieties and mixtures of potato and faba beans (*Vicia faba*). It will be tested whether mixed cropping can reduce late blight in potatoes and aphid problems in faba bean. By running the project we will be able to verify our assumptions, that ridge tillage and mixed cropping may improve organic row crop production in terms of higher yields and lower impacts on the environment.

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

No.	Work package title	Partici-pants*	Budget (1.000DKK)	Start	End	Deli-verable no(s):
WP1	Protecting nitrogen from leaching in ridge tillage systems	CBH, JPM, JR	1029	1/9 2000	30/6 2004	
WP2	Growing row crops in ridge tillage systems with and without catch crops	CBH, JR	1824	1/9 2000	30/6 2004	D1-D4
WP3	Growing row crops in ridge tillage systems with and without catch crops with emphasis on stem canker (*R. solani*) in potato	LB (BJN)	494	1/9 2001	31/12 2003	D1-D2
WP4	Improving crop growth by subsoiling in different tillage systems	CBH, JR	229	1/9 2000	30/6 2004	D1
WP5	Mixing potato varieties	LM (BJN)	708	1/3 2001	31/12 2002	D1
WP6	Mixing potato and faba beans	JPM	416	1/3 2001	30/6 2004	D1-D3

* Responsible participants are underlined

B. Objectives and expected achievements

The overall objective of the project is to contribute to better growing systems in organic row crop production resulting in higher yield, better quality and lower nutrient losses.
The project focuses on ridge tillage and mixed cropping as new methods to improve nutrient cycling and growth conditions at the field level and to strengthen prophylactic measures against serious diseases and pests. The project focuses on potatoes as a model crop but other crops are considered as well. In potatoes, late blight and stem canker is selected as model diseases.
The project is approached from an innovative point of view. That means that ridge tillage and mixed cropping are adapted and developed into the context of organic row crop production. Our key question is: If we develop the techniques of ridge tillage and mixed cropping in the context of organic agriculture, how far will it then bring us? By running the project a number of hypotheses concerning ridge tillage and mixed crops are tested:

1) Ridge tillage can protect nitrogen from leaching in winter through
   - higher immobilisation of nitrogen
   - reduced percolation through the ridges

2) Ridge tillage can increase crop yield through
   - earlier and better establishment of the crop
   - higher mineralisation in spring
   - increased crop nitrogen uptake in the growing season
   - reduced disease severity of *Rhizoctonia* stem canker

3) Catch crops can improve yield and quality of potato through

- improved nutrient cycling in ridge tillage systems
- reduced disease severity of *Rhizoctonia* stem canker

4) Subsoiling can improve crop growth in ridge tillage systems

5) Mixing potato varieties can slow down the epidemic development of potato late blight

6) Mixing potato and faba beans can reduce attack of late blight in potato and reduce attack of aphids in faba beans and thereby increase yields

C. Midterm results and progress

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

Short summary

The aim of the project is to increase the efficacy of row crop production by improving nutrient cycling at the field level and by strengthening prophylactic measures against pathogens via mixed cropping. At the time being, enhanced nutrient cycling shows the best prospects in a practical context and the project has created valuable knowledge concerning the prophylactic measures in a scientific context. The practical prospects of the prophylactic measures, however, seem to be limited.

The project has shown that ridging hold some positive prospects concerning enhanced nutrient cycling. However, the effect of ridging is highly dependent on soil type, timing of setting up ridges, use of catch crops, weed control strategy and previous fertilization of the soil.

The positive effects of ridges were restricted to loamy soil and the effects seem to be caused by higher soil nitrogen in spring. There was found a strong correlation between a higher level of available soil nitrogen in spring (ridges 15% higher than ploughing) and higher potato yield (ridges 16% higher than ploughing). Generally, ridging may decrease leaching but it may both mobilize and immobilize nitrogen. Timing of ridge establishment relative to catch crops, crop residues and nutrient status of the soil is crucial. To fully understand how to optimise timing of ridge establishment, nitrogen dynamics in ridges have to be studied in detail. This project, however, is first of all aiming to establish an empirical foundation, which may answer the question: Do ridges hold significant prospects concerning improvements of nutrient cycling at the field level, which make it worthwhile to initiate mechanistic based research and technical innovations aiming to optimise ridge tillage? At the current status of the project, the answer is yes.

Subsoiling in emerging potato on sandy soils has shown positive as well as negative effects on total yield. However, marketable yield was either increased or unaffected by subsoiling, which was carried out when about 10% of the potato plants were emerged.

The project shows that the influence of potato variety mixtures on late blight development is insignificant. Even if minor reductions in late blight development have been observed, there have been no positive yield responses. Valuable scientific knowledge about the epidemics of late blight has been achieved. It has not been possible to show positive effects of mixing potato and faba beans as regard to late blight and aphids on faba beans, and it has not been possible to show any significant influence of ridging on *Rhizoctonia* stem canker. However, different catch crops reduced severe attack of *R. solani* by about 50% in experiments with artificial inoculation. It has not been possible to prove any impacts of soil tillage, manure and catch crop on *R. solani* in field experiments with low and natural infestations. Lack of aphid response in faba beans grown in potato mixtures may be due to low aphid occurrence.

WP1: Protecting nitrogen from leaching in ridge tillage systems

The potential of ridges to reduce leaching and increase available nitrogen for the subsequent crop has been investigated in several experiments.

Two field experiments at KVL (loamy soil) and St. Jyndevad (sandy soil), respectively, have been conducted to examine the main effects and interactions between soil tillage (ridges and ploughing), timing of soil tillage (early autumn, winter and spring) and catch crop (none, ryegrass and brassicas). Soil samples were taken in winter and spring to determine soil inorganic nitrogen in different soil layers. Since soil samples from the second experiment (2001-2002) are currently being analysed, the following conclusions are based on measurements from the first experiment (2000-2001).

At KVL, ridging increased plant available nitrogen in spring by15% compared with ploughing, however, the effect was highly dependent on timing of tillage and use of catch crops. The most effective way to reduce leaching was to establish ridges in winter after a ryegrass catch crop. If catch crops were not used, ridging in early autumn protected nitrogen from leaching better than all other treatments. However, ridging may also increase nitrogen leaching when ridges are flatten out in late autumn and re-established in order to control weeds. This treatment caused an increased soil nitrogen mineralization in late autumn and thereby increased the leaching potential.

At St. Jyndevad, it was not possible to compare ridging and ploughing carried out at the same time of the year. Ploughing was only carried out in spring as it is well known that ploughing in autumn increases N-leaching on sandy soils. Winter ridging increased plant available nitrogen in spring by 19% compared with early autumn ridging and there was no difference in the performance of winter ridging and spring ploughing as regards to soil nitrogen in spring. Independently of soil tillage, catch crops increased plant available nitrogen in spring by 44%.

An experiment with bromide used as a tracer was carried out to simulate nitrate transport in ridges. The experiment demonstrated that bromide was more protected in the middle of the ridge than on the side of the ridge or in the furrow. Under normal conditions leaching below the furrows was 104% higher than below the ridges, but if the furrows were compacted due to traffic, leaching below furrows was only 18% higher than below ridges.

Lysimeter experiments were conducted in 2001-2002 and 2002-2003 to get direct measurements of leaching associated with ridging and ploughing as primary soil tillage. In late October, farmyard manure was incorporated into ridges or ploughed in. Lysimeter leachate was sampled continuously from November to April and subsequently a barley crop was sown. Inorganic nitrogen from lysimeter leachate is currently being analysed. Ridging showed a 17% higher yield in 2002 and a 8% higher yield in 2003 ($P<0.001$). Yield gains were dependent on soil type and the leaching potential of soil. Ridging showed better results on loamy soil than on sandy soil. The higher effect of ridging in 2002 is probably caused by higher precipitation during autumn and winter 2001-2002 compared with autumn and winter 2002-2003.

WP2: Growing row crops in ridge tillage systems with and without catch crops

Two field experiments at KVL (loamy soil) and St. Jyndevad (sandy soil), respectively, have been conducted to examine how soil tillage (ridges and ploughing), timing of soil tillage (early autumn, winter and spring) and catch crop (none, ryegrass and brassicas) influence the growth and yield of potato. Two field experiments at KVL (loamy soil) have been conducted to examine how ridge size and placement of animal manure influence yield of sugar beet. Furthermore, three pilot studies have been conducted to answer practical questions related to ridging.

Experiments in potato showed that soil tillage was of major importance in terms of tuber yield at KVL (loamy soil) and that catch crop was of major importance to tuber yield at St. Jyndevand (sandy soil). At KVL there was no significant main effect of tillage over years, but there was a significant yield increase by ridging in 2001. Total yield was increased by 16% ($P<0.05$) and marketable yield by 20% ($P<0.05$) compared with ploughing. This effect, however, was highly dependent on timing and frequency of tillage and use of catch crops. The highest total yield and marketable yield was obtained when brassicas were sown as a catch crop on ridges set up in early autumn. If catch crops were not used ridges set up in autumn also gave the highest total yield and commercial yield. A strong correlation between plant available soil nitrogen and tuber yield was demonstrated. If tuber yield was adjusted relative to available soil nitrogen, no effect of tillage was found. This indicates that the effect of ridging on potato yield is caused by effect of ridges on available soil nitrogen in spring. In 2002 there were no significant differences between ridging and ploughing in terms of yield.

At St. Jyndevad there was no significant main effect of tillage but treatments with undersown ryegrass had an 8% higher total potato yield and a 17% higher marketable yield averaged over two years than any treatment without catch crops and autumn ridges with brassicas ($P<0.05$). There was a significant difference between the years primarily caused by the fact that autumn ridges with brassicas that had been flatten out and re-established in late autumn had a comparable total yield with the ryegrass treatments in 2002 and all treatments except autumn ridges and winter ridges without catch crops had a comparable marketable yield with the ryegrass treatments in 2002.

A field experiment with sugar beets was established at KVL in autumn 2000 to investigate how ridge size and placement of animal manure influenced yield. Animal manure was either placed in strings and incorporated in ridges (50 cm and 75 apart) or broadcasted at the surface before ridging. The experiment showed that deep incorporation of farmyard manure was important to avoid that manure was harrowed up to soil surface in spring. Ridging resulted in poor seedbed quality in 2001 due to shallow incorporation of manure. The experiment was replicated in 2001-2002 with a more powerful ridger which succeeded in placing the manure deep enough to avoid problems with a poor seedbed the following spring. There was no significant main effect of soil tillage and placement of manure, but there were significant differences between years and significant year*tillage and year*tillage*row interactions. In 2001 there was no significant effect of soil tillage but sugar beet grown after ridges yielded 17%-23% at 50 cm row spacing than at 75 cm row spacings ($P<0.05$). In 2002 spring ploughing yield 6% higher than ridges and sugar beet grown after ploughing yielded 7%-10% higher at 50 cm row spacing than at 75 cm row spacings ($P<0.05$).

Three pilot studies with incorporation of clovergrass in ridges at St. Jyndevad (sandy soil) and cereals established on ridges were conducted in 2002 to achieve answers to some practical questions about the ridge tillage system. The studies showed that clovergrass incorporated in ridges in autumn strongly reduced yield of winter rye and oats as compared with spring ploughing. This was most likely caused by increased leaching from decomposed clovergrass in ridges. The pilot studies also showed that seedbed preparation in ridge tillage systems need to be further improved. Yields of rye and oats were reduced when sown on ridges compared with sowing in a flat seedbed. The pilot studies will not be repeated.

A pilot study was performed in 2003 to compare the growth of different crops on ridge tops, on ridge shoulders and in flat seedbeds. At St. Jyndevad maize and faba bean showed promising results when grown on ridges, whereas soybean, sugar beet, lentil, oats, barley, lupin and pea did not seem to benefit by ridges. At KVL soybean emergence on ridge shoulders was increased by 32% compared with soybean emergence on ridge tops

and in the flat seedbed. Dry matter production of maize in August was increased by 79% on ridge shoulders (P<0.001) and 49% on ridge tops (P<0.001) compared with a flat seedbed. Soybean harvest has not yet been performed, but the plants on ridges were visibly larger in late September. The pilot study will be repeated at KVL in 2004.

WP3: Growing row crops in ridge tillage systems with and without catch crops with emphasis on *Rhizoctonia* stem canker in potato

In previous field experiment the natural level of infestation of *R. solani* was very low and it was not possible to study the impacts of catch crops. In consequence, a field experiment was set up at Flakkebjerg august 2002 with a 3 factorial design with ridging, catch crop and with artificial inoculation. As catch crop were used oat or a seed mixture sown in the autumn on either bare soil or in the ridges. As artificial inoculum was used sclerotia produced on malt extract agar. In 2002 it was shown in the preliminary trials that artificial inoculum produced on this agar gave the best results. In June 2003 assessments were made and the results show rather severe attack of *R.* solani in the plots that were artificial inoculated in the autumn. There was no effect of ridging but catch crop (oat or seed mixture) sown on bare soil reduced the attack to approx. 50 % estimated on percent attack of *R. solani* on the stems.

WP4: Improving crop growth by subsoiling in different tillage systems

Field experiments in potatoes on sandy soils were conducted in three years to investigate the interactions between soil tillage (ridge tillage versus ploughing), irrigation (fully versus half irrigated) and subsoiling when 10% of the potato plants have emerged. There was no main effect of tillage, irrigation and subsoiling on total yield, but there was a significant effect of subsoiling and irrigation on marketable yield. While full irrigation actually decreased the marketable yield from 94 hkg/ha to 87 hkg/ha averaged over three years, subsoiling increased average marketable yield from 84 hkg/ha to 96 hkg/ha (P<0.05), but there were significant differences between years.

In 2001 subsoiling increased total yield from 272 hkg/ha to 286 hkg/ha (P<0.05) and marketable yield from 101 hkg/ha to 150 hkg/ha (P<0.001). In 2002 there was no effect of subsoiling and in 2003 subsoiling decreased total yield from 250 hkg/ha to 232 hkg/ha (P<0.05) while there was no effect on marketable yield. In 2003 additional plots were established to investigate if subsoiling performed at various growth stages or within the row would improve yield, but none of these treatments had a positive effect.

A permanent field experiment has been established at KVL in spring 2001. Before crop establishment plots were a) totally loosened to a depth of 90 cm by digging, b) subsoiled with a commercial subsoiler and c) untreated with respect to subsoiling. In 2001 there was found positive correlations between loose soil and plant growth in spring barley and winter rapeseed. In 2001, crop yield in barley-pea and oat-lupin mixtures were unaffected and in 2002 a clover-grass mixture was unaffected by soil structure.

No clear-cut effect of subsoiling on potato quality has been determined in the years 2001 and 2002, the harvested potatoes from 2003 have not been analysed yet.

WP5: **Mixing potato varieties**

The influence of potato variety mixtures on late blight development was studied in two field experiments at research stations at St. Jyndevad and Borris in 2001 and in 2002. Four varieties (Kuras, Danva, Oleva, Producent) were grown in pure stands and the 4-way mixture in 24x24 m plots in 2001. Experience from detailed studies in 2001 allowed for a reduction in the size of plots of the varieties in pure stands, which were reduced to 12x10.5 m in 2002. At both stations in both years, late blight severity was assessed weekly in 4 -16

subdivisions of every plot depending on plot size. The field trial at St. Jyndevad was selected for more detailed studies, - in 2001, including late blight severity assessments in 25 subplots per plot and foci development, and in 2002, assessments of disease on individual randomly selected plants (Kuras, Oleva) and by remote sensing. At harvest, tuber yield of subplots was determined, and approx 3 weeks later the percent late blight infected tubers was determined. The analysis of the data shows a slightly lower disease level in three of the four trials on infected stem and leaf tissue, but only a significant lower disease level in one out of the four trials (highest reduction 13%). The rate of disease development, measured as the 'apparent infection rate' is significantly reduced in mixtures for all trials. The disease reduction on leaf and stem tissue in mixtures is, however, very small and is not reflected in the tuber yield or in the amount of blight infected tubers. It is concluded that potato variety mixtures can delay an epidemic of potato late blight slightly, and that the tuber yield equals the mean of the component varieties. A high amount of useful data was obtained. The different detailed assessment methods secured a high value of data and set down a method for future studies. The results have shown that airborne diseases in relatively large plants such as potato can be reduced. Finally, it should also be emphasized that the experimental design used in this study gives strong evidence to say that mixing the potato varieties used in practical farming today does not improve control of late blight considerably.

WP6: **Mixing potato and faba beans**

Field experiments have been conducted with inter-cropping of potatoes and faba bean with 4 rows of each crop in alternating order to delay late blight development. In 2001 and 2002 mixtures have contributed with minor reductions of late blight without any influence on crop yield. In 2003 mixtures had no influence on late blight. In order to investigate the effect of the row direction the rows have been oriented both north-south and east-west in large 24 x 24 m plots. Reference plots with potatoes and faba beans in pure stands have been established for comparison in a randomised block design. In order to investigate in detail the effect of the intercropping system and row direction the establishment and spread of blight infections in the plots have been carefully observed and mapped. Likewise the attacks of aphids on faba beans have been recorded. Results show no clear differences on blight infection or yield between the treatments. Aphid attacks in the faba beans has been insignificant and therefore no difference between treatments could be observed. Mixing potatoes and faba beans within the same row increased late blight attack, probably due to unfavourable microclimate.

It has been observed that the root system of faba beans develops more vigorously when grown on ridges compared to flat soil. In collaboration with two other projects the nitrogen fixation in faba beans on ridges is being investigated. The preliminary results are promising.

C.2 Fulfilment of deliverables and milestones

WP1 Protecting nitrogen from leaching in ridge tillage systems	Time schedule according to application	Deviations, if any*
Deliverables		
1. Evaluation of ridges set up in autumn as an alternative to autumn ploughing for reducing nitrate leaching 2. Paper in international journal on the effects of shape, size and orientation of ridges 3. Paper in international journal on the effects of timing of different soil tillage operations and placement of crop residues/animal manure 4. Paper in popular magazine summarising the results in this workpackage 5. Paper in popular magazine describing a guideline for setting up ridges in autumn		
Milestones		
1. Field experiments finished	09 2003	Achieved
2. The effects of shape, size and orientation of ridges has been determined	11 2003	Achieved
3. The effects of type and placement of crop residues and animal manure has been determined	11 2003	Achieved
4. The effects of timing of setting up ridges has been determined	11 2003	Achieved
5. The effects of growing catch crops on ridges has been determined	11 2003	Achieved
6. Final evaluation of ridge tillage as an alternative to mouldboard ploughing for reducing nitrate leaching	06 2004	
7. Papers have been written	06 2004	

WP2: Growing row crops in ridge tillage systems with and without catch crops		Deviations, if any*
Deliverables		
1. Evaluation of ridge tillage for organic row crop production 2. Evaluation of the interaction between tillage system and catch crops 3. Evaluation of the effects of ridge tillage and catch crops on stem canker 4. Evaluation of the effects of soil tillage and type/timing of animal manure on potato yield and quality 5. Paper(s) in international journal(s) on the ridge tillage system for organic row crop production 6. Paper in international journal on the effects of soil tillage and timing/type of animal manure on potato yield and quality 7. Several papers in popular magazines describing the progression and results of this workpackage		Delivered Delivered Delivered Delivered
Milestones		

1. Field experiments finished	09 2003	Achieved
2. The performance of tillage systems based on ploughing and ridges with and without catch crops has been determined	11 2003	Achieved
3. The effects of soil tillage and timing/type of animal manure has been determined	11 2003	Achieved
4. The energy consumption and economy of ridge tillage for organic row crop production has been determined	02 2004	
5. Final evaluation of ridge tillage for organic row crop production	06 2004	
6. Papers have been written	06 2004	

WP3: Growing row crops in ridge tillage systems with and without catch crops with emphasis on *Rhizoctonia* stem canker in potato	Time schedule according to application	Deviations, if any*
Deliverables		
1. Evaluation of ridge tillage with organic soil amendments on *Rhizoctonia* stem canker		Delivered
2. Evaluation of the importance of soil-borne inoculum in ridge tillage with organic amendments.		Delivered
3. Paper in international journal on catch crops in a ridge tillage system with emphasis on *Rhizoctonia* stem canker in potato.		
4. Paper in popular magazine describing a guideline for Danish farmers for using organic soil amendments in organic potato production with emphasis on the control of *Rhizoctonia* stem canker.		
Milestones		
1. Methods have been developed for producing large amount of artificial inoculum of *R. solani*. Several growth media and containers have been investigated (Primo 2001)	05 2001	Achieved
2. The effect of manure, soil tillage, timing and catch crops on occurence of *Rhizoctonia* stem canker has been studied in the field trial under WP2 at St. Jyndevad (Medio 2001).	06 2001	Achieved
3. Field experiment has been conducted at Flakkebjerg to test the effect of the different inoculum types (Medio 2001).	07 2001	Achieved
4. The effect of manure, soil tillage, timing and catch crops on occurence of *Rhizoctonia* stem canker has been studied once more in the field trial under WP2 at St. Jyndevad (Medio 2002).	06 2002	Not achieved because plans have been modified
5. Artificial inoculation with *R. solani* of field experiment at Flakkebjerg and sowing of catch crops and establishment of ridge tillage systems have been performed (Medio 2002).	08 2002	This is a new experiment in relation to application
6. Healthy seed tubers have been planted in the field experiment at Flakkebjerg (Primo 2003).	05 2003	Continuation of the new experiment

7. The disease severity of *Rhizoctonia* stem canker has been scored and field experiment at Flakkebjerg finished (Medio 2003)	07 2003	Termination of the new experiment
8. Papers have been written (Ultimo 2003)	12 2003	

WP4: Improving crop growth by subsoiling in different tillage systems		Deviations, if any*
Deliverables		
1. Evaluation of subsoiling for potato production in ridge tillage systems 2. Paper in international journal on the effects of subsoiling on potato yield and quality in different tillage systems. 3. Paper in popular magazine summarising the results in this workpackage		Delivered
Milestones		
1. Field experiment finished	07 2003	Achieved
2. The effects of subsoiling on potato yield and quality in different tillage systems have been determined (	12 2003	Achieved
3. Papers have been written	06 2004	

** Deviations are to be further discussed at D*

WP5: Mixing potato varieties		Deviations, if any*
Deliverables		
1. Evaluation of the efficacy of using potato mixtures as a late blight control measure in organic grown potatoes in Denmark **2.** Paper in international journal on the effect of potato mixtures on late blight development **3.** 2 Papers in popular magazines or proceedings		Delivered
Milestones		
1. A method for assessing late blight in potato mixtures has been developed	07 2001	Achieved
2. First years field trials have been analysed and possible adjustments of design of the field trials can be decided	12 2001	Achieved
3. AUDPC measurements in two years field trials completed	11 2002	Achieved
4. The efficacy of organic grown potato mixtures as a late blight control measure is determined	12 2002	Achieved

** Deviations are to be further discussed at D*

WP6: Mixing potato and faba beans		Deviations, if any*
Deliverables		

1. Evaluation of intercropping of potatoes and faba bean as a growing system 2. Evaluation of the possibility to reduce attack of late blight in potatoes using intercropping 3. Evaluation of the possibility to reduce colonisation of aphids in faba bean using intercropping 4. Paper in international journal describing the potato faba bean intercropping and effect on pests and diseases. 5. Paper in popular magazine summarising the results of this workpackage		Delivered Delivered Delivered
Milestones		
1. Field experiments finished	12 2003	
2. Influence of intercropping on potato late blight epidemiology has been determined	12 2003	Achieved
3. Influence of intercropping on aphid abundance in faba bean has been determined	12 2003	Achieved
4. Final evaluation of possibilities and perspectives of potato intercropping with faba bean	06 2004	
5. Papers have been written	06 2004	

** Deviations are to be further discussed at D*

D. Description of deviations and subsequent adjustments of plans

The project is based on an innovative approach, which means that adjustments are a part of the project. A balance is attempted between adjustments and repetition of experiments in at least two years to ensure the possibilities of publication. As it was very expensive, and more expensive than expected, to run field experiment with potatoes and sugar beets, some experimental plans in WP1 and WP2 have to be reduced according to the Midterm Status Report 2002. The greatest modifications of the original plans have been in WP3 (Growing row crops in ridge tillage systems with and without catch crops with emphasis on *Rhizoctonia* stem canker in potato) as described and justified in the Midterm Status Report 2002. Instead of natural occurring infections of *R. solani* in the field experiments at St. Jyndevad there has been applied artificial inoculum in field experiments at Flakkebjerg in 2003. This modification gave high quality data. Encouraging results with growing various crops on ridges in pilot studies at KVL and St. Jyndevad implies that it will be attempted to repeat some of the experiments and even extend some of the most promising aspects.

Scientific publications form the projects have not been delivered yet but a plan for publications has been worked out.

E. Project publications and other products

From http://orgprints.org/:

Never intended to be peer-reviewed

Dansk - Danish

Christian Bugge, Henriksen (2000) Kamme - et alternativ til pløjning?. Paper presented at Det Kgl. Danske Landhusholdningsselskabs Akademiråds Efterårsseminar, Foulum, Denmark, November 8, 2000; Published in P. Dam, Hans, Eds. *Tidsskrift for Landøkonomi* 187(4), page 311-314. Det Kgl. Danske Landhusholdningsselskab.

Henriksen, C.B. and Rasmussen, J. (2002) Kamdyrkning (drill) – et økologisk alternativ. Paper presented at Den nasjonale kongres for økologisk jordbrug, Hamar, Norway, 21/2-22/2 2002; Published in Cottis, T., Eds. *Den nasjonale kongres for økologisk jordbrug, Rapport nr. 3 - 2002*, page 61-68. Høgskolen i Hedmark.

Thomsen, Henning C. (2001) Kan hestebønner forsinke skimmelangreb. *Kartoffelproduktion* 27(4):6-7.

Peer-review not relevant

Dansk - Danish

Bugge Henriksen, Christian (2000) Er kamme et alternativ til pløjning?. [oral] Presentation at *Det Kgl. Danske Landhusholdningsselskabs Akademiråds efterårsseminar*, Foulum, Denmark, November 8. 2000.

Rasmussen, Jesper (2000) Alternative jordbearbejdningsmetoder. [oral] Presentation at *Seminaret "Jordbearbejdning og jordfrugtbarhed", Landsforeningen Økologisk Jordbrug*, Bygholm Landbrugsskole, 19. september 2000.

Rasmussen, Jesper and Henriksen, Christian Bugge (2000) Jordløsninger - er det svaret? [oral] Presentation at *Økologikongres 2000. Troværdighed og succes*, Hotel Pejsegården i Brædstrup, 1. og 2. november 2000.

Rasmussen, Jesper and Henriksen, Christian Bugge (2002) Kamdyrkning i stedet for pløjning. [oral] Presentation at *Nasjonal kongress for økologisk landbruk*, Hamar, Norge, 21.-22. februar.

This list was generated on **Tue Sep 30 00:18:17 CEST 2003**.

Grossmann, Freya (2002) *Forbedring af jordkvaliteten efter jordpakning - er løsning løsningen?*. MSc thesis, Sektion for Økologisk Jordbrug, KVL**

Full text available as: Source file (MS Word)

Not yet in http://orgprints.org/. The publisher is currently evaluating a request for publication of abstracts/papers on Organic Eprints.

1. Articles in international, scientific journals with review procedures

Henriksen C.B., Rasmussen J., Søgaard C (2003): Kemink subsoiling before and after planting. *Soil & Tillage Research* (Accepted)**.

Henriksen C.B., Rasmussen J., Søgaard, C. (2003): Ridging in autumn as an alternative to ploughing. *Soil & Tillage Research* (submitted).

Submitted to http://orgprints.org/

3. Reports, articles in agricultural journals, etc.

Henriksen, C.B. (2003): Alternativ til pløjning - Erfaringer med kamme som alternativ til pløjning. Økologisk Jordbrug 287, 18 April, side 6.

Not available on http://orgprints.org/

3. Reports, articles in agricultural journals, etc.

Dahlmann-Hansen, L. (2002): Hestebønners tidlige rodudvikling ved dyrkning på kamme (The initial development of root in faba beans grown on ridges) B.Sc.-project. KVL (available at http://dvjb1.kvl.dk/ALEPH)**

Kock, T & Kromann, P (2002): Blandingskulturer til bekæmpelse af kartoffelskimmel / udført af: Torben Koch, Peter Kromann. MSc thesis. Institut for Plantebiologi. KVL (available at http://dvjb1.kvl.dk/ALEPH)*

Mathiasen, K. (2002) Effekter af midlertidige kamme på temperatur, vandindhold, volumenvægt og fremspiring i såbed til majs. MSc thesis. Faggruppen for Økologisk Jordbrug, KVL (available at http://dvjb1.kvl.dk/ALEPH)**

Larsen, L. U. (2003): Langtidseffekten af dyb jordløsning – samt indflydelse på samdyrkning. B.Sc-project. KVL (available at http://dvjb1.kvl.dk/ALEPH)**

F. Scientific education

Grossmann, Freya (2002) *Forbedring af jordkvaliteten efter jordpakning - er løsning løsningen?*. MSc thesis, Sektion for Økologisk Jordbrug, KVL**
Full text available as: Source file (MS Word)

Dahlmann-Hansen, L. (2002): Hestebønners tidlige rodudvikling ved dyrkning på kamme (The initial development of root in faba beans grown on ridges) B.Sc.-project. KVL (available at http://dvjb1.kvl.dk/ALEPH)**

Kock, T & Kromann, P (2002): Blandingskulturer til bekæmpelse af kartoffelskimmel / udført af: Torben Koch, Peter Kromann. MSc thesis. Institut for Plantebiologi. KVL (available at http://dvjb1.kvl.dk/ALEPH)*

Mathiasen, K. (2002) Effekter af midlertidige kamme på temperatur, vandindhold, volumenvægt og fremspiring i såbed til majs. MSc thesis. Faggruppen for Økologisk Jordbrug, KVL (available at http://dvjb1.kvl.dk/ALEPH)**

Larsen, L. U. (2003): Langtidseffekten af dyb jordløsning – samt indflydelse på samdyrkning. B.Sc-project. KVL (available at http://dvjb1.kvl.dk/ALEPH)**

G. National and international cooperation

The project cooperates with Finn Pilegaard Vinther and the DARCOF-project 'Dinitrogen fixation and nitrous oxide losses in organic grass-clover pastures: An integrated experimental and modelling approach (DINOG)' and the EU-project 'Greenhouse gas mitigation for organic and conventional dairy production (MIDAIR)' on investigating the nitrogen fixation in faba beans grown on ridges compared to flat soil.

WP 5 and WP 6 are closely co-ordinated with the research conducted in the EU project 'Development of a system-approach for the management of late blight in EU-organic potato production' (Blight MOP) in which Bent J. Nielsen and Jens Peter Mølgaard are participating. Where possible, the same varieties and design have been used. Possibly the results from WP 6 will be published in a joint publication with the research team of Prof. Maria Finckh, University of Kassel.

H. Critical reflection on the project

General reflections for the project as a whole

The project is running fairly close to the initial plans described in the application.

It is considered to be disappointing from an applied perspective that the project has not shown any strengthening of the possibilities to control late blight by mixing potato varieties or mixing potato and faba bean. This disappointment is counterbalanced by valuable scientific knowledge on the epidemics of late blight and knowledge about the required plot size to make conclusions about potato mixtures relevant in a practical context.

It was hypothesized that catch crops were able to reduce *Rhizoctonia* stem canker. This was supported by field experiments in 2003 where a new experimental approach based on artificial inoculum was used. Previous findings in this project could not support the hypothesis, most likely due to methodological problems by using natural infestation of *R. solani*. Considerations about developing a new experimental technique were discussed in the Midterm Status Rapport 2002.

This project has shown significant differences in prospect of ridge tillage on different soil types. At present, the best results from a scientific point of view have been found on loamy soil with 15-20% clay. It requires, however, good workmanship and appropriate machinery to establish ridges on wet soils with relatively high clay content in late autumn. It also requires new implements to establish crops on ridges. On sandy soils it is questionable whether there exists competitive soil tillage alternative to spring ploughing combined with catch crops Growing rows crops on ridges has given encouraging results in pilot studies. This aspect has been emphasised in the last part of the project and it will be attempted to make "low cost" experiments at KVL and St. Jyndevad in 2004 to strengthen the experiences from year 2003. From the beginning it was not planned to study the performance of various row crops grown on ridges.

Reflections on soil tillage

The factorial field experiments with catch crops and incorporation of animal manure in WP1 and WP2 were found to be significantly more expensive than budgeted. In consequence, the most expensive experiments were terminated after two years and the main efforts in the last experimental year were concentrated on 1) the lysimeter experiment (WP1), 2) pilot studies comparing various crops grown on ridges (WP2), 3) the subsoiling experiment at St. Jyndevad (WP4) and 4) a pilot study with subsoiling in different growth stages of potato (WP4).

Regarding nitrogen management, the experiments have so far confirmed that ridging may hold the potential to decrease leaching and increase plant available nitrogen on loamy soil. Measurements of bromide transport have demonstrated decreased leaching and measurements of soil inorganic nitrogen has demonstrated increased nitrogen availability in spring. At the same time, the higher yield of barley grown after ridging in the lysimeter experiment indicates that barley is capable of utilizing the extra nitrogen. Since yield advantages in barley have also been found in previous studies at KVL, but not consistently in other crops in this study, it could be hypothesized that ridging is more successful in crops with a high nitrogen requirement early in the growing season than in crops with a more sustained nitrogen requirement during the growing season.

Experiments with maize have demonstrated difficulties with crop establishment on ridges. With current equipment it has not been possible to establish an appropriate seedbed on top of ridges. Furthermore, it has been necessary to suspend an experiment because black birds preferred to eat seeds and seedlings planted on ridges. Instead of repeating this study a smaller net covered pilot study with hand-sown maize and soybean on ridge tops and ridge shoulders has been carried out.

It has been difficult to establish Brassica catch crops on ridges. Catch crops are almost solely established in the furrows between ridges. This may not have a negative impact on leaching but a better establishment would stabilize the soil, increase soil porosity and secure competition against weeds. This emphasises the need to develop a drill for ridges.

Our experiments show that ridges established in autumn increase available nitrogen if they are established in a ryegrass catch crop. This, however, increases the risk of soil compaction in the furrow if soil is wet. At the same time ridge-incorporated ryegrass is not fully decomposed in spring and may decrease seedbed quality in spring.

Weed control in autumn after early autumn ridging is challenging. It is not advisable to flatten out ridges and rebuild them in late autumn because materialisation will be enhanced. Weed seedlings, however, may be controlled efficiently by repeated weed harrowings. Perennial weeds, however, cannot be controlled without flatten the ridges.

In this project, ridging is used as a one-year treatment in an existing arable system based on ploughing. Ridges have been set up after spring barley at KVL and after winter rye at St. Jyndevad. Results have to be interpreted in this context. Timing of setting up ridges, weed pressure and residual soil nitrogen would be different if the experiments had been established in a vegetable cropping system.

Reflections on mixed cropping

The experiments have been conducted according to the plans. The results in terms of postponing the epidemic development of late blight have been somewhat disappointing. One possible explanation for the lack of treatment effects in the year 2001 was very strong winds, which blew at the time of the first blight infections in the trial field. However, in 2002 and 2003 we had usual weather conditions, which indicate that the mixed cropping does not have the presumed positive effect on late blight. We therefore have to conclude that under the given conditions a mixture of potatoes and faba bean and mixtures of potato cultivars did not postpone the development of late blight as expected. The faba bean mixture may still have a positive effect in terms of reducing aphid attacks in faba beans, but due to inferior prevalence of aphids no conclusion can be drawn on this point. The experiments have revealed a positive effect of growing faba beans on ridges. In collaboration with two other projects the nitrogen fixation in faba beans on ridges is being investigated. The preliminary results are promising. This has inspired us to establish a pilot project investigating the possibilities of growing other nitrogen fixing crops as well as non-fixing crops on ridges.

8. Budget

A. Account for any change in budgets

B. Budget for the whole project (1.000 DKK)

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

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months	61	41	12.5	0	87.5
Scientific personnel	43	8	12.5	0	63.5
Technical personnel	18	6	0	0	24.0

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries	1833	397	440		2670
Scientific personnel	1403	253	440		2096
Technical personnel	430	144	0		574
Other operational costs	1041	140	66		
Equipment					
Others (please specify)					
Direct costs	2874	537	506		3916
Indirect costs (20% of direct costs)	574	108	101		783
Total	3448	654	607		4700

Comments:

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project Jesper Rasmussen	Department of Agricultural Sciences KVL	1.10.2003	

Appendix I. Detailed budget

A. Budget for each participating institute (1.000 DKr)

Name of Institute: KVL

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months	29	3[1)]	11[1)]	0	43
Scientific personnel	29	3[1)]	11[1)]	0	43
Technical personnel	0	0	0	0	0

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries	915	85[1)]	390	0	1390
Scientific personnel	915	85[1)]	390[1)]	0	1390
Technical personnel	0	0	0	0	0
Other operational costs	611	113	11	0	735
Equipment					
Others (please specify)					
Direct costs	1526	198	401	0	2125
Indirect costs (20% of direct costs)	305	40	80	0	425
Total	1831	238	481	0	2550

Comments:

[1)] We kindly ask for a transfer of 10 months scientific personnel from 2003 to 2004 to finish data processing and publications. Thereby the project is not terminated in June 2004 as originally planned but in November 2004. Christian Bugge Henriksen has been on leave from February 2003. He is expected to be back December 2003. He wanted leave to finish his ph.d. thesis and to take care of the woman with whom he cohabits. She has been seriously ill. Christian Bugge Henriksen's leave will not influence the quality of the project in a negative direction, on the contrary the prospects of making high quality scientific papers is considered to be improved.

A. Budget for each participating institute (1.000 DKr)

Name of Institute: DJF

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Man-months	32	11	1.5	0	44.5
Scientific personnel	14	5	1.5	0	20.5
Technical personnel	18	6	0	0	24.0

Year:	Consumption before 2003	Expected consumption 2003	2004	2005	Total
Salaries	918	312	50	0	1280
Scientific personnel	488	168	50	0	706
Technical personnel	430	144	0	0	574
Other operational costs	430	27[1)]	55[1)]	0	512
Equipment					
Others (please specify)					
Direct costs	1348	339	105	0	1792
Indirect costs (20% of direct costs)	269	68	21	0	358
Total	1617	407	126	0	2150

Comments:

[1)] We kindly ask for a transfer of 50.000 DKK (operational costs) from 2003 to 2004 to continue preliminary experiments on growing non-fixing crops on ridges in WP6.