



Annual Status Report 2001 and Application for Continuation in 2002

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

1. Research program

Research in organic farming 2000-2005 (DARCOF II)

2. Project title and number

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

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7. **Start of project:** 09 2000
End of project: 06 2004
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8. Annual report/Application for continuation in 2002

A. Objectives and expected achievements (from application)

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:

Ridge tillage can protect nitrogen from leaching in winter through

- higher immobilisation of nitrogen
 - reduced percolation through the ridges
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- 1) 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
- 2) Catch crops can improve yield and quality of potato through
 - improved nutrient cycling in ridge tillage systems
 - reduced disease severity of *Rhizoctonia* stem canker
- 3) Subsoiling can improve crop growth in ridge tillage systems
- 4) Mixing potato varieties can slow down the epidemic development of potato late blight
- 5) 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

B. Project summary (from application)

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 (*Phytophthora 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 set 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 1: Work package list (from application)

Workpackage Number	Work package title	Responsible participant	Budget (DKK1000)	Start	End
WP1	Protecting nitrogen from leaching in ridge tillage systems	JR	1029	1/9 2000	30/6 2004
WP2	Growing row crops in ridge tillage systems with and without catch crops	JR	1824	1/9 2000	30/6 2004
WP3	Growing row crops in ridge tillage systems with and without catch crops with emphasis on stem canker (<i>R. solani</i>) in potato	LB	494	1/9 2001	31/12 2003
WP4	Improving crop growth by subsoiling in different tillage systems	CBH	229	1/9 2000	30/6 2004
WP5	Mixing potato varieties	LM	708	1/3 2001	31/12 2002
WP6	Mixing potato and faba beans	JPM	416	1/3 2001	30/6 2004

C. Progress

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

WP1: Protecting nitrogen from leaching in ridge tillage systems

Task 1 Optimising ridge tillage to reduce nitrate leaching:

Field experiments were set up in autumn 2000 at Højbakkegård and St. Jyndevad to examine main effects and interactions between soil tillage (ridging and ploughing), timing (early autumn, winter and spring) and catch crops (ryegrass and brassicas) on nitrate leaching in potatoes. The experiment at St. Jyndevad has been set up in 3 different manuring systems. Soil samples from all plots have been taken in November 2000 and May 2001 to determine soil inorganic nitrogen in different soil layers. The analysis of the soil samples is not yet been concluded.

Task 2: Measuring nitrate leaching in lysimeter experiments

In autumn 2001 the first lysimeter experiment will be set up to study the interactions between soil tillage system (ridging and ploughing) and residual N on leaching during the winter time. The lysimeter experiment has been postponed one year because the lysimeters were not available for experiments in autumn 2000.

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

Task 1 and 2 (merged). Optimising crop production in ridge tillage systems and investigating the interactions between tillage and manuring.

All planned experimental treatments in potatoes, fodder beet and maize have been carried out, but several crops have not been harvested at the time being. Therefore, no clear conclusions can be drawn from the experiments until later.

Potato experiments. Field experiment were set up in autumn 2000 at Højbakkegård and St. Jyndevad to examine main effects and interactions between soil tillage (ridging and ploughing), timing (early autumn, winter and spring) and catch crops (ryegrass and Brassica species) on yield (experiments are the same as used in WP1/task 1). The potatoes at KVL have not been harvested, yet (Oct 2001) at KVL. Results from St. Jyndevad showed that timing was the most important factor with respect to tuber yield. Spring ploughing and winter ridges resulted in the highest yields. There was no significant effect of catch crops and soil tillage.

Fodder beet experiment: A field experiment at Højbakkegård was set up in autumn 2000 to examine main effects and interactions between soil tillage (ridging and ploughing), placement of farmyard manure (rows and full surface) and row spacing (50 cm and 75 cm). Fodder beets have not been harvest, yet (Oct 2001)..

Maize experiments: A field experiment at Højbakkegård was set up in autumn 2000 to examine main effects and interactions between soil tillage (ridging and ploughing), placement of farmyard manure (rows and full surface) and seed bed (ridges and flat seed bed). Maize has been harvested but data has not been analysed.

Another field experiment has been conducted in maize to examine how ridges and crop residues affect soil temperature and crop establishment. The results show that ridges increase temperature in the seedbed but decrease the quality of the seedbed.

Pilot experiments at St. Jyndevad: Three pilot studies with incorporation of clovergrass in ridges and cereals established on ridges has been conducted to achieve answer 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 of clover-grass. Increased leaching from decomposed clovergrass in ridges most likely caused this. The pilot studies also showed that seedbed preparation in ridge tillage need to be further improved. Yield of rye and oats were reduced when sown on ridges compared with sowing in a flat seedbed. The pilot studies will not be repeated.

Task 3: Estimating energy consumption and economy of ridge tillage for organic row crop production

Starts in 2003.

WP3: Growing row crops in ridge tillage systems with and without catch crops with emphasis on stem canker (*R. solani*) in potato

Manure, soil tillage and catch crop had no clear effect on natural infection of *Rhizoctonia solani* in the field trial under WP2 at St. Jyndevad.

A method for producing large amount of artificial inoculum of *Rhizoctonia solani* has been developed. Several growth media (infected tubers, mixture of wheat bran and saw dust, potato dextrose agar and maltose dextrose agar) and containers (sterile glass bottles and plastic bags) for producing the inoculum were investigated.

A field experiment was conducted to test the effect of the different inoculum types on healthy tubers. This experiment showed large difference in disease incidence and disease severity. Sclerotia produced on malt dextrose agar showed the highest level of disease severity on potato where as sclerotia produced on potato dextrose agar did not cause any disease level different from the control.

WP4: Improving crop growth by sub-soiling in different tillage systems

One field experiment has been set up in autumn 2000 at St. Jyndevad to investigate possible interactions between soil tillage system, irrigation and subsoiling. The results in 2001 show that subsoiling during the growing season increased tuber yield from 272 hkg/ha to 286 hkg/ha. There was no effect of soil tillage system and irrigation.

WP5: Mixing potato varieties

The influence of potato variety mixtures on late blight development was studied in two field experiments at St. Jyndevad and Borris. Four varieties (Kuras, Danva, Oleva and Producent) were grown in pure stands and the 4-way mixture in 24x24 m plots in four replicates. At both stations, late blight severity was assessed weekly as % of 9 subplots per plot. At St. Jyndevad more detailed studies were carried out, as well: Late blight severity (%) was assessed in 25 subplots per plot approximately every 5 day from the 13 July 2001 to 17 August 2001. In addition, measuring expansion in four directions assessed foci development. At harvest, the yield of 6 x 24m (check) row per plot was determined. Preliminary calculations show that the late blight development in the mixture was slightly delayed compared to the mean development of the varieties in pure stand. The mixture did not affect tuber yield in St. Jyndevad and yield data from Borris is not available yet due to late harvest.

WP6: Mixing potato and faba beans

A field trial has been conducted with inter-cropping of potatoes and faba bean with 4 rows of each crop in alternating order. The general experience is that blight is spreading in accordance with the prevalent wind direction. 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. The detailed blight registrations have not been analysed at this moment but the preliminary results of this first year of field trials indicate no clear differences on blight infection or yield between the treatments. One possible explanation for this lack of treatment effect is the very strong winds, which blew at the time of the first blight infections in the trial field. Aphid attacks in the faba beans were insignificant and therefore no difference between treatments could be observed.

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

(To be completed for each work package)

WP1 Protecting nitrogen from leaching in ridge tillage systems	Time schedule according to application	Deviations, if any*
Tasks		
1 Optimising ridge tillage to reduce nitrate leaching	2000-2004	
2 Measuring nitrate leaching in lysimeter experiments	2001-2004	
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	
2. The effects of shape, size and orientation of ridges has been determined	11 2003	
3. The effects of type and placement of crop residues and animal manure has been determined	11 2003	
4. The effects of timing of setting up ridges has been determined	11 2003	
5. The effects of growing catch crops on ridges has been determined	11 2003	
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	

* *Deviations are to be further discussed at C3*

WP2: Growing row crops in ridge tillage systems with and without catch crops		Deviations, if any*
Tasks		
Optimising crop production in ridge tillage systems	2000-2004	
Investigating the interactions between soil tillage and manuring	2000-2004	
Estimating energy consumption and economy of ridge tillage for organic row crop production	2000-2004	

Deliverables		
<ol style="list-style-type: none"> 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 		
Milestones		
1. Field experiments finished	09 2003	
2. The performance of tillage systems based on ploughing and ridges with and without catch crops has been determined	11 2003	
3. The effects of soil tillage and timing/type of animal manure has been determined	11 2003	
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	

* *Deviations are to be further discussed at C3*

WP3: Growing row crops in ridge tillage systems with and without catch crops with emphasis on stem canker (<i>Rhizoctonia solani</i>) in potato		Deviations, if any*
Task		
1. Investigating the effect of catch crops on potato stem canker	2001-2003	
Deliverables		
<ol style="list-style-type: none"> 1. Evaluation of ridge tillage with organic soil amendments on <i>R. solani</i> stem canker 2. Evaluation of the importance of soil-borne inoculum versus seeds with black scurf in ridge tillage with organic amendments 3. Paper in international journal on catch crops in a ridge tillage system with emphasis on <i>R. solani</i> 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 <i>R. solani</i> stem canker 		

Milestones		
1. Infestation of first year field trials is performed (Ultimo 2001)	12 2001	
2. Healthy and diseased seed tubers have been planted in field trials (Primo 2002)	05 2002	
3. Quantitative and qualitative tuber yields from field trial have been determined (Ultimo 2002)	11 2002	
4. Infestation of second year field trials is performed (Ultimo 2002)	11 2002	
5. Healthy and diseased seed tubers have been planted in field trials (Primo 2003)	05 2003	
6. Field experiments finished (Medio 2003)	09 2003	
7. Quantitative and qualitative tuber yields from second year field trial have been determined (Ultimo 2003)	11 2003	
8. Papers have been written (Ultimo 2003)	12 2003	

* *Deviations are to be further discussed at C3*

WP4: Improving crop growth by subsoiling in different tillage systems		Deviations, if any*
Tasks		
1. Comparing subsoiling for potato production in different tillage systems	2000-2004	
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		
Milestones		
1. Field experiment finished	07 2003	
2. The effects of subsoiling on potato yield and quality in different tillage systems have been determined (12 2003	
3. Papers have been written	06 2004	

* *Deviations are to be further discussed at C3*

WP5: Mixing potato varieties		Deviations, if any*
Task		
Investigating the effect of potato variety mixtures on late blight development	2001-2002	
Deliverables		
<ol style="list-style-type: none"> 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 		
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	
3. AUDPC measurements in three years field trials completed	11 2002	
4. The efficacy of organic grown potato mixtures as a late blight control measure is determined	12 2002	

* *Deviations are to be further discussed at C3*

WP6: Mixing potato and faba beans		Deviations, if any*
Task		
Developing potato and faba bean intercropping	2001-2004	
Deliverables		
<ol style="list-style-type: none"> 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 		
Milestones		
1. Field experiments finished	12 2003	
2. Influence of intercropping on potato late blight epidemiology has been determined	12 2003	
3. Influence of intercropping on aphid abundance in faba bean has been determined	12 2003	
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 C3*

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

The project is in progress as planned. It is too early to make preliminary conclusions about the hypotheses of the project. The majority of the yield data from the first growing season has not been analysed, yet, due to late harvest of fodder beets, maize and potatoes. The first year of experiments have given a number of valuable experiences of practical relevance. Some of these experiences will be outlined in the following, because they are important to the further development of the ridge tillage system.

It has been possible to achieve more detailed and better registrations by connecting MSc-students to the project. Kresten Mathiasen has been associated to WP2, Freya Grossman has been associated to WP4 and Torben Koch and Peter Kromann have been associated to WP5.

Experiments have been conducted according to the original plans except for **WP3**.

Based on the experiences from 2001 it has been decided to change the experimental approach in **WP3**. The aim was - and still is - to evaluate how ridge tillage influences *Rhizoctonia solani*. The original experimental approach was to use soil-borne inoculum and seeds with black scurf in field experiments. A field trial, however, has shown that infected tubers with black scurf were not resulting in deceased plants. Furthermore, it has been shown that it is very costly to carry out field experiments with artificial inoculum. In consequence, it has been decided to assess the natural occurring infections of *Rhizoctonia solani* in the field trial with ridges (WP2) at St. Jyndevad. Fortunately, there was a high infestation level of *Rhizoctonia solani* in 2001, which made it possible to test the effect of the full ridge tillage system on stem canker. Assessments of natural infestations will be repeated. This change will give a deeper understanding of the variation in natural infestations in the field and the possibility to use ridge tillage to control stem canker caused by *R. solani*.

WP5 Milestone 1 has been fulfilled. A method for assessing late blight in potato mixtures has been developed as described in C1

Practical experiences and considerations

According to the innovative approach in the project the following experiences and considerations are given.

Potato establishment

At St. Jyndevad potatoes has been planted directly in ridged plots as planned. This has not been possible at Højbakkegård due to heavy soil. Ridged plots have been harrowed thoroughly before planting.

Fodder beet establishment

Ridges were levelled in spring and fodder beets were sown in all plots. Even though the seedbed looked a little rougher in the ridged plots, no difference in crop establishment or weed pressure was observed

Maize establishment

Maize establishment was not optimal in the ridged plots. Seedbed preparation in the ridge system needs to be improved.

Catch crop establishment

Establishment of catch crops on ridges has been (and still is) a challenge. In year 2000 catch crop was sown with an ordinary sowing machine by simply dropping the seeds to the ground. This procedure resulted in well-established catch crops in ridge furrows but hardly any crop plants on top of ridges. In 2001 seeds of catch crops has been sown into the ridges by using a modified sowing machine with mounted tubes. This procedure, however, did not improve crop establishment significant. In order to improve germination and crop plant establishment on top of ridges a new project has been initiated in co-operation with DJF-Bygholm.

Weed pressure

There was no significant difference in weed infestation between soil tillage systems.

Placement of farmyard manure

In the ridge tillage system it has been difficult to create adequately deep furrows for in-row placement

of manure at Højbakkegård. Therefore, some of the manure was harrowed up in spring. More powerful tools are required to incorporate the farmyard manure in the ridges.

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

WP1

Task 1. The experiments with tillage, catch crop and manure will be repeated at Højbakkegård and St. Jyndevad. Pilot studies on the effects of ridge orientation on soil temperature will be conducted in spring 2002.

Task 2. A lysimeter experiment with ploughing and ridge tillage will begin in October/November 2001.

WP2

Task 1+2 (merged): The experiments with tillage, catch crop and manure will be repeated at Højbakkegård and St. Jyndevad. The fodder beet experiment at Højbakkegård will also be repeated. The experiment with maize will be changed. Instead of manure placement orientation of rows will be integrated in the experiment. Detailed studies on soil temperature and crop establishment will be carried out.

WP3: In 2002, assessment of stem canker and quantitative and qualitative tuber yield will be performed in the ridge tillage system in WP2 at St. Jyndevad.

WP4

The field experiment will be repeated .

WP5: Field trials with potato mixtures will be conducted in growth season 2002. Except for minor adjustments the design used in 2001 will be repeated, but less detailed assessments will be carried out.

WP6

The field experiments will be repeated.

E. Project publications

1. Articles in international, scientific journals with review procedures

2. Presentations at congresses, symposiums etc.

Rasmussen, J. (2000): Alternative jordbearbejdningsmetoder. LØJ-seminar om jordbearbejdning og jordfrugtbarhed. Byholm Landbrugsskole, 19/9 2000
(www.agsci.kvl.dk/~jeraj5/jordbearb_pr.PDF)

Rasmussen, J. & C.B. Henriksen (2000): Jordløsninger - er det svaret? Økologi Kongres 2000. Kongresbilag: 26-27

Henriksen, C. B. (2000): "Er kamme et alternativ til pløjning". Presentation ved Det Kgl. Danske Landhusholdningsselskabs Akadimiråds efterårsseminar. 8/11 2000.

3. Articles in agricultural journals etc.

Henriksen, C. B. (2000): Kamme som alternativ til pløjning. Tidsskrift for Landøkonomi Nr. : 311-314

Thomsen, H.C. (2001) Kan hestebønner forsinke skimmelangreb. Kartoffelproduktion 29 (4): 6-7

4. Other presentations at meetings, field days etc.

Henriksen, C.B. FØJO Field day at Jyndevad with presentation of Carmina experiments at Jyndevad. 20/6 2001

Henriksen, C.B. Field day at KVL with presentation of experiment with ridge cultivation of maize for visitors from Asia. 22/6 2001

Henriksen, C.B. Field days at KVL with presentation of experiment with ridge cultivation of maize for visitors from Africa, 29/6 2001

Henriksen, C.B. Field day at KVL with presentation of experiment with deep litter and fodder beet for the Technical School of Slagelse. 29/8 2001

Mølgaard, J.P. FØJO Field day at Jyndevad with presentation of Carmina experiments at Jyndevad. 20/6 2001

Rasmussen, J. (2001): Alternativer til pløjning. Kursus arrangeret af Sjællandske Familiebrug, Roskilde 10/10 2001 (www.agsci.kvl.dk/~jeraj5/jordbearb_ros01.pdf)

Thomsen, H.C.:

Date (Year 2001)	Name of visitors	Number of visitors
22-maj	Landskont./DJF	22
23-maj	DJF Økologisk sædskifte projekt	11
31-maj	Vejlby Landbrugsskole	17
06-jun	Gråsten Landbrugsskole	27
11-jun	Økologi kontakt udvalg	10
14-jun	Økologiske landmænd	4
20-jun	<i>Markvandring 10:00 /13:00</i>	75
21-jun	<i>Bredstätt Forsøgsstation</i>	15
26-jun	KVL studerende	15
26-jun	Kursus/rundvisning 2 timer i marken + kaffe som Kjeld medbringer	15
04-jul	Erfarings-gruppe	12
18-jul	Kartoffel landmænd	11
25-jul	Tyske Øko. Konsulenter	15
Sum		199

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

G. National and international co-operation

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 Lars Bødker 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. Lisa Munk has collaboration with other researchers working with mixtures of cereals.

H. Possible elaboration of project and achieved results

Nothing