



## 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

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### 1. Research program

Research in organic farming 2000-2005 (DARCOF II)

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### 2. Project title and number

Band heating for intra-row weed control

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### 3. Head of project

Martin Heide Jørgensen  
Head of research unit  
Danish Institute of Agricultural Sciences  
Dept. of Agricultural Engineering

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### 4. Participating institutes

Danish Institute of Agricultural Sciences (DIAS)  
The Royal Veterinary and Agricultural University (RVAU)

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### 5. Contact persons

DIAS: See 3: Head of project  
RVAU: Hans-Werner Griepentrog

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### 6. Other project staff

Erik Fløjgaard Kristensen, DIAS, Dept. of Agricultural Engineering.  
Bo Melander, DIAS, Dept. of Crop Protection  
Torben Heisel, DIAS, Dept. of Crop Protection

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

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## 8. Annual report/Application for continuation in 2002

### A. Objectives and expected achievements (from application)

The aim is to develop a system for thermal soil treatment in close bands covering the crop rows. The system has to be optimised for minimum energy consumption and effective weed control in the intra-row area. In relation to the development of the system it is highly demanded to respect the structure of the soil and its positive biological activity.

The objective will be achieved through the following activities:

- Establishment of a prototype of an implement that will permit the performance of thermal soil treatment in narrow bands covering the crop rows. The prototype will be a result of a detailed analysis of the thermal processes involved
- Establishment of basic biological knowledge for erasing the germination capacity of weed seeds in soil
- Realisation of the adaptation of precision sowing equipment to special demands involved with band treatment. Modification and investigation of particular tools to achieve good seed placements and covering in treated bands. Determination of the position of each placed seed by means of high precision GPS. Utilisation of the position data to optimise the energy input on thermal soil treatment (spot treatment) and to allow a guidance of weeding tools between crop rows and plants in order to remove unwanted plants (inter and intra-row weeding).

### A. Project summary (from application)

The project aims at the development of a new integrated machinery system, where the soil in a narrow band around the crop rows is being thermally treated, with which the germination of weeds in between the crops can be effectively limited. Weed control of inter-row weeds is achieved by means of precision hoeing, where the implement is automatically guided by a vision sensor based control system, which is basically developed by the applicant and commercialised by ECO-DAN. The possibility of combining the implement for thermal treatment with a system for precision sowing will be analysed.

In combination with the automatic hoeing system the proposed system for thermal row treatment will provide effective elimination of the need for manual weeding in row cultivated crops, such as beets and vegetables. The recommended system will enable the farmers and the agricultural industry to meet the customers' demand for growing organic products.

The research is carried out in close collaboration with the firm ECO-DAN that supports the prototype development and establishment.

**Table 1: Work package list (from application)**

Work package No.	Work package title	Responsible participant	Budget DKK	Starting date	Closing date	Deliverable No.
1	Technical process analysis	MHJ	978	4/00	12/02	1a,1b,,,
2	Basic biological analysis ( <i>lab. test</i> )	BM	990	4/00	12/04	2a,2b,,,
3	Establishment of prototype and technical field validation	MHJ	1.246	1/01	12/04	3a,3b,,,
4	Biological field validation	BM	810	4/02	12/04	4a,4b,,,
5	Precision sowing in treated bands and determination of seed positions	HWG	976	4/00	3/02	5a,5b,,,

## Progress

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

The analysis has confirmed that steam is an effective medium for heating of soil, especially because it penetrates effectively in the soil and it is easy to control the distribution in the soil band. Based on this recognition, a laboratory process rig is established, calibrated and documented. Soil batches are treated for 2 biological lab experiments to test the germinating capacity of weed seeds in thermally treated soil with different process history. The results shows that it is possible to perform a effective weed control at temperatures about 70 to 90°C. The documentation of the lab rig and the biological data will be prepared for publication in international articles within the next year.

The first prototype is developed for 1 row-field trials and initial trials have been carried out. In the field there are still problems on order to obtain an effective heating of the soil in the surface layer without too much energy loss. Solving this problem is one of the main challenges for the next project period.

Concerning precision sowing, commercial mechanical precision drill is equipped with optical sensors and RTK navigation equipment to log the precise position of every single seed. The system is operative and has been tested in initial trials. For the next growing season it will be equipped with additional tillth sensors to be able to compensate for the projection of the position from the antenna to the drill units on undulating fields.

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

<b>WP1 Technical Process Analysis</b>	Time schedule according to application	Deviations, if any*
Tasks		
1. Basic process analysis	– 06 2002	
2. Investigation of possible process methodology	– 06 2002	
3. Publication	– End 2002	
4. Supplementary studied	– 06 2002	
Deliverables		
1a. A setup for producing batches of thermally treated soil with a well-defined and documented treatment history.	08 2000	OK
1b. Documentation of the possibility of designing thermal soil treatment systems to give the soil a treatment with a given temperature history. The technical documentation includes heating source and temperature of transfer medium (heated air). The tillage/handling system is interacting with the soil	06 2001	OK
1c. The theoretical energy consumption for different technical systems analysed under laboratory conditions	12 2001	OK
Milestones		
1. Establishment of laboratory processing rig, capable of producing batches of heat-treated soil.	Mid-2000	OK
2. Ready-to-carry-out methodology test	Autumn 2000	OK
3. 1 <sup>st</sup> phase of methodology investigations to be completed	Mid-2001	OK
4. Supplementary investigations and publication to be finished	Mid-2002	

- *Deviations are to be further discussed at C3.*

<b>WP2 Basic Biological analysis</b>	Time schedule according to application	Deviations, if any*

<b>WP2 Basic Biological analysis</b>	Time schedule according to application	Deviations, if any*
<b>Tasks</b>		
1. Theoretical considerations and data capture for building the basic biological model (Objective 1):	04 2000-12 2000 02-2001-10 2001	
2. Model extension to include the effects of major key factors (Objective 2)	03 2001-12 2001 02 2002-10 2002	
3. Publication of the results achieved in Task 1)	2002	
4. Crop establishment in heated soil (Objective 3)	04 2002-12 2002	
5. Publication of results from Tasks 2) and 4)	2003 + 2004	
<b>Deliverables</b>		
Man. annual progress reports completed by a final report	2000-2004	
2a. Draft paper for international publication of the basic model	2002	
2b. Draft papers on 1) model extension and 2) crop establishment in pre-heated soil for international publication	2004	
2c. National publication, as required	2002-2004	
<b>Milestones</b>		
M1. Preliminary structure of the basic biological model including preliminary definitions of technical requirements for band-heating	Autumn 2001	OK
M2. Completion of model extension to explain the impact of major factors affecting the biological effect of band-heating on weed seed germination	Autumn 2002	
M3. Final results on crop establishment in pre-heated soil and statements on the agronomic consequences	Spring 2003	

- *Deviations are to be further discussed at C3.*

<b>WP3 Establishment of prototype and technical field validation</b>	Time schedule according to application	Deviations, if any*
<b>Tasks</b>		
1. The system approach	– 12 2000	
2. Establishment of prototype 1	– 02 2001	
3. Field test and evaluation	– 06 2004	
4. Publication	–12 2004	
<b>Deliverables</b>		
3a. Establishment of an operative prototype for field test	02 2001	OK
3b. Establishment of an optimised prototype for technical field validation and validation of the basic biological knowledge	02 2002	
3c. Documentation of the technical system	11 2004	
<b>Milestones</b>		
1. Prototype 1 ready for field test.	Spring 2001	OK

- *Deviations are to be further discussed at C3.*

<b>WP4 Biological field validation</b>	Time schedule according to application	Deviations, if any*
Tasks		
1. Planning of the biological and agronomic validation of the prototype	2002 + 2003	
2. Conduction of biological field assessment	2002 + 2003	
Deliverables		
Man. annual progress reports	2002-2004	
4a. Draft papers on the perspectives of a weed control system for row crops based on band-heating for intra-row weeding and automatically row-guided hoeing for inter-row weeding	2003-2004	
4b. Arrangement of demonstrations and seminars	2003-2004	
Milestones		
M1. Final plans for field experimentation with band-heating including validation of the performance of the band-heater prototype	Spring 2002	
M2. Finalising field experimentation with band-heating including validation of the performance of the band-heater prototype	Autumn 2002	
M3. A final description of the potential and practical implementation of band-heating techniques in organic as well as in conventional row-cropping systems for herbicide saving purposes.	2004	

- *Deviations are to be further discussed at C3.*

<b>WP 5 Precision sowing in treated bands and determination of seed position.</b>	Time schedule according to application	Deviations, if any*
Tasks		
1. Establishment of the seeder	– 06 2001	
2. Optimisation of the seeding tools	– 04 2002	
3. Field trials	–06 2002	
4. Documentation	– 12 2002	
Deliverables		
Man. annual progress reports		
5a. Conference paper about RTK GPS and precision sowing	10 2001	OK
5b. Good adaptation of precision seeder to band treatment equipment	12 2001	OK
5c. Optimised seed placement tools of precision seeder with regard to special soil properties of treated bands	06 2002	
5d. Draft paper about determination accuracy of row and seed positions for international publishing	4 2002	
5e. Information of placed seed positions for inter-row hoeing and intra-row weeding		
5f. Final report	4 2002	
Milestones		
1. Seeder ready for first field trials		
2. First field trials finished	11 2000	Delayed – OK
3. Results from first field trials available (accuracy of crop row and seed/plant position determination)	3 2001	OK
4. Seeder ready for second field trials	8 2001	OK
5. Second field trials finished	11 2001	
6. Results from second field trials available (accuracy of crop row and seed/plant position determination in treated soil bands)	3 2002	

\* *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 and according to the plans the activities in WP1, WP2 and WP5 are started**

Due to the delayed project start the first field trials were carried out in spring 2001. These trials gave results to evaluate the performance of the seeder under field conditions. First field data were logged and analysed. The objective were i) to determine the absolute deviations between seed position and plant position and ii) to get data about the deviations between estimated seed position and plant position by using GPS. The first was done to investigate the influence of different soil types and seedbed qualities on the plant deviations. The later was carried out to assess the overall accuracy of the determination process.

More field trials are planned for spring 2002 because additional sensors - e.g. to measure the slope of a field - have to be added to the data logging system in order to make the system suitable for operating on slightly or strongly sloped fields. For example most sugar beet fields have a sloped surface.

Input is needed to modify and adapt the machine to the special requirements for seeding into thermally treated soil strips.

Due to the delayed start of the WP5 - salary money was not spent - and the need for more field trials the end of the WP5 should be moved to 8/2002. Therefore, the budget has been changed.

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

Until now the activities have in principal followed the plans described in C2. . In some areas the activities has been modified due to experiences from the performed activities. In general the activities follows the plans described in C2.

In 2002 the priority for publication is the International publications described in WP 1, WP 2 and WP 5.

### **E. Project publications**

#### **1. Articles planned for international, scientific journals with review procedures**

WP2 working titles:

- a. Weed seedling emergence following soil heating by steaming at increasing intensities (submission 2002).
- b. Cultural and biological factors influencing the effect of steaming on weed seedling emergence (submission 2003).

#### **2. Presentations at congresses, symposiums etc.**

WP2:

- a. Band-steaming for intra-row weed control. Bo Melander, Torben Heisel & Martin Heide Jørgensen. 5<sup>th</sup> Workshop of the EWRS working group: Physical and cultural weed control, Pisa, Italy, 11-13 March 2002.
- b. Aspects of steaming the soil to reduce weed seedling emergence. Bo Melander, Torben Heisel, & Martin Heide Jørgensen. 12<sup>TH</sup> EWRS SYMPOSIUM, Arnhem, The Netherlands, 24-27 June 2002.

#### **3. Articles in agricultural journals etc.**

Stribedampning mod ukrudt i højeværdiafgrøder. Bo Melander, Torben Heisel, & Martin Heide Jørgensen. Forskningsnytt om Økologisk Landbrug i Norden. (To be published in October 2001).

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

No scientific education is planned in the project.

**G. National and international co-operation**

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