

Final Report

For DARCOF II 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

Development of sustainable production systems of apples. (ORGAPP) No. I.2.

3. Head of project

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6. Project period (month, year)

Start of project: 01.09.00
 End of project: 31.12.04

7. Final report

A. Project summary

The project aimed to try to reduce the infection risk of apple scab in organic apple orchards using culture techniques to increase the Danish production of high quality organic apples. The partial objective was to find the best combination of nitrogen supply, use of rootstocks and planting distance to prevent apple scab infections and improved productivity.

Tree trials were carried out in the project.

Trial 1:

A cover crop trial, where the following cover crops were established in alleyways in 1994:

- a. A permanent grass mixture of *Festuca rubra* and *Poa pratensis*.
- b. Clover grass mixture of *Trifolium repens* and *Lolium perenne*.
- c. Annual cover crop of *Lolium multiflorum* and *Trifolium resupinatum*, sown every year in July.
 The soil has been kept black from April to July.

The conclusion of the trials was that in an unsprayed organic apple orchard the best fruit quality based on fruit colour and the lack of pest and disease damage was obtained in trees grown in an alleyway system which gave a nitrogen supply in the lower end of the optimum range.

As the cover crop trial showed an increasing infection of diseases with an increasing nitrogen level and a tendency towards a lower yield with lower nitrogen the trial was basis for the following trials where the goal was to find the optimum level of nitrogen in the soil and plants in relation to the disease infection, fruit quality and yield.

Trial 2:

In the variety 'Discovery' 6 soil treatments in the tree row were combined with 4 rootstocks and three planting densities.

Soil treatments in the rows:

1. Mechanical cleaning, no fertiliser

2. Mechanical cleaning, fertigation with water and biovinasse, product from beer industry.
3. Mechanical cleaning, poultry fertiliser.
4. Mechanical cleaning, poultry fertiliser and drip watering.
5. Mechanical cleaning, fertigation with water and liquid manure.
6. 20 cm straw mulch, wheat.

For Discovery the yield in 2002-2004 was generally strongly influenced and reduced by infestation of apple sawflies. Mulching with straw increased the level of potassium and reduced the nitrogen in the leaf dry matter and available nitrogen in the soil. In 2004 the straw also reduced the level of soil water and tree growth, whereas the red skin colour increased. The rootstock M9 had the weakest growth and was most productive. Planting Discovery trees on 0,6 m distance in the tree row on rootstock M9 reduced the tree growth and increases the yield per tree in the first and second cropping year, which again increased the cross yield per ha compared to other combinations of rootstocks and planting densities.

Trial 3.

In the variety 'Ingrid Marie' 6 soil treatments were combined with 4 rootstocks and three planting densities.

Soil treatments in the rows:

1. Weed in the tree row, no fertiliser.
2. Mechanical cleaning, no fertiliser
3. Mechanical cleaning, poultry fertiliser.
4. Mechanical cleaning, poultry fertiliser and watering.
5. Mechanical cleaning, dairy manure compost, 25 kg Ha.
6. Mechanical cleaning, dairy manure compost, 50 kg Ha.

The yield in Ingrid Marie was generally reduced by infestation of apple sawflies. Weed in the tree row reduced the level of nitrogen in leaves and soil, reduced available water in the soil and growth and yield of the trees. Fruits grown in weed were ripest at harvest and had the lowest skin damage caused by apple scab. The rootstocks M9 and B9 had a weaker growth than M26 and MM106 and in 2004 there was a tendency towards a higher yield for M9. Planting Ingrid Marie on 0,6 m between the trees in the tree row on rootstock M9 reduced the growth and increases the yield per tree in the first cropping year but not in the second year.

Results about effect of cultural techniques on yield and fruit quality with focus on rootstocks during establishment will be concluded in a scientific article very soon.

The two trials include many of the very actual questions in organic apple research in Europe. Therefore we in 2004 became a part of the big EU-project Qlif: Qualitylowinputfood", which runs for 2004 and 2005. Therefore we have the opportunity to work another year especially on inner fruit quality in relation to fertility and planting distance effects.

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

No.	Work package title	Participants*	Budget (1.000 DKK)	Start	End	Deliverable no(s):
1	Reducing apple scab infection risk using cultural methods.	<u>Hanne Lindhard</u> Wiedersheim Bertelsen	1.350	2000	2004	D1, D2, D3, D4, D5, D6, D7, D8, D9.

Responsible participants are underlined

B. Objectives and expected achievements

The overall objective is to reduce the infection risk of apple scab in organic apple orchards using culture techniques.

The expected achievement is to increase the Danish production of high quality organic apples.

The partial objective is the following:

1. To find the best combination of nitrogen supply, use of rootstocks and planting distance to prevent apple scab infections and improved productivity.

C. Progress and results

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

WP1. Reducing apple scab infection risk using cultural methods.

Cover crop trial.

Results are published or submitted.

Main results:

The following cover crops were established in alleyways in 1994:

1. A permanent grass mixture of *Festuca rubra* and *Poa pratensis*.
2. Clover grass mixture of *Trifolium repens* and *Lolium perenne*.
3. Annual cover crop of *Lolium multiflorum* and *Trifolium resupinatum*, sown every year in July. The soil has been kept black from April to July.

Fruits produced on trees managed with a grass alleyway had a lower nitrogen supply to the trees and obtained the best skin coloration. A lower nitrogen supply, especially during fruit development resulted in more red fruits. 15 tons fruits from the grass cover crop had more than 75 percent red surface as average for 1999 - 2001; whereas only 8-9 tons fruits grown in the clover grass or the annual cover crop had more than 75 percent red surface.

The apple scab infections were less numerous on apples grown with an alleyway of a permanent grass mixture of *Festuca rubra* and *Poa pratensis*. The level of total nitrogen in the leaves was in the lower range of the optimum level for apple production.

The fruits were graded into marketable and discarded fruits on the basis of the severity of the disease and pest damages. Overall the fruits from the permanent cover crops had the highest percentage of marketable fruits. Even though the gross yield was bigger from trees grown in the annual cover crop, the crop of marketable fruits was at the same level for the three alleyway management systems due to different levels of pest attack. In 2001 the amount of marketable fruits was 30 percent higher for apples grown with grass alleyways compared to the annual cover crop. The varieties Otava, Prima and Florina produced the biggest yields. Vanda had the biggest fruits. The resistance to apple scab was broken down in most varieties. The varieties: 'Florina', 'Vanda', 'Retina' and 'Redfree' was less infected by apple scab. Only Florina was still fully resistant.

The most common pest damaging the fruits was different species of tortrix and sawflies. Codling Moth was no problem. Apple scab, fly Speck and Sooty blotch were the most serious diseases. Flyspeck and sooty blotch especially developed the last two years.

Conclusion.

In an unsprayed organic apple orchard the best fruit quality based on fruit colour and the lack of pest and disease damage was obtained in trees grown in an alleyway system which gave a nitrogen supply in the lower end of the optimum range.

The varieties: 'Florina', 'Vanda', 'Retina' and 'Redfree' was less infected by apple scab. The resistance to apple scab was broken down in most varieties

The results from the cover crop trial have been of great interest for growers as the general trend is to supply more fertiliser to the trees. This trial shows that the level of nitrogen in an organic system should be kept rather low to increase the quality of the fruits.

After the end of the cover crop trials the trees were used for Darcof project no. III.4, Organic food and health – a multigeneration animal experiment and Darcof project no. VII.5 Control of scab in organic apple growing (Stop Scab).

Lately the trees are basis for collaboration with **Dr. Bruno Le Cam**, UMR Pathologie Végétale (PaVé), Centre INRA Angers, France; who looks at the genetic diversity of populations of *Venturia inaequalis* in relation with behavior of Apple cultivars in the field. A scientific publication with basis in 3 years study is planned for late summer 2005. Trees will be removed in autumn 2005. This work is a new field of competence of the projects staff, maybe it can lead to basis for new projects.

As the cover crop trial showed an increasing infection of diseases with an increasing nitrogen level and a tendency towards a lower yield with lower nitrogen the trial was basis for the following trials where the goal was to find the optimum level of nitrogen in the soil and plants in relation to the disease infection, fruit quality and yield.

Cultural techniques 1 and 2.

To investigate the optimum level of nitrogen in the soil and plants in relation to the disease infection, fruit quality and yield, two new trials were planted in April 2001. Since the aim was to investigate the apple scab infection in relation to soil treatment the non-resistant varieties 'Discovery' and 'Ingrid Marie' were chosen. They can be infected by apple scab, but are recommended for organic production because they are less susceptible. In spring 2002, the fertiliser treatments were established.

Methods.

In the variety 'Discovery' all soil treatments are replicated 3 times and combined with 4 rootstocks and three planting densities. Each plot comprises 4 trees. Rootstocks: M9, B9, M26 and MM106. Planting distances: 0.6m, 0.9 m and 1.2 meter.

In the variety 'Ingrid Marie' all soil treatments are replicated 4 times and combined with 4 rootstocks and three planting densities. Four trees constitute a plot. Rootstocks: M9, B9, M26 and MM106. Planting distances: 0.6m, 0.9 m and 1.2 meter.

Variety: Discovery.

Soil treatments in the rows:

1. Mechanical cleaning, no fertiliser
2. Mechanical cleaning, fertigation with water and biovinasse, product from beer industry.
3. Mechanical cleaning, poultry fertiliser.
4. Mechanical cleaning, poultry fertiliser and drip watering.
5. Mechanical cleaning, fertigation with water and liquid manure.
6. 20 cm straw mulch from wheat.

Variety: Ingrid Marie.

Soil treatments in the rows:

1. Weed in the tree row, no fertiliser.
2. Mechanical cleaning, no fertiliser
3. Mechanical cleaning, poultry fertiliser.
4. Mechanical cleaning, poultry fertiliser and watering.

5. Mechanical cleaning, dairy compost, 25 kg N.
6. Mechanical cleaning, dairy compost, 50 kg N.

Results.

Discovery 2003

Table 1: Potassium and nitrogen in leaves, nitrogen in soil, soil water, trunk diameter, yield, fruit colour and apple scab infection on Discovery in 6 soil treatments in the tree row 2003.

	Potassium	Nitrogen	Nitrogen	Soil water	Trunk diameter	Yield	Fruit colour	Apple scab
Treatment	Leaf samples % of dry mat.	Leaf samples % of dry mat.	Nmin Kg/ha	% in upper 50	Mm/tree	Kg/tree	% surface colour	% Fruit without apple scab
1.	1,37 c	2,24 a	29,6 a	24,9 b	33,1 a	0,7 c	69,8 a	93,1 a
2.	1,63 ab	2,33 a	29,0 a	24,9 a	29,0 a	1,5 a	72,3 a	87,4 a
3.	1,34 c	2,27 a	27,8 a	20,2 b	28,6 a	0,8 bc	68,9 ab	89,2 a
4.	1,44 bc	2,29 a	31,6 a	.	29,1 a	1,4 ab	69,2 ab	86,6 a
5.	1,37 c	2,27 a	22,0 a	.	30,1 a	1,0 abc	65,4 b	86,5 a
6.	1,79 a	1,99 b	14,4 a	16,3 c	28,0 a	1,4 ab	69,1 ab	91,1 a

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

Table 2. Trunk diameter, yield and fruit colour for Discovery on 4 rootstocks at planting distance 1,2 m in 2003.

	Trunk diameter	Yield	Fruit colour
Rootstock	Mm/trunk	Kg/tree	% surface colour
M9	26,5 c	1,2 a	68,9 bc
B9	29,9 bc	1,0 ab	74,7 a
M26	31,8 b	0,7 bc	64,8 c
MM106	36,6 a	0,3 c	72,5 ab

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

Table 3. Trunk diameter, yield per tree and ha, and fruit colour for Discovery on M9 at 3 planting distances in 2003.

M9	Trunk diameter	Yield	Yield	Fruit colour
Planting distance	Trunk diameter	Kg/tree	Ton/ha	% surface colour
0,6	24,8 b	1,9 a	10,5	66,3 a
0,9	26,9 a	1,7 ab	6,3	66,1 a
1,2	27,8 a	1,2 b	3,3	68,9 a

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

The yield in 2003 was strongly influenced and reduced by infestation of apple sawflies. The soil treatments affected the level of leaf nutrients and available nitrogen in the soil. Mulching with straw increased the level of potassium and reduced the nitrogen in the leaf dry matter (Table 1). The rootstock M9 had the weakest growth and was most productive (Table 2). Planting Discovery very dense on rootstock M9 reduced the growth and increases the yield in the first cropping year, which again increased the cross yield per ha (Table 3).

Discovery 2004.

Table 4: Potassium and nitrogen in leaves, nitrogen in soil, soil water, growth, yield, fruit colour, fruit firmness, fruit content of starch and sugar and apple scab infection on fruits for Discovery in 6 soil treatments in the tree row 2004.

	Potassium	Nitrogen	Nitrogen	Soil water	Growth 2004	Yield	Fruit colour	Firmness	Starch	Sugar	Apple scab
Treatment	Leaf samples % of dry mat.	Leaf samples % of dry mat.	Nmin Kg/ha	% in upper 50	Mm/tree	Kg/tree	% surface colour	Red side		Red side	% Fruit without apple
1.	1,48 b	2,34 ab	23,2 a	27,1 b	5,4 a	0,60 a	63,0 b	87,0 a	8,8 b	129 a	96,8 a
2.	1,53 b	2,44 a	25,9 a	27,9 a	4,8 ab	0,78 a	64,9 b	83,2 bc	9,0 ab	130 a	85,6 a
3.	1,37 b	2,44 a	25,8 a	27,1 ab	5,0 ab	1,28 a	63,0 b	80,9 c	9,2 a	130 a	90,7 a
4.	1,48 b	2,32 ab	13,3 a	.	4,9 ab	0,38 a	64,6 b	85,8 ab	9,0 ab	130 a	92,6 a
5.	1,49 b	2,47 a	32,5 a	.	5,2 ab	0,83 a	55,7 c	86,8 a	8,7 b	131 a	94,4 a
6.	1,81 a	2,14 b	16,2 a	24,0 c	4,5 b	0,82 a	70,9 a	85,1 ab	8,0 c	124 b	95,8 a

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

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Table 5. Growth and yield for Discovery on 4 rootstocks at planting distance 1,2 m in 2004.

	Growth 2004	Yield
Rootstock	Mm/trunk	Kg/tree
M9	3,98 d	1,28 a
B9	4,89 c	1,00 ab
M26	6,06 b	0,53 c
MM106	7,24 a	0,78 bc

Values followed by the same letter in columns

Table 6. Growth, yield per tree and ha for Discovery on M9 at 3 planting distances in 2004.

M9	Growth 2004	Yield	Yield
Planting distance	Mm/tree	Kg/tree	Ton/ha
0,6	3,24 b	1,75 a	9,71
0,9	4,40 a	1,59 a	5,88
1,2	4,33 a	1,28 a	3,55

Values followed by the same letter in columns do not

differ significantly at $p < 0,05$.

The yield was also in 2004 strongly influenced and reduced by infestation of apple sawflies. The soil treatments affected the level of leaf nutrients and nitrogen in soil water. Mulching with straw increased the level of potassium and reduced the nitrogen in the leaf dry matter and in the soil (Table 4). The straw also reduced the level of soil water and tree growth, whereas the red skin colour increased. The fruits from trees grown in straw were also riper at harvest as the starch content was lowest (Table 4). The rootstock M9 had the weakest growth and was most productive like in 2003 (Table 5). Planting Discovery very dense on rootstock M9 reduced the growth and increased the yield in the second cropping year, which again increased the cross yield per ha like in 2003 (Table 6).

Ingrid Marie 2003

Table 7. Potassium and nitrogen in leaves, nitrogen in soil, soil water, trunk diameter, yield and apple scab infection for Ingrid Marie in 6 soil treatments in the tree row 2003.

	Potassium	Nitrogen	Nitrogen	Soil water	Trunk diameter	Yield	Apple scab
Treat ment	Leaf samples % of dry mat.	Leaf samples % of dry mat.	Nmin Kg/ha	% in upper 50	Mm/tree	Kg/tree	% Fruit without apple scab
1.	1,33 a	1,60 b	24,7 a	5,2 c	28,1 d	1,96 bc	2,2 ab
2.	1,34 a	1,96 ab	29,2 a	17,9 b	31,6 c	1,98 bc	28,7 abc
3.	1,34 a	2,09 a	30,4 a	16,7 b	35,9 a	2,25 ab	33,5 a
4.	1,34 a	2,13 a	32,2 a	21,7 a	36,5 a	1,81 c	26,8 abc
5.	1,24 a	1,77 ab	.	.	37,2 a	2,51 a	24,6 bc
6.	1,34 a	2,09 a	.	.	33,8 b	2,42 a	23,0 c

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

Table 8. Trunk diameter and yield for Ingrid Marie on 4 rootstocks at planting distance 1,2 m in 2003.

	Trunk diameter	Yield
Rootstock	Mm/tree	Kg/tree
M9	32,1 b	2,14 a
B9	33,3 b	2,21 a
M26	36,8 a	2,03 a
MM106	37,9 a	2,18 a

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

Table 9. Trunk diameter, yield per tree and ha for Ingrid Marie on M9 at 3 planting distances in 2003.

	Trunk diameter	Yield	Yield
Planting distance	Mm/tree	Kg/tree	Tons /ha
0,6	28,9 b	2,39 a	13,3
0,9	33,5 a	1,98 a	7,3
1,2	33,8 a	2,14 a	5,9

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

The yield in 2003 was influenced and reduced by infestation of apple sawflies. Weed in the tree row reduced the level of nitrogen in leaves and soil, reduced available water in the soil and the growth of the trees (Table 7). The rootstocks M9 and B9 had a weaker growth than M26 and MM106 and no differences were observed in the yield per tree (Table 8). Planting Ingrid Marie very dense on rootstock M9 reduced the growth and increases the yield in the first cropping year, which again increased the cross yield per ha (Table 9).

Ingrid Marie 2004

Table 10: Potassium and nitrogen in leaves, nitrogen in soil, soil water, growth, yield, fruit firmness, fruit content of starch and sugar and apple scab infection on fruits of Ingrid Marie in 6 soil treatments in the tree row in 2004.

	Potassium	Nitrogen	Nitrogen	Soil water	Growth	Yield	Firmness	Starch	Sugar	Apple scab
Treat ment	Leaf samples % of dry mat.	Leaf samples % of dry mat.	Nmin Kg/ha	% In the upper 50 cm	Mm/Tree.	Kg/Tree	Red side		Red side	% Fruit without apple
1.	.	.	21,2 a	24,4 a	3,43 c	0,27 c	68,6 c	4,8 c	138,6 ab	8,4 a
2.	.	.	24,4 a	24,0 ab	6,13 b	2,50 b	66,4 c	6,0 a	138,6 ab	8,3 b
3.	.	.	21,4 a	23,2 bc	6,05 b	3,13 a	80,4 a	5,6 b	137,8 b	6,2 b
4.	.	.	26,9 a	22,3 c	6,84 a	2,69 ab	71,2 b	5,9 a	139,1 ab	7,8 b
5.	.	.	24,6 a	.	7,18 a	2,48 b	72,4 b	5,6 b	141,5 a	4,8 b
6.	.	.	18,7 a	.	7,23 a	2,74 ab	72,7 b	5,7 ab	137,9 b	5,8 b

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

Table 11. Growth and yield for Ingrid Marie on 4 rootstocks at planting distance 1,2 m in 2004.

Rootstock	Growth	Yield
	Mm/trunk	Kg/tree
M9	5,37 b	2,89 a
B9	5,94 b	2,51 a
M26	7,42 a	2,47 a
MM106	7,83 a	2,57 a

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

Table 12. Growth, yield per tree and ha for Ingrid Marie on M9 at 3 planting distances in 2003.

Planting distance	Growth	Yield	Yield
	Mm/tree	Kg/tree	Tons/ha
0,6	5,52 b	1,63 b	9,1
0,9	5,65 b	2,73 a	10,1
1,2	6,71 a	2,89 a	8,0

Values followed by the same letter in columns do not differ significantly at $p < 0,05$.

The yield in 2004 was influenced and reduced by infestation of apple sawflies. The leaf samples are not processed yet, but will be finished by the subcontractor very soon. Weed in the tree row reduced the level of available nitrogen in the soil and reduced the growth and yield of the tress (Table 10). Fruits grown in weed were ripest at harvest, which can be seen of the low firmness and starch contents. The fruits also had the lowest skin damage caused by apple scab (Table 10). The rootstocks M9 and B9 had a weaker growth than M26 and MM106 and there was a tendency towards a higher yield for the rootstock M9 (Table 11). Planting Ingrid Marie dense on rootstock M9 reduced the growth and also the yield per tree in the second cropping year (Table 12).

Conclusions.

Results about effect of cultural techniques on yield and fruit quality with focus on rootstocks during establishment will be concluded in a scientific article very soon.

The two trials include many of the very actual questions in organic apple research in Europe. Therefore we in 2004 became a part of the big EU-project Qlif: Qualitylowinputfood”, which runs for 2004 and 2005. Therefore we have the opportunity to work another year especially on inner fruit quality in relation to fertility and planting distance effects.

C.2 Fulfilment of deliverables and milestones

WP1 Reducing apple scab infection risk using cultural methods.	Time schedule according to application	Deviations, if any*
Deliverables		
D1. Report about rootstock effect on shoot termination	Apr. 2001	Achieved
D2, D5, D6, D7. Annual reports	Sep. 2001, 2002, 2003.	Achieved
D3. National article cover crop	Mar. 2002	Achieved
D4. International article cover crop	April 2002	Achieved
D8. National publication cultural techniques and fruit quality	Dec. 2004	Achieved with at delay of 6 month*
D9. International publications cultural techniques, effects on yield, external and internal fruit quality	Dec. 2004	Achieved with a delay of 6 month*
Milestones		
M 1. Planing of new trail	Winter 2000/2001	Achieved
M 2. Report on terminal bud development	Spring 2001	Achieved
M 3. Data analysing	Winter every year	Achieved
M 4. Growers and consultants are informed yearly about the results in annual reports and field days.	Every year in February and	Achieved
M 5. National article about cover crop effects	Spring 2002	Achieved
M 6. International article about cover crop effects	Spring 2002	Achieved
M 7. Visiting scientist at FiBL and study tour through Europe.	Summer 2003	Achieved

M 8. Planning and execution of fruit quality analyses	Autumn 2003	Achieved
M 9. Execution of fruit quality analyses	Autumn 2003	Achieved*
M 10. National article about cultural practises and fruit quality.	Winter 2004/2005	Achieved with at delay of 6 month*
M 11. International article about cultural practises, effects on yield, external and internal fruit quality	Winter 2004/2005	Achieved with a delay of 6 month*

* Deviations are to be further discussed in D

C. Description of deviations and subsequent adjustments of plans

Deliverable D8 and D9 are delayed 6 month but are achieved before 1st of July 2005. My contribution to the congress on ORGANIC FARMING FOOD QUALITY AND HEALTH in January in New Castle has meant that my subject was chosen as one of the papers to be included a special edition of the *Journal of the Science of Food and Agriculture*.

Milestone 9 was delayed because of the low yield in Discovery in 2003. The inner fruit quality investigation planned for 2003 were moved to 2004 as the analysing did not make any sense in a low cropping year. Both money and work where transferred to 2004.

The delay of milestone 10 and 11 is due to the same reasons as the delay of D8 and D9.

E. Project publications and other products

1. Products from Organic Eprints archive

* 25-75% financed by DARCOF

** 5-25% financed by DARCOF

*Jørgensen, Mrs. Gitte Hallengreen and Pedersen, Senior scientist Hanne Lindhard (2001) [Vælg den rigtige type feromonfælde til viklere](#). In *Frugt og Bær*, April, No 4, page pp. 88-90. Frugt og Grønt.

*Kühn, Scientist Birka Falk (2001) [Perspektiver for skurvresistente æble sorter](#). In *Gartner Tidende*, page pp. 12-13.

*Kühn, Scientist Birka Falk and Pedersen, Senior scientist Hanne Lindhard (2003) [Evaluation of 14 Old Unsprayed Apple Varieties](#). *Biological Agriculture & Horticulture* 20(4).

*Kühn, Scientist Birka Falk and Thybo, Senior Scientist Anette (2000) [Sådan smager de skurvresistente æblesorter](#). In *Frugt og Bær*, page pp. 242-243.

Lindhard, Hanne (2000) [Økologisk frugt og bær: Et langt, sejt træk](#). In *Forskningsnytt om økologisk landbrug i Norden*, August, page pp. 1-2.

*Lindhard, Hanne and Callesen, Ole (2001) [La Production fruitiere biologique en europe](#) [The production of organic fruit in Europe]. In *Le fruit belge*, No 492, page pp. 111-114.

*Lindhard, Hanne and Callesen, Ole (1999) [Questionnaire on organic fruit and berry production in Europe](#). The result of the questionanaire is published as: La production fruitiere biologique en Europe. In *Le Fruit Belge*, page 111-114. See <<http://orgprints.org/00001749>> . Department of Horticulture, Danish Institute of Agricultural Sciences.

*Lindhard, Senior scientist Hanne and Korsgaard, Mrs Maren (2000) [Organic fruit production in Denmark](#). Paper presented at Organic Fruit Oppentunities and Challenges, UK, 16-17 October 2002; Published in *Organic fruit production in Denmark*.

- Lindhard, Senior scientist Hanne (2002) [Nye æbler på vej](#). In *Økologisk Jordbrug*, page pp. 6-6.
- **Lindhard, Senior scientist Hanne (2001) [Plant et frugttræ](#). Grøn Viden, Havebrug no. 142, Afdeling for Prydplanter og Vegetabilsk Fødevarer, Danmarks JordbrugsForskning.
- **Lindhard, Senior scientist Hanne (2001) [Vurdering af mulighederne for forebyggelse og alternativ bekæmpelse i frugt og bær](#). Report, Department of Horticulture, Danish Institute of Agricultural Sciences.
- Lindhard, Senior scientist Hanne (2000) [Dækkulturer og skurvresistente æblesorter](#). In *Forskningsnytt om økologisk landbrug i Norden*, August, page pp. 13-16.
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Pedersen, Senior scientist Hanne Lindhard and Kühn, Senior scientist Birka Falk (2003) [Gamle æblesorter er modtagelige for sygdom](#). In *Økologisk Jordbrug*, 22. August, Volume 23, No 294, page 10. Økologisk Jordbrug.

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

Talk: Cover crops for scab resistant apple varieties. Nordic scientist meeting 28-29 September 2000. At The Agricultural university of Norway.

*Evaluation of Swedish fruit and berry project for a Swedish organic scientific research programme. October 2000. Skogs- och Jordbrukets Forskningsråd (SJFR).

Exhibition of scabresistant apple varieties at the organic congress at Bræstrup. November 2000.

Collaboration meeting among organic scientists in Europe. 29-30. November 2000. Switzerland. Frigg. FIBL. HLP.

Invited speaker to Sweden. Resistant varieties at distrikt Vests årsmøde, 15. January 2001 Helsingborg Sweden.

Control and prevention of apple scab. Talk at organic meeting at Flakkebjerg. Marts 2001.

Education of organic apple growers. Koldkærsgaard. 14. marts 2001

Field day for organic growers. 9. August 2001

Field day, for organic and traditional growers. 6. August 2001

*Field day for traditional apple growers. 4. September 2001.

Education of organic apple growers. Lolland June, 2002.

Field day for organic and traditional growers 26. May 2002.

*40 Visitors from Czech republic especially interested in organic apple production. May 2002.

Field day for organic growers, August 2002.

EU journalist visiting interested in organic apple production. Sep. 2002.

Public open day 5. October 2002.

*Organiser of the NJF-seminar: Organic production of fruits and berries. 22nd Oct 2002.

Participate in the Danish Organic Congress, Talk: Intensive apple production. 21st Nov. 2002.

Participate in the organic EUGROF-meeting at FiBL, Frick, chairman of a session. 28-29th November 2002.

Nordic fruit growers visiting in combination with 'Nordic fruit growers course'. Field day and talk. 28th January 2003.

Talk at Ph.D. course in Sweden. Subject: Results for organic apple research. 4. Marts 2003.

European study trip in June and July 2003. Milestone 7.

Field day for organic growers 7. August 2003.

*Field day for traditional growers 28. August 2003.

*Field day at organic apple grower, Tirsstrup. Talk to growers. 13. August 2003.

**Talk for Swedish fruit growers at 'Fejø-Forsøgsplantage'. Subject: Results from cover crop trial. 8. August 2003.

Participating in the 11th International Conference on Cultivation technique and Phytopathological problems in Organic Fruit-Growing, Weinsberg Germany 3-5th February 2004. **

*Talk to growers. Experience with Apple scab warning model RIMpro. Frugt og Grønt rådgivningen. 2. Marts 2004.

Field day. Organic apple production. 26th May, 2004.

Education of organic fruit and berry producers. Intensive organic apple production. 23. November 2004.

Education of organic fruit and berry producers. Soil treatment and fertilization of organic apples. 23. November 2004.

Field day for organic growers 5. August 2004.

Study trip to Germany and Holland with a group of organic apple producers 11-14th of August, 2004.

Plan for remaining publications:

B. F. Kühn and H. L. Pedersen. 2005. Cover crops and mulching effects on yield and fruit quality in unsprayed organic apple production. Submitted to Biological Agriculture & Horticulture in marts 2005.

Manuscript planned, experiment and data processing not fully finished, planned to be written in late summer 2005.

Le Cam, B. and Lindhard Pedersen H. Working title: Genetic diversity of populations of *Venturia inaequalis* in relation with behavior of Apple cultivars in the field.

Manuscript planned (Data processing not fully finished).

Lindhard Pedersen, H. Working title. Quality of organic apples in intensive production systems. My abstract for the congress on ORGANIC FARMING FOOD QUALITY AND HEALTH in

January in New Castle has been chosen as one of the papers to be included a special edition of the *Journal of the Science of Food and Agriculture*.

F. Scientific education

None

G. National and international cooperation

National:

Kirsten Brandt, Organic food and health – a multigeneration animal experiment. Darcof project no. III.4.

John Hockenhull and Marianne Bengtsson. Royal Veterinary and Agricultural University, Department of Plant Biology, Frederiksberg C, Denmark). Control of scab in organic apple growing (Stop Scab) Darcof project no. 1.14

Maren Korsgaard. Demonstration project for organic fruit and berry production, Industrivej 31 C, 4230 Skælskør, Denmark.

Birgitte Pedersen, Fejø Research Orchard,, Slettervej 27, 4944 Fejø, Denmark. A private research institution.

International:

Marc Trapman, Private, Dutch organic consultant, specialised in development of an advanced apple scab warning system.

Dr. Bruno Le Cam, UMR Pathologie Végétale (PaVé), Centre INRA Angers, France

Member of the organic Expert Group for Organic Fruit Production in the EU which includes fruit scientists from 14 European countries.

Chair of the session on perennial crops of the Int. Scientific Conference on Organic Farming in Adelaide, Australia. ISOFAR.

Participating in Eu-projects:

1. In framework 6: QualitylowinputFood. WP 3.5.1: Integration of fertility management and cover-crop/weed management on disease and pest incidence and crop yield and quality in organic apple production systems.

2. Specific targeted research project: REPCO: Replacement of copper fungicides in organic production of grapevine and apple in Europe. WP 4.4. Screening of potentiators of resistance and organically based fungicides for *Venturia inaequalis* control in apple.

H. Critical reflection on the project

The project has been the basis of successful participating in the international research environment being a member of the Expert Group for Organic Fruit Production and two EU-projects with focus and apple production and quality.

The project trees used for the cover crop trials have after 2001 hosted two other Darcof projects:

1. Organic food and health – a multigeneration animal experiment. Darcof project no. III.4 and
- 2: Control of scab in organic apple growing (Stop Scab) Darcof project no. VII.5

The yields in the Cultural techniques trials 1 and 2 were low or nearly not existing in 2002, due to

a heavy attack of the pest: apples sawfly. Therefore we decided in 2003 and 2004 to spray with the pesticide Quassia. Quassia is allowed for organic fruit production in the European guidelines and in Denmark some organic growers have had dispensation from the Ministry of Environment to use Quassia in 2001-2003 and again in 2004-2005. The project leader also had the dispensation in 2003-2005. In other European countries growers and advisers tell us that production of organic apples are not possible without using quassia. Therefore most, if not all, imported organic apples probably are treated with quassia.

Apple sawflies have been a big problem for many organic apple growers the last 5-7 years. It is especially the early variety 'Discovery' that is infested. Also 'Ingrid Marie' is infested in warm springs. A heavy infestation causes a 100 percent loss of yield. Quassia is 70-80 percent effective against the larvae of the apple sawfly. This was the result of trials ran by 'Flakkebjerg' at growers sites. The trials were paid by a group of four organic apple growers. During the testing period of Quassia the 4 growers became a dispensation from the Ministry of Environment to use Quassia in their orchards. The growers used quassia had significant higher yields especially in the variety 'Discovery' in those years. The growers now want to apply for a permanent permit to use quassia in Denmark. But this is expensive and time consuming and therefore difficult for a small group of private growers to do the needed paperwork.

One of the four growers did not use quassia. He decided to stop being an organic apple grower, because he did not harvest fruit in his 4 ha orchard in 2002 and 2003, especially due to infestation of apple saw flies

Quassia is not sold in Denmark as a pesticide, but you can buy it as herb tea and quassia is used as herbal medicine to control malaria in the tropical countries where the trees grow.

In an intensive research programme paid over 5 years it is crucial to have yield in the project period. The aim of this project was to investigate outer and inner fruit quality caused by growing factors. For this we needed apples.

The experience of lacking fruits due to apple sawfly infestation stress the research of finding alternative techniques to control or prevent infestation of apple sawflies.

8. Budget

A. Account for any change in budgets

As the crop was low in 2003, due to high infestation of the pest: apple sawfly, it was not possible to do detailed research of optimum harvest time and inner fruit quality of the variety Discovery. Therefore I asked for transfer of salary and cost to cover fruit analyses from year 2003 to year 2004. In total transfer of salary for ½ scientific month, 1 technical month and 15.000 Dkr to cover expenses of fruit analyses.

The study travel through Europe was not as expensive as expected. In February 2004 the biannual conference in organic fruit growing in Weinsberg, Germany was taking place. I asked for transfer of 20.000 Dkr. From 2003 to 2004 to cover expenses to participate in this conference.

B. Budget for the whole project financed by DARCOF. (1.000 DKK)

Year:	Original budget	Consumption before 2003	Consumption 2003	Consumption 2004	Total
Man-months	28,5	21	6,5	1	28,5
Scientific personnel	10	7	2,5	0,5	10
Technical personnel	18,5	14	4	0,5	18,5

Year:	Original Budget	Consumption before 2003	Consumption 2003	Consumption 2004	Total
Salaries	846.000	600.000	198.000	52.000	850.000
Scientific personnel	380.000	250.000	98.000	34.000	382.000
Technical personnel	466.000	350.000	100.000	18.000	468.000
Other operational costs					
Travel	40.000	13.000	19.000	8.000	40.000
Analyses, soil, leaves and fruit.	116.000	32.000	35.000	19.000	86.000
Others	124.000	139.000	1.000	8.000	148.000
Consumables total	280.000	184.000	55.000	35.000	274.000
Direct costs	1.126.000	784.000	253.000	87.000	1.124.000
Indirect costs (20% of direct costs)	225.000	159.000	50.000	18.000	227.000
Total	1.351.000	943.000	303.000	105.000	1.351.000

Comments:

The general workload in this project was higher than expected. Especially the establishment of the trial and treatments was very time consuming in the beginning of the project period. In year 2003 the crop was low and the workload for the technical personal was reduced. In 2004 the used labour was high due to cropping tress and a high sampling level of soil-, leaf-, wood- and fruit samples. A scientific article was written and increased the consumption of scientific personnel.

The extra workload and equipment in the project was co-financed by ordinary funding from Danish Institute of Agricultural Sciences, Department of Horticulture.

The consumption of money used for soil and leaf analyses is lower that the budget, this is due to a delay in the caring out of the analyses. We are receiving the results in April 2005 but the expenses are accounted the project: QLIF WP 3.5.1.

9. Signatures and stamps

Name	Institute	Date	Signature
Head of project Hanne Lindhard peder- sen	Danish Institute of Agri- cultural sciences. Department of Horticul- ture	20th of April 2005.	