Indkaldelse af projektansøgninger til forskningsprogrammet

Forskning i økologisk jordbrug 2000 – 2005 (FØJO II)

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1. **Projekttitel** (max. 10 ord):
I.2 Udvikling af bæredygtigt produktionssystem for økologisk æbledyrkning

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2. **Projektleder**

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3. **Projektet hører under område:**

I: Plantedyrkning

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4. Deltagende institutioner: (navn, adresse, tlf., fax. og e-mail)

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7. Projektets varighed: __5__ år Fra __2000__ Til _2005___

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8. Hovedformål

1) Reducere infektions risikoen af svampesygdommen æbleskurv (*Venturia inaequalis*) ved at bruge dyrknings teknikker.

2) Forøge den danske produktion af økologiske kvalitets æbler.

9. **Projektresume** (resumé af projektets baggrund, mål, metode og forventede resultater – ca. 2 sider):

I. Udvikling af bæredygtigt produktionssystem for økologisk æbledyrkning

Projektleder: Hanne Lindhard Pedersen, seniorforsker, Danmarks JordbrugsForskning. Afdeling for Prydplanter og Vegetabilske fødevarer, Forskergruppe for Frugt og Bær.

Baggrund:

Det totale økologiske areal med frugt og bær i Danmark er ca. 340 ha, heraf er 25 ha æbler og 120 ha er uspecificeret træfrugt. 2 procent af det totale frugtareal er økologisk, og der har været et lille nedgang de sidste 5 år. Æble- og solbærarealet er faldet mens jordbærarealet er steget (Lindhard og Callesen 1999).
Æbler sælges oftest til frisk konsum, det betyder, at produkterne skal leve op til meget høje kvalitetskrav. Som grundregel skal frugterne opfylde størrelseskravene, være hele og sunde. Den skadevolder, som oftest forhindrer en god ydre kvalitet af frugten, er æbleskurv. Skurv forårsager brune til sorte pletter på frugten og kan i nogle år og på nogle sorter angribe så kraftigt, at æblerne bliver meget små, misdannede og fuldstændig uegnede til spisning. Denne svampesygdom er årsag til et stor udbytte og en meget stor kvalitetsnedgang i økologisk produktion.
Udbyttet af udvalgte sorter hos økologiske avlere ligger fra 0-50 procent af udbyttet hos traditionelle avlere. I gennemsnit for 6 æblesorter var udbyttet hos økologiske avlere på 14 procent af de traditionelle udbytter (Lindhard et al. 1998).
For at få den samme indtjening som en konventionel avler behøver den økologiske avler en salgspris på produktet, som er 100 procent større end de i øjeblikket får (Daugaard et. al 1999).
Mange økologiske avlere bruges økologiske bekæmpelsesmidler for at forsøge at kontrollere svampesygdomme. På dette punkt er økologisk æbleproduktion anderledes end mange andre økologiske produktioner. Uden i Europa går diskussionen ikke på om der skal bruges økologiske bekæmpelses midler, men om hvilke produkter, som er mest effektive overfor sygdommen. Kobber, som er et effektivt middel og som bruges til økologiske æbleproduktion i de fleste andre europæiske lande, er ikke længere godkendt i Danmark (Lindhard og Callesen 1999).

Forskning i økologisk æbleproduktion er foretaget i Danmarks JordbrugsForskning siden 1987. Arbejde med at undersøges forebyggende metoder til at undgå æbleskurv infektioner har været en væsentlig del. En af de vigtigste metoder til at forebygge æbleskurv er at plante modstandsdygtige eller resistente sorter (Lindhard Pedersen H. Vittrup Christensen J. and Hansen P. 1994; Lindhard Pedersen H. and J. Vittrup Christensen. 1994). Det forventede totale forbud mod kobber i EU, samt en begyndende nedbrydning V_f- resistensen i de skurvresistente sorter (Bengtsson M, Lindhard H. and Grauslund J. 1999) har yderligere forværret udsigterne for en økonomiske rentabel æbleproduktion.
Forædling hen i mod resistente sorter, som indeholder flere resistens typer er stadig meget aktuel. De forædlings institutioner, som findes, der arbejder med resistente sorter er i gang med opgaven, men arbejder på at finde sene lagersorter, som ikke udvikles optimalt i vores lidt køligere klima.

Af andre dyrkningstekniske tiltag, som kan reducere angreb af æbleskurv, er det vigtigt at have mindre åbne træer med en moderat vækst. Derved bliver infektionesbetingelserne for æbleskurv reduceret.
Niveauet af tilgængeligt kvælstof har vist sig også at påvirke angrebet af æbleskurv. Hvis træer har en hurtigere og længere vækstsæson forbedres skurvens infektionsbetingelser. En øget tilførsel af kvælstof vil også reducere plantens indhold af phenoler. Dette øger også æbleskurvens muligheder for at trænge ind i planten.

Mål:

1) At finde nye resistente æblesorter tilpasset det danske klima ved et tæt samarbejde med det store forædlingsprogram i Frankrig.

2) At finde den bedste kombination af kvælstofforbrug, grundstamme og planteafstand til at forebygge æbleskurv infektioner og forbedre produktiviteten.

Projektet er inddelt i 2 delprojekter, de såkaldte workpackages (WP). Delprojekterne, den ansvarlige medarbejder, budget, samt start og slutår fremgår af tabel 1.

Table 1: Workpackage list

WP nr.	Workpackage titel	Ansvarlig deltager	Budget Mio. kr.	Start	End
WP 1	Tidlig test af nye skurvresistente æblesorter.	**Birka Falk Kühn**	**1.227**	**2000**	**2004**
WP2	Reducering af æbleskurv infektionsrisikoen ved brug af dyrkningteknikker**.**	**Hanne Lindhard Pedersen**	**1.196**	**2000**	**2004**

Metode:

I det følgende gives en kort beskrivelse af de enkelte delprojekter.

WP 1: Tidlig samarbejde med forædlings institutioner.
Forædling af æbler er en langvarig proces. Fra forædlingsarbejdet sættes i gang og til den første sort kan blive frigivet skal man påregne, at der går 20 år. For at lette processen og stadig have en kraftig indflydelse på de sorter, der kommer ud, kunne der tages kontakt til Frankrig, som har et stort forædlingsprogram.
I Frankrig satses der på sent modende skurvresistente sorter. De nye krydsninger screenings først for om de er skurvresistente, dernæst ses på frugtkvaliteten. Hvis sorterne modner tidligt, kasseres de. Målet her er at kunne gå ind så tidligt i forædlingen og få en aftale om, at vi kunne få disse frasorterede tidlige skurvresistente sorter til screening i Danmark. Disse tidlige sorter vil kunne passe under vores klimatiske dyrkningsforhold. Projektet vil gå ud på at få en aftale istand med Frankrig, således at de første langvarige test af materialet er foretaget inden

vi får tilsendt materialet. Dernæst vil yderlige kvalitetssorteringere og udvælgelse foregå i Danmark.
En anden del af projektet vil være at udbrede æbleavlernes kendskab til de eksisterende skurvresistente sorter ved at udstationere træer hos avlerne og følge sorternes udvikling i forskellige klimaer.

WP 2: Reducere æbleskurvinfektion ved brug af optimeret dyrkningsteknik.
Forskellig jordbehandling og gødskning påvirker træernes vækstkraft og deres følsomhed overfor skurv. Forsøg med forskellige dækkulturer og dermed kvælstoftilførsel videreføres. Her undersøges dækafgrødernes påvirkning af angreb af svampesygdomme i æbler.
For at optimere den økologiske æbleproduktion bliver der etableret en ny moderne plantage, hvor effekten af gødskning, grundstammer, planteafstand og rodbeskæring på angreb af æbleskurv, udbytte og frugtkvalitet undersøges. For at undersøge disse effekter vælges sorter, som er modstandsdygtige, men ikke resistente overfor æbleskurv. Sprøjtning med svovl vil blive udført ved store udslyngninger af askosporer. Varslingsprogrammet RIMpro bruges til forudsigelse af disse alvorlige infektionsperioder.
Målet er at finde en ligevægt mellem en tilfredsstillende tilvækst i træerne og dermed udbytter og infektioner af æbleskurv.

Forventede resultater:

WP 1: Det forventes på sigt at kunne stille klimatilpassede skurvresistente sorter til rådighed for de danske økologiske æbleavlere. I projektperioden vil der blive afholdt årlige åbenthusdage, samt skrevet om resultater i relevante fagblade.

WP 2: Dækafgrødernes virkning på kvælstoftilførsel og indflydelse på angreb af svampesygdomme specielt æbleskurv undersøges.
Den økologiske æbledyrkning optimeres ved at undersøge dyrkningsteknikkers indflydelse på træernes vækst og følsomhed overfor angreb af æbleskurv. I projektperioden vil der blive afholdt årlige åbenthusdage, samt skrevet om resultater i relevante fagblade.

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10. Samarbejdsrelationer til andre institutioner

Der samarbejdes med det franske forædlingsprogram på INRA.

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11. Koordination til andre projekter.

12. Budgetforslag

Budget for hele projektet i 1000 kr.:

Tidlig test af nye skurv-resistente æblesorter.	**2000**	**2001**	**2002**	**2003**	**2004**	**Total**
VIP månedsværk	1	2	2	2	2	9
TAP månedsværk		2	4	4	4	14
Lønudgifter VIP	37.5	75	75	75	75	337.5
Lønudgifter TAP	0	50	100	100	100	350
Rejser	10	10	10	10	10	50
Øvrige driftsudgifter	5	20	20	20	20	85
Betaling til INRA		50	50	50	50	200
Direkte udgifter	52.5	205	255	255	255	1.022,6
Indirekte udgifter (20 % af direkte udgifter)	10.5	41	51	51	51	204.5
I alt	***63***	***246***	***306***	***306***	***306***	***1,227***
Reducering af æble-skurv infektionsrisiko-en ved brug af dyrk-ningteknikker.	2000	2001	2002	2003	2004	
VIP månedsværk	1	2	2	1	2	8
TAP månedsværk	2	4	4	3½	3½	17
Lønudgifter VIP	37.5	75	75	37.5	75	300
Lønudgifter TAP	50	100	100	87.5	87.5	425
Rejser	0	0	0	20	0	20
Øvrige driftsudgifter	50.8	50	5	5	5	115.8
Analyser	5	10	20	20	20	75
Direkte udgifter	143.3	235	200	170	187.5	935.8
Indirekte udgifter (20 % af direkte udgifter)	28.7	47	40	34	37.5	187.2
I alt	***172***	***282***	***240***	***204***	***225***	***1,123***
I alt WP 1 og WP 2	**235**	**528**	**546**	**510**	**531**	**2,350**

13. Støtte fra anden side/medfinansiering

Såfremt der stilles andre eller egne midler til rådighed (evt. i form af månedsværk) til gennemførelse af projektet, redegøres der nærmere for dette i nedenstående skema.

er ikke søgt _X__ søges_____ er bevilget _____ **(sæt kryds)**

Hvorfra:_____

14. Supplerende oplysninger.

Her kan f.eks. også vedlægges oplysninger om planlagt forskeruddannelse, udlandsophold, gæsteforskere, workshops m.v.:

15. Underskrifter og stempler

Navn	**Institution**	**Dato**	**Underskrift**
Projektleder:			
Institutionens ledelse:			

16. Beskrivelse af projektet (ca. 5 sider):

Se vedlagte projektbeskrivelse

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17. CV for de deltagende forskere:

se vedlagte appendiks

Projekt beskrivelse:

Title:
Development of sustainable production systems for apples.

1. Summary

For several fruit crops, organic production is extremely difficult because of the high quality demands of the product. In Denmark, only about 2% of the fruit production area are grown organically, and there has been a slight decrease during the last 5 years. The reason for the decrease in the apple area is that the control of apple scab (*Venturia inaequalis*) has been very difficult the last 5 years.
The use of cultural methods to reduce the apple scab infection is stressed in Denmark where the use of organic pesticides is limited compared to other countries in the world.
The overall objective in this project 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 objectives are 1. To find new resistant varieties suitable for the Danish climate through a close co-operation with the big breeding program in France. 2. To find the best combination of nitrogen supply, use of rootstocks and planting distance to prevent apple scab infections and improve productivity.

2. Research group

Hanne Lindhard Pedersen (HLP), senior scientist, Birka Falk Kühn (BFK), scientist, and Marianne Bertelsen (MB), scientist, all from Danish Institute of Agricultural Sciences, Department of Horticulture, Research Group of Pomology (DIAS).

3. Introduction

The total organic area in Denmark with fruit and berries is approximately 340 ha, from this the apple area constitutes 25 ha and 120 ha are unspecified tree crops.
About 2% of the fruit production area is organic, and there has been a slight decrease during the last 5 years. The apple and black currant areas have decreased while the strawberry area has increased. In most other European countries the organic fruit production area is increasing (Lindhard and Callesen 1999).
Apples are mostly sold for fresh consumption. Therefore the products must have high quality standards, compared to crops sold to juice or jam manufactoring. As a minimum the fruits have to fulfil the size norms and appear healthy and undamaged.
Apple scab (*Venturia inaequalis*) is the disease that most frequently causes quality reductions of the fruits. Apple scab appear as brown and black spots on the fruit and in years with severe infections the apples become small and deformed not suitable for consumption. This disease causes a profound yield and quality reduction in organic apple production.
Apple production became commercialised in the beginning of the 20th century, when pesticides like copper in the form of Bordeaux liquid and sulphur as in lime sulphur became known as effective against apple scab (Lindhard og Daugaard, 1998). Organic apple growers around the word still use these products.
One of the reasons for the decrease in the apple area in Denmark is that the control of apple scab has been very difficult the last 5 yeas. Control of heavy scab infections is impeded by the band on copper usage in organic apple production in Denmark. Copper is allowed in most other European countries (Lindhard and Callesen 1999). In Denmark sulphur is the only allowed compound against apple scab. Sulphur, however, is not very effective compound.

In Danish organic apple orchards the yields are from 0-50 percent of the conventional figures, depending on the varieties. In average of the 6 main varieties in Denmark the organic yield is only 14 percent of the conventional (Lindhard. et al. 1998).
To make the same profit as a conventional grower the organic grower needs a price 100 percent larger than they already get (Daugaard et al l999).
Many organic fruit and berry producers choose to use the pesticides allowed in organic production to try to control diseases and pests to increase the yield and their economy. This especially is the case for apple growers. This shows that organic fruit production is different from many of the other organic productions.
In Europe most organic apple producers do not debate whether they should use pesticides or not. Usage is taken for granted and focuses on efficiency and optimal use.

From 2002 the ban on copper usage in organic production will be put into force in all European Union member states. This change in the European Guidelines causes trouble in organic apple, grape and potato production. The growers have been fighting to keep copper in use. The main trend among apple producers and scientist is still to ask for alternative products to control apple scab.

The demand for organic apples is not fulfilled by the Danish production. The Danish production is very small. Most apples are sold direct from the orchard, so there is not trustworthy statistics. Most apples sold in supermarkets are imported, often from countries where the growers are allowed to use more products to control pest and diseases. Foreign growers can produce a larger amount and a better quality of apples to a lower price than the Danish organic apple growers are able to. This open marked is a hard competition.

As Denmark is one of the most restrictive countries, when it comes to pesticide usage, it would be logical that we go in front in the attempt to reduce the apple scab infections using alternatives to spraying. The best way to control apple scab would be to combine all the possible cultural practices to reduce infections of the pathogen. When this is done we must still expect infections, and these should be controlled using the organic allowed pesticides in the best strategic way.

4. State of the art

Organic research

Research in organic apple production has been carried out for a number of years. In the late 80´ties the environment aspect became an important issue in many countries. In central Europe, Germany, Switzerland, Austria and Italy organic fruit and berry research became a part of the organic research theme. In DIAS the first trials in organic fruit production also started late 1980'ies, covering variety susceptibility to pest and diseases, effects of cover crops and disease management.
Important problems still to be solved world-wide is how to reduce apple scab (*Venturia inaequalis*) in organic apple production. This tropic has been the aim of many research projects all over the world.

Pesticides

The main way to reduce the disease has been to look for effective sustainable pesticides. This has been a key subject in the organic apple scab research. In the German "Internationaler Erfarungsaustausch über ökologischen Obstbau" held nearly annual since 1988 more than 50 percent of the talks have been about organic acceptable pesticides.
In Switzerland hundreds of compounds have been screened for their effect on apple scab (Häseli and Bosshard, 1993) out of these two emerged as effective and are now among the most commonly used pesticides in organic apple production. In Italy and Germany several products have been tested too (Kelderee et al 1997; Kienzle et al 1995).

Microbiological control

Microbiological control is another way to combat the pathogen. Antagonists may reduce ascospore or conidia release and thereby reduce the risk of apple scab infections.
In Canada an extensive research program is in progress (Carisse et al 1999) and a similar but smaller is ongoing in Denmark (Lindhard and Bengtsson, 2000).

Breeding:

The main focus in apple breeding is apple scab resistance. This way has been the main goal for breeding programs all over the world the last 20 years.
The last 10-15 years a number of resistant varieties have been releases from these programs. Breeding is a long-term process in apples. From the breeding program starts until the first variety is released a minimum of 20 years is required. In the first resistant varieties the V_f resistance originating from *Malus floribunda* is the resistance source. In varieties currently released the resistance is manly based on this single gene resistance. The new races 6 and 7 of *Venturia inaequalis* overcome this resistance and both races are now present in Denmark (Bengtsson M., Lindhard H. and Grauslund J. 1999). Luckily this break down is not wide spread yet, but growers cannot relay on the resistance in the future.
The breeders are well aware of the problem and started years ago to use other sources of resistant breeding material, but so far few multi-resistent varieties have been released.
Breeding of apples is done very few places in the world. New Zealand, Italy, Spain, France, and USA. All breeding institutes concentrate on developing resistant varieties suitable for their own climatic zone. They go for late season varieties with a long storage period. These varieties need a too long growing period to be suitable for the Danish climate. In the future we cannot expect others to do the breeding for the Danish organic growers.

Varieties.
Work to evaluate the resistance of different apple varieties has previously been carried out in Denmark and based on this work suitable apple varieties have been recommended for organic production (Bertelsen and Grauslund, 1995; Lindhard Pedersen H., Vittrup Christensen J. and Hansen P. 1994; Lindhard Pedersen H. and J. Vittrup Christensen. 1994; Nielsen 1987).

Phenol synthesis:
Research aimed at identifying the mechanisms responsible for differences in variety resistance has focused on phenolic substances in the plants. Mikalek et al.(1996) found that if the level of phenols in the trees is reduced, the risk of a scab infections is increased. High nitrogen supply reduces the phenolic synthesis in the trees and this is the mechanism behind the increased susceptible to apple scab infection (Buchter-Weisbrodt,1996). Conventional research has also shown that high mineral fertilisation increases the incidence of apple scab and powdery mildew (Kulik et al. 1974). In an ongoing organic apple cover crop trail the breakdown of the scab resistance in former resistant varieties was earlier and more severe in the cover crop treatment that gave the largest supply of nitrogen to the trees. This was the case even when the level of total nitrogen in the leaves was within the optimum level for fruit production (Lindhard H.2000). Apples do not normally need more than 0-100 kg nitrogen per ha per year depending on the soil treatment to produce high yields. Too much available nitrogen during fruit ripening also reduces the fruit colour and thereby the quality.
However, the tree still needs nitrogen to produce a reasonable growth and flower bud formation, which is the fundament for at sufficient yield.
The aim would be to find an optimum content of nitrogen in the plant, balancing sufficient tree growth, flower bud formation and yield with a reduced likelihood of scab infections.

Rootstocks and planting density.
During the last 50 years the planting systems in apple orchards have evolved from large extensively planted crown trees to high-density small trees. High-density systems are more productive and yield fruit of a higher quality. The change in system has been achieved by using weak growth controlling rootstocks. Organic growers in Denmark have been reluctant to change to the more efficient production systems, fearing such a system would be harder to manage without the availability of pesticides and fertiliser.
High-density systems, however, inertly posses advantages that would help organic growers. The smaller trees are less dense and dry faster after rains and thereby the risk of apple scab infection is lowered (Grauslund 1991). Weaker rootstocks produce less shoot growth and some (but not all) tend to terminate shoot growth earlier. The amount and duration of shoot growth is important in respect to scab susceptibility. Apple scab overwinters in leaves on the ground and on young shoots. The infection source ‘ascospores’ from leaves can be reduced by a good break down of the leaves (MacHardy, 1996). But conidia coming from shoots, particular immature late season growth, constitute a bigger problem, and are normally controlled by the use of copper. Since copper has been banned growth reduction and in particular early growth termination have become important aspect of fruit production.
Shoot growth is controlled by multiple of interacting factors. The effect of rootstocks is fundamental in this aspect, but so are also fertiliser, pruning and watering schemes as well other methods to control growth. These need to be optimised within the organic production system using varieties previously identified as suitable for this type of production. There is a distinct need to demonstrate to organic growers that such modern plantings are feasible.

Warning programs to predict apple scab infection risk.
Apple scab infections are correlated with the temperature, and spores need wet leaves to germinate. Warning programs using weather data to predict apple scab infections have been in use since 1990 in traditional apple orchards. The equipment predicts when the conditions for spore germination are met and issues appropriate warnings. To control the infection after spore germination the use of curative pesticides is necessary. Pesticides used in organic production are not curative. Therefore this warning equipment has not been suitable for organic production.
A new PC warning program is currently being developed that incorporates knowledge obtained from research into the apple scab life circle, ascospore release, climatically conditions and combines it with knowledge about pesticides (Trapman 2000). This program is also useful in organic apple production as it predict the release of the ascospores. The organic growers will then have to use sulphur in the hours after ascospore release, but before the condition for germination are full filled. Using this program timing and effect of the pesticides used in organic production will be improved.

5. Objectives and expected achievement
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 principal objectives are:
1. To find new resistant varieties suitable for the Danish climate through a close co-operation with the big breeding program in France.
2. To find the best combination of nitrogen supply, use of rootstocks and planting distance to prevent apple scab infections and improved productivity.

WP 1: Early testing of new resistant selections.
WP 2: Reducing apple scab infection risk using cultural methods.

6. Description of workpackages including methods

Table 1: Workpackage list

Work-package no.	Workpackage title	Responsible participant	Budget	Start	End	Deliverable no.
Apples WP1	Early testing of new resistant selections.	BFK	1.227 Mill DKkr	2000	2004	D1, D3, D6, D7, D8, D9 D12.
ApplesWP2	Reducing apple scab infection risk using cultural methods.	HLP	1.196 Mill DKkr	2000	2004	D2, D3, D4, D5, D6, D7, D9, D10, D11.

Table 2: Description of workpackages

Early testing of new resistant selections.

Workpackage number:	1
Start date:	September 2000
Responsible person:	BFK
Contributing persons:	HLP
Person-months:	Scientist 9, technician 14.

Objectives:

1. To find new resistant varieties suitable for the Danish climate through a close cooperation with the big breeding program in France.

Description of work:

Apple scab (*Venturia inaequalis*) is the biggest problem in organic apple production. The disease reduces yield, fruit quality, and the growers economy.

Resistant varieties are the most important cultural technique to prevent apple scab in organic production.

The last 10-15 years a number of resistant varieties have been released from the apple breeding programs. The eating quality of these varieties is not impressive. Therefore a general recommendation for these varieties has not been given. The breeders go for varieties suitable for the big fruit production areas with a warmer climate and a longer production period than we have in northern Europe. They reject all varieties ripening earlier than the variety 'Golden Delicious'. Golden Delicious is the latest variety we can ripen in Denmark. It is harvested at the beginning of November, at a time when frosty weather is imminent.

In the future we cannot expect many varieties from these breeding programs to develop satisfactory in our climate. It is essential to get involved in some kind of apple breeding ourselves to ensure that we have apple selection in the future suitable for organic production in our climate.

Apple breeding is very long-term work. An appropriate alternative to initiating a breeding program of our own is to engage in a co-operation with foreign breeders, where we can be integrated in their breeding programs and ensure that selections for our conditions are selected.

Positive contacts to INRA in Angers, where the French apple breeding takes place, indicate that such a co-operation is realistic.

The aim is to find new resistant apple varieties for organic production, suitable for the Danish climate. These varieties must be resistant to apple scab and maybe powdery mildew too, have an acceptable eating quality, big fruits, nice fruit appeal and ripen at least two weeks before 'Golden Delicious'.

13-15 years is the normal time span from an apple variety arrives in the country until commercial production takes place and fruits appear in the shops. A similar amount of years are expected in this project. However, 5 years is a reasonable time to find out if the concept is valid and investigate if further work in this direction has any perspective.

Apple breeding is a new research area in Denmark, but it is of great importance if continuity in the organic apple production is to be achieved in the long run.

Method:

The INRA institute has many years' experience of apple breeding are present, but they only aim for resistant varieties suitable for a long growth season. All varieties ripening earlier than the variety 'Golden Delicious' are rejected. These varieties are not suitable for the Danish climate.

During the breeding process the first step is to test for resistances. Only the resistant selections go further. The next step is to test the fruit quality. If selections ripe early they are discarded.

We intend to negotiate collaboration agreement with INRA, which gives us the opportunity to take over some of the material ripening at a relevant time for Danish conditions. This material is tested and further selections are made in Denmark. The result is new varieties suitable for our climate zone.
Resistant selections are taken to Denmark as scions, and grafted on rootstocks. Trees are planted in the organic areas at research group for pomology. When trees start fruiting quality tests are made and further selection will be based on fruit quality scores as well as resistance.

When promising varieties have been identified organic growers will be offered trees to test.

No agreements have been made with INRA so far, but the project has been discussed and the initial response from INRA is positive. Most of the breeding research is privately founded and royalties and variety rights have not yet been negotiated. This process, however, cannot start before there is reality behind the co-operation.

The following data are collected:
From the selections:
Growth, tree shape, flowering time, yield, fruit size, eating quality (sugar/acid- content, fruit firmness and eating quality is test using a test panel), storability in cold storage, physiological disorders an susceptibility to pest and diseases.

Deliverables:

Agreement with INRA
Annual reports
A national publication in year 2003.
An international publication in year 2004.

Milestones:

1. Agreement with INRA about selection rights.
2. Production of selections for screening every year
3. Planting of selections in organic research area every year
4. Evaluation selections every year.
5. Promising selections propagated for test plantings at organic growers.
6. Planting of selections at organic growers.

WP2: Reducing apple scab infection risk using improved productivity.

Start date:	September 2000
Responsible person:	HLP
Contributing persons:	MB
Person-months:	Scientist 8, technician 17.

Objectives:
2. Reducing apple scab infection risk using cultural methods.

Description of work:
Cover crops and soil management is currently investigated in an organic apple trail. The trail consists of the best scab resistant varieties selected in 1993. The effects of cover crops on nitrogen supply, tree growth, fruit quality and infections of pest and diseases are investigated. Cover crops are important as fertilisers in an organic specialised plant production where animal manure is not available. The trees are planted in 1994 and have been cropping for 3 years. Before final conclusions can be made at least another 2 years of cropping are necessary. The work that has been going on for three years is continued 2-3 more years. Keeping this trail running is also important to continuity in the organic apple research and to ensure that there are apples present in the first years of this project.

Knowledge about shoot termination on different apple rootstocks as well as yield and leaf density differences is important in respect to apple scab infection risk. At the research group for fruit and berries these data are present from former rootstock work but the data has not been processed. This data is going to be analysed and used for following research.

To optimise the organic apple production a new modern orchard is established where the effect of fertilising, rootstocks, planting distances and root pruning on infections of apple scab, yield and fruit quality are investigated.
The production is optimised using the temporary results of the just described cover crop trail. The weak grass mixture of *Festuca rubra* and *Poa pratensis* are sown in the alleyways to delay apple scab infections. Irrigation, high-density plantings and use of sulphur to control the most severe apple scab infections risks will also be used. The apple scab-warning program RIMpro is used to pick the most severe ascospore discharges for control.
As we cannot expect the resistans of the apples scab resistant varieties to keep, we need to employ other culture techniques than resistant varieties to reduce the risk of apple scab. To investigate the effect of culture techniques on apple scab infections we choose non-resistant but less susceptible varieties previously recommended for organic production. This trail is planted in the winter 2000/2001. When the orchard starts cropping the older cover crop trail is cleared.

Method:
Cover crops:
The 10 most promising resistant apple varieties in 1993 were selected and their value in an organic production is beeing evaluated. The varieties are: ‘Delorina, ‘Florina’, ‘Otava’, ‘Prima’, ‘Redfree’, ‘Retina’, ‘Rewena’, ‘Saturn’ (Sa15/4), ‘Vanda’, ‘X6398’. The yield and fruit quality including the variety susceptibility to other pest and diseases are investigated.
All varieties are planted in 3 different cover crops.
1. A permanent week grass mixture of *Festuca rubra and Poa pratensis.*
2. A permanent mixture of white clover and grass (*Trifolium repens and Lolium perénne).*
3. Annual cover crop sown every year in early July (*Lolium multiflorúm*, *Trifolium resupinatum*).

The soil is kept mechanically clean from April to 1st of July.
The soil in the tree row is kept free of weed using mechanical cleaning. No fertiliser is supplied. Temporary results shows that even though the annual cover crop gives the highest supply of nitrogen, the best growth and a slightly higher yield of well-coloured unblemished fruit is achieved in trees grown in a permanent weak grass cover crop.

Cultural techniques 1:
In the organic research area of the Institute, an irrigated apple orchard with alleyways of *Festuca rubra* and *Poa pratensis* will be established.
The early variety 'Discovery' recommended for organic apple production is selected.
Planting distances between the trees in the rows of 0.8, 1.0 and 1,2 meter are combined with the following rootstocks: J9, M26, MM106 in plots of 4 trees repeated 3 times.
All the combinations of rootstocks and planting distances are combined with 6 methods of keeping the tree row clean and ferlilise the trees.
Treatments in the tree row:
1: Mowed grass in the tree row.
2: Mechanical cleaning without manure
3: Mechanical cleaning and poultry manure
4: Mechanical cleaning and compost.
5: mechanical cleaning and slurry
6: 20 cm of wheat straw.
Total tree use: 648.

Cultural techniques 2:
The Danish variety 'Ingrid Marie' is recommended for organic production. Root pruning as a method of reducing the tree growth and thereby the risk of apple scab infections are tried in the variety 'Ingrid Marie'. The root pruning is combined with 3 rootstocks, 3 planting densities and 3 treatments in the tree row.
Planting distances between the trees in the rows of 0.8, 1.0 and 1,2 meter are combined with the following rootstocks: M9, J9 and MM106 in pots of 8 trees repeated 3 times. 4 trees in a plot are root pruned prior to full bloom.
All the combinations of rootstocks and planting distances are combined with 3 methods of keeping the tree row clean and fertilise the trees.
Treatments in the tree row:
1: Mechanical cleaning without manure
2: Mechanical cleaning and poultry manure
3: mechanical cleaning and slurry
Total tree use: 648.

The following data are collected:
Tree growth, leaf samples and soil samples to investigate the nitrogen content and supply. Percentage of water in the upper 50 cm of the soil surface to show the water use of cover crop and the tree supply. Visual control of pests and predators are carried out after flowering to se the effect of cover crops and the insect's populations. Powdery mildew and fruit tree canker is removed and the number of infections per tree is noted. Yield, fruit size, and fruit colour is recorded after grading. Skin damage caused by pest and diseases is evaluated on 25 fruits per tree.

Deliverables:

Annual reports.
Report about development of terminal buds in rootstocks.
National article about cover crop trail.
International article about cover crop trail.
National article about cultural techniques.
International article about cultural techniques.

Milestones:

1. Planting of new apple trail
2. Analysing existing data about development of the terminal bud on different apple rootstocks.
3. National article about cover crop trail.
4. International article about cover crop trail.
5. Clearing of old cover crop trail.
6. National article about cultural techniques.

International article about cultural techniques.

Table 3: Deliverables list.

Delive-rable no.	Deliverable title	Delivery date	Meet-ing	Nature
D1	Agreement with INRA	Oct 2001		
D2	Report about rootstock effect on shoot termination	Apr. 2001		
D3	Annual reports	Sep. 2001		
D4	National article cover crop	Mar. 2002		
D5	International article cover crop	April 2002		
D6	Annual reports	Sep 2002		
D7	Annual report	Sep 2003		
D8	National publication resistant selections	Dec 2003		
D9	Annual report	Sep 2004		
D10	National publication cultural techniques	Dec. 2004		
D11	International publications cultural techniques	Dec. 2004		
D12	International publication resistant selections	Dec. 2004		

Table 4: Time table

SOS		2000												2001												2002												2003												2004											
	Month	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
K 1	**Early testing of new resistant selections.**																																																												
M1	Negotiation and agreement with INRA									x	x	x	X	X																																														
M2	Production of tress														x	x											x	x												x	x												x	x	X						
M3	Planting															x	x											x	x											x	x													x	X					
M4	Evaluation of selections Data collections																				x	x	x										x	x	x										x	x	x								x	X	X		
M 5	Data analysing																									x												x												x											X
M6	Growers and consultants are informed yearly about the results in annual reports and field days.																					x					x							x					x							x						x					X		
M7	Promising selections are selected for planting at growers.																																																											X		
M8	Trees for growers are produces																																																										X	x					
M9	Trees are planted in organic orchards																																																											x	x					
M10	Results are analysed and published national and international.																																																													x	X	x	x	X
TASK 2	**Reducing apple scab infection risk using cultural methods**																																																															
M12	Planing of new trail											x	x	x	x																																																		
M13	Report on terminal bud development														x	x	X																																															
M14	Data analysing													x	x											x	x											x	x											x	x								x	X	
M15	Growers and consultants are informed yearly about the results in annual reports and field days.									x					x							x					x							x					x							x						x					X		X
M16	National article about cover crop effects																										x	X																																		
M17	International article about cover crop effects																										x	x																																		
	National article about cultural practises																																																											x	X	
M18	International article about cultural practises																																																										x	X	

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Appendix to projekt number I.2.

Title:

Development of sustainable production systems for apple.

Short curriculum vitae for project employees:

Hanne Lindhard Pedersen. Born Nielsen
Date of birth: 8th. June 1961, Denmark.

Education and Professional Work Experience:
M. Sc. Horticulture, KVL. (1987). Scientist at Department of Fruit and Berries (1987). PhD minor in Plant Pathology and Entomology, KVL (1995). PhD in Pomology, KVL (1996). During this period visiting scientist 6 months at Hort+Research in New Zealand. Senior Scientist (1997). Head of research unit Fruit and Berries (1997). Visiting scientist 4 month at Hort+Research in New Zealand (1999-2000).
Hanne Lindhard is instructor for 2 PhD student and is involved in instruction for 2 Master students.
9 study trips, 11 in-service training and participating in 15 international symposia has been carried out.

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Curriculum Vitae

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Publikationer:

1992 Bertelsen, M og Grauslund, J. Rovmiderne kommer. Frugt og Bær 21, 328-330.

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Description of special expertise's at research group for Fruit and berries.

Organic production areas for Fruit and Berries.

These areas are placed at the research group and were established in 1996. The aim of the areas is to have disposal areas for projects where research in organic fruit and berry trails are carried out.
The area where established under FØJO I in 1996 and was under conversion to organic production the first years but are now organic and management are carried out due to the organic guidelines.
Present are trail with apples, black currants and strawberries.
Fruit and berries are perennial crops where current problems are not examine in one year. Treatment effects are carried over to the following years. In addition there is an increasing yield potential the first cropping years. Therefore it is necessary with at least 5 years of yielding to make a final conclusion.

Fruit grader for apples and pears.

The quality of apples and pears is very important because the price is calculated due to the quality. A colour grader has been present at the group since 1986, but due to new technique a new grader was necessary. In1999 the group applied a private fond for founding of the equipment and in the end of the year a new grader was installed. The grader is able to sort single fruits after diameter, weight, colour, russeting and some skin damage for example caused by diseases and pests. These facilities are very important to investigate the outcome of a production system.

Equipment to mechanical weed cleaning:

At the research group diverse machinery for mechanical weed cleaning are present.
We have a 'Clemens' soil plane, a 'Humus', milling machine and a 4-rowed strawberry milling machine.
In addition we have the soil management machinery, which were used in fruit orchards before herbicide cleaning became common in the sixties. We use these different harrows quite often.
To be able to handle the permanent grass or other cover crops we got two new effective orchards movers in the group. They are also able to mow the grass inside the tree rows.
A narrow milling machine for cover crop management in the alleyways is also present.

Scientific experience:

At the research group technical experient people are present. They have handled organic trail since 1985. The staff has large experience with mechanical cleaning, methods for plant handling, for training and pruning and organic use of pesticides. Also people with large experience in diagnosing and scoring of all diseases, pests and physiological disorders in fruit and berries are working in the group.
The large activities in the group inside variety testing of apples, pears, sweet and sour cherries, black currant and strawberries form a big basic knowledge about varieties and variety testing. This work is also the basic for organic variety testing.