SLU
EkoForsk

Research on organic farming

The Swedish University of Agricultural Sciences (SLU) coordinates a programme for research projects within organic agriculture and horticulture called 'SLU EkoForsk'.

List of projects 2008-2010

Results from the projects are published at http://Ekoforsk.slu.se
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Control strategies against *Tussilago farfara* in organic agriculture

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Coltsfoot (*Tussilago farfara* L.) has begun to appear as an aggressive weed species in organic agriculture. Early seed dissemination and rapid establishment from underground rhizomes make it possible for this species to exploit the period in the spring when crops have poor access to plant nutrients and thus weak growth. The rhizomes, the belowground propagative organs, undergo bud dormancy in late summer, which means that they do not shoot even if growing conditions are good. Since successful mechanical control (e.g. stubble cultivation) is based on weed rhizomes producing new shoots and thus depleting their nutrient reserves, the results as regards coltsfoot are strongly dependent on the buds not being dormant. The timing of such cultivation is thus very important.

The main aim of this project is to devise an effective control strategy for coltsfoot through studying the effects of varying timing and intensity of mechanical break-up and/or ploughing in of rhizomes under different competitive conditions. To achieve this, we have established the following sub-objectives:

1) Determine the compensation point for growth for different degrees of mechanical break-up and rhizome depth, and relate this to establishment in the field.
2) Investigate how cultivation practices affect coltsfoot propagation and how these effects are related to compensation point and rhizome bud dormancy.

In two years of pot experiments, we will study the effects of degree of break-up and rhizome depth on plant establishment. Four lengths of rhizomes will be planted at four depths, and biomass will be harvested on five occasions. The weight of aboveground and belowground biomass will be used to calculate the compensation point.

In two years of field experiments at two sites, we will investigate how different combinations of rotavation, stubble cultivation, ploughing date and competition (with and without spring-sown crop) affect coltsfoot. The experimental treatments (with and without spring crop) will comprise:

- Control (no soil cultivation)
- One stubble cultivation + early autumn ploughing
- Two stubble cultivations + late autumn ploughing
- Two stubble cultivations + spring ploughing
- One stubble cultivation + early autumn ploughing + rotavation in spring

Increased biodiversity improves pollination in organic production of white and red clover seed

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Access to clover seed poses a bottleneck in efforts to meet the demand for organically produced clover. Insufficient insect pollination can severely restrict yields of red and white clover seed, while yields can increase by 600-700% when honeybees and bumblebees are present. The importance of access to wild insects such as bumblebees has increased, since beekeeping has strongly declined. Pollination by bumblebees in particular is improved if a flower resource is provided early in the season, so that the population increases in time for flowering of the clover.

The aim of this project is to demonstrate the importance of biological diversity in arable fields and in the surrounding landscape for degree of pollination. We intend to investigate the possibility of improving pollination of red and white clover by sowing in rows of early-flowering plants. We will also investigate whether this contributes to increased parasitism and predation on pest insects.

The project comprises two series of experiments:

A. In a total of 16 red clover fields, we will investigate the effects of biological diversity in the surrounding landscape on fields of winter oilseed rape. We will record pollination success, insect damage and seed yields. The experiment will be repeated in a second year.
B. In this series of experiments we will investigate the effects of occasional rows of early flowering plants in white clover and red clover crops. Winter oilseed rape and phacelia will be used as lure plants, and early flowering white clover will also be used in red clover. The experiment will be repeated in a second year.

This project forms part of a larger programme of studies of pollination and biodiversity that also includes a Formas-funded project. We expect the results to be applied to increase the degree of pollination of clover seed crops using relatively simple cropping measures. In addition, knowledge of the importance of the surrounding landscape should provide an indication of when and where these extra measures are relevant. Overall, the project should contribute to higher and more stable yields of clover seed.

SAFEPEAS - Effects of brassica intercrops on soil structure, disease suppression, rhizobia efficiency and crop growth

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Photo: Ullalena Boström

The EU requirement that all animal feed used in organic production must be organically produced means that production of legumes will have to be improved so as to achieve higher and more stable yields. However, pea growing is surrounded by problems: soil compaction, nutrient deficiency in the establishment phase and attack of pea root rot caused by *Aphanomyces euteiche*s are some of the issues that make pea growing difficult.

Interest in intercrops such as oilseed radish and mustard is currently very great. These species are interesting from a soil structure perspective, as green manures and as catch crops. Because of their high glycosinolate content, after chopping and incorporation into the soil they can form isthiocyanates, which inhibit soil-dwelling crop pests. The complex problems associated with pea growing make it necessary for a number of disciplines to work together to produce results that can be applied in practical pea cultivation.

In this project, we will be working from the following hypotheses:

- Ineffective rhizobial bacteria contribute to prolonging the establishment phase of peas and thereby lower crop reliability.
- Direct incorporation of biomass from a growing glucosinolate-containing species has a green manuring and soil structure promoting effect, and also an inhibitory effect on A. euteiches, thereby limiting the development of pea root rot.

In greenhouse experiments in large crates of non-infected soil, we will study under controlled conditions how growing and incorporation of intercrops with different glycosinolate concentrations affect pea plant establishment, soil structure, soil biology, nitrogen availability and development of pea root rot. The soil in the crates will be inoculated with *A. euteiche*s and rhizobial bacteria. Growth and development of the pea crop will be monitored during the experiment, soil structure will be characterised, the effect on the rhizobial bacteria will be determined and pea root rot symptoms will be recorded.

The project will be associated with a reference group consisting of growers and crop production advisors. In the project we will combine expertise from soil physics, soil biology, plant pathology and crop production with consideration of experiences and ideas from practice. A postgraduate student will be associated with the project.

Development of organic ley seed production by participatory learning and action research

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Production of organic ley seed has increased strongly in recent years. Availability of clover seed is limited and the presence of excessive amounts of volunteer crop and weed seeds causes rejections. Production of organic white clover seed, which had previously been negligible, increased by 70% to 418 ha in the period 2004-2006. Contract growing is now carried out in central Sweden, where this crop was not grown previously, and demand for technical production information is great. The experiences and knowledge of organic ley seed producers are important for future research and development in this area.

This project will constitute a continuation of our project which was carried out in the period 2005-2007 (http://Ekoforsk.slu.se/en), where we worked for shared learning and change in a participatory research process. New growers will be invited to join the group, which will be expanded and will consist of approx. 15 organic seed producers, preferably in the Mälar-Hjälmar area and in Östergötland, together with an advisor and one or more researchers. The advisor and researcher/s will act as facilitators for work in the group.

The group will continue to identify and develop relevant issues for commercial production of organic ley seed of:

- timothy,
- red clover,
- meadow fescue and
- white clover

and to define methods and analyses to be used in answering questions.

The focus is expected to be on growing of clover, where questions concerning the effects of pollinators on yield levels have attracted great attention. We will also be working on strategies for price setting, knowledge of the yield potential of different cultivars and improvement of harvesting techniques. The group will analyse and assess the results, which will then form the basis for changes in growers' own operations and for driving and participating in changes in the surrounding sector, such as actions by industry and authorities, KRAV regulations, EU directives, etc.

Lower nitrogen losses and improved hygiene of the outside concrete area for organic growing finishing pigs

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In order to be able to create a sustainable organic pig production in all aspects it is necessary to find practical solutions for the problems with ammonia emissions and hygiene observed on the outdoor concrete areas. This is particularly important since organic production systems with outdoor concrete areas are most commonly used. During 8 months of the year, the pigs have access to outdoor concrete areas without access to pasture areas. In year 2003, 70 % of the piglet production and 60 % of the finishing pigs were kept in such systems.

Results from a previous organic pig project (part of SLU's EcoPig project http://Ekoforsk.slu.se/en) showed that the total nitrogen losses were much higher (by about a factor of 4) in organic pig production as compared to conventional pig production. A main reason was the larger dirty area, especially, the outside concrete area in organic production.

The objectives of the present project are to explore possible ways for improving the hygiene and reducing the ammonia emission and nitrogen losses (N) from the outdoor concrete areas in organic growing-finishing pig production. The planned measures are to cover parts of the concrete area (= the animal activity area) with different types of rooting material.

The hypothesis is that animal activity will be increased in the area with rooting material while at the same time dunging and urinating will be concentrated to a more limited part (= the dunging area) of the outdoor area. This will decrease the total area with manure and decrease ammonia emission. In addition, the rooting material is also expected to have the ability to bind ammonia.
A total of four different treatments will be applied and compared:

1) control (no rooting material),
2) wood shavings,
3) peat,
4) peat daily enriched with green feed pellets, sugar beet pellets, etc.

Evaluation of the different treatments will be made by means of observations of growth and feed utilization, animal health, behaviour and hygiene and by measuring the ammonia emission from the outside concrete area.

Nitrogen and phosphorus availability in organic greenhouse tomato production

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In organic greenhouse tomato production, the nitrogen and phosphorus levels in the plants are often low. This plant deficiency is probably not due primarily to deficiencies in the soil, but to the release rate being slow in relation to plant requirements. One reason for low phosphorus uptake despite good availability in the soil can be immobilisation due to increasing pH. Lack of phosphorus can in turn give rise to nitrogen deficiency through disruption of protein synthesis in the plant.

This two-year project will investigate the effects of some common soil improvers and fertilisers on pH. The project will be based on the existing conditions in three production units included in the participatory research group and will begin with characterisation of soil nutrient status in the three production units, which represent different fertilisation strategies. These soils will be used throughout the project's sub-studies, which will be carried out on-site and at small scale at SLU-Uppsala. Nitrogen and phosphorus availability in the soil in the production units and uptake in the plant will be monitored once a week for 10 weeks.

In incubation and greenhouse experiments at SLU, the pH decrease after application of:

- unlimed peat
- urine
- silage
- kieserite
- blood meal

will be compared with the pH decrease after application of oxalic acid.

We will also investigate whether lowering the pH increases phosphorus uptake and elevates the nitrogen concentration in the tomato plant and whether any increase that occurs in phosphorus availability affects the uptake of zinc, copper, iron and manganese. Through antagonism during uptake by the plant, high availability of phosphorus can cause deficiency of these elements.

In greenhouse experiments we will also investigate how straw affects nitrogen and phosphorus availability in the tomato beds. After application of a readily available carbon source such as straw, the soil microflora multiplies and during subsequent turnover of this microflora, immobilised plant nutrients are released and made available to plants. Organic acids are released simultaneously and these temporarily lower the pH and form stable chelates with aluminium, calcium and iron, which decreases phosphorus immobilisation. Nitrogen is also immobilised in the microflora after addition of straw but since unlike phosphorus nitrogen is not immobilised in poorly degradable compounds, the net affect of straw addition can be expected to be negative in the case of nitrogen.

New weed control methods in organic orchards

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The overall aim of the proposed project is to assess whether some new methods for weed control in organic apple production (primarily the Sandwich system) can provide increased financial returns compared with mechanical weed control and manual weeding.

The proposed project will be an interdisciplinary research project studying the effects of different types of ground treatments in apple orchards (particularly mechanical weed control and grass cutting) on e.g. fruit quality and tree growth. In practical trials, the influence of some important parameters *i.e.*:

- weed cover,
- quality and quantity of apples produced
- time of harvest
- storability and
- tree growth

will be investigated.

Scientists working at Forschungsinstitut für Biologischen Landbau in Switzerland have developed a so-called Sandwich system, which reduces the disadvantages associated with mechanical weed control within tree rows. The system involves sowing a 30-50 cm wide band of weakly growing vegetation (grass and herbaceous plants) in the centre of the tree row. On each side of this band, the ground is kept bare by mechanical cultivation. The advantage of the system is that there is no damage to tree trunks and roots. Mechanical weed control can be carried out using simple and robust machines and at greater capacities.

The aim of this project is to study the effects of different parameters (quality and quantity of the apple harvest, time of harvest, storability, tree growth and degree of weed cover) in practical trials comparing two models of the Sandwich system with traditional cropping. The project will study a range of cropping systems, from completely bare ground within tree rows to the Sandwich system (living mulch within rows of apples trees, combined with mechanical weed control between rows) and to a full covering of short-clipped grass on the entire surface.

The hypothesis underlying this research project is that it is possible to reduce costs and energy use for weed control in organic orchards using the Sandwich system compared with traditional techniques with open ground under the trees, while maintaining yields, fruit quality, tree growth and total income. The project will begin in 2008 and end in March 2011.

Faster emergence and earlier tuber development with a new developed pre-sprouting technique - a technique suitable for organic potato production

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Organic potato production is very difficult, as evidenced by the fact that the area of organically grown potatoes in Sweden has decreased by 10% since 2004. The great problem for production is the risk of leaf blight attack. There are no properly effective control methods available and the existing control products can at best delay attack by a week or so.

Pre-sprouting speeds up development of the potato plant and gives faster emergence, by up to 7 days compared with non-sprouted seed potatoes. Adventitious root formation on the tubers is important for emergence rate.

Pot experiment 2005

Tuber with adventitious root formation


The same tuber 5 days after planting

Pot and small-plot experiments carried out during the period 2005-2007 (http://Ekoforsk.slu.se/en) produced very good results. In pot experiments with a number of harvesting times, it was possible to demonstrate that tuber formation began earlier in plots where root development had been stimulated. In small-scale field experiments, the new method gave 6-21 %-units higher tuber yield in comparison with traditional pre-sprouting. Potato variety and pre-sprouting period influenced the results.

In this project, the method will be tested on a larger scale under more field-like conditions. The importance of

- cultivar,
- length of the pre-sprouting period and
- sensitivity to mechanical handling during planting

will be investigated.

Evaluation of thistle mower

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Control of creeping thistle (*Cirsium arvense* (L.) Scop. and sow thistle (*Sonchus arvensis* L.) is one of the great challenges in organic cropping. In this context, it is important to have a well-balanced crop rotation that improves the competitive ability of the crop against the weeds.

However, in certain situations there is a need for direct control measures against the weed in a growing crop. The methods available are mainly weed harrowing, row hoeing and mowing.

Jonas Carlsson, an organic arable farmer in Blekinge, has developed a very interesting implement, a vegetation cutter/thistle mower. This cuts the weeds in the growing crop but does not damage the crop. The technology involved is mechanical and uncomplicated, which gives low manufacturing costs and a high degree of reliability.

The Swedish Institute of Technology (JTI) and the farmer have together developed a prototype and carried out a preliminary assessment of the implement.

In this project we will proceed to a more comprehensive evaluation of the thistle mower. In four field trials, we will study the short-term and long-term effects of cutting weeds, in the first instance creeping thistle and sow thistle.

Weed control in organically grown maize

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Interest in growing feed maize has increased strongly in recent years, not least from organic growers. In Sweden there is very limited experience of organic maize growing, so experimental results and strategies from Denmark have to be used to a large extent.

The completely dominant problem in organic maize growing is weeds and therefore there is a demand from growers for effective weed control strategies. The aim of the project is to identify effective, non-chemical weed control methods for organic maize and the importance of these for yields and feed value. It has been shown that for practical reasons and because maize can tolerate high nutrient levels, dairy farmers often apply large amounts of fertiliser to maize. We therefore intend to test the hypothesis that it is possible to improve the weed control effects by splitting the fertiliser dose and by placing the fertiliser within the maize row instead of broadcasting it. Through row fertilisation and possibly also splitting the dose, it should be possible to increase plant nutrient use efficiency.

Two series of trials (in total 5 trials/year) will be carried out in the field at three sites, in Skåne, Östergötland and Uppland, between 2008 and 2010:

Series 1) Direct weed control in organic maize crops
Weed control will consist of different strategies for mechanical control and flaming. Mechanical weed control methods will include *e.g.*:

- false seedbed
- blind harrowing
- weed harrowing
- row hoeing and
- ridging

in various combinations. These measures will be carried out at three different times: Before sowing; after sowing until 1-2 leaf stage of the maize; and after the two-leaf stage.

Series 2) Importance of nutrient supply for weed control in organic maize
The importance of nutrient supply for weed control will be studied with respect to placement, amount and timing.

1) nutrients placed on the entire surface or beside the maize seed
2) small or large dose of nutrients
3) nutrients placed as a full dose at sowing or as a split dose.

Weed control will consist of e.g. false seedbed before sowing, weed harrowing and row hoeing.

This project is a collaboration with the Rural Economy and Agricultural Societies (Hushållningssällskapen) in Uppland and Östergötland and the Department of Crop Production Ecology at SLU.

Oilseed radish and mustard - disease sanitisers with great potential

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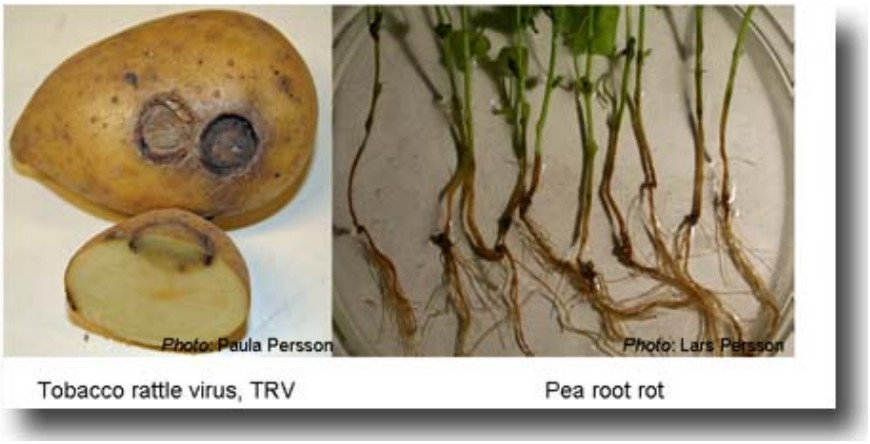
Soil-borne plant diseases are a serious impediment in organic crop production. Several species within the plant family *Brassicaceae* are very important potential sanitisers of plant pathogens that can survive in the soil. Oilseed radish (*Raphanus sativus ssp. oleifera*), white mustard (*Sinapis alba*) and oriental or Indian mustard (*Brassica juncea*) are the main focus of interest. In addition to being disease sanitisers, these intercrops are also catch crops, green manure crops and structure improvers. International literature shows that a number of pathogenic fungi, but also certain nematodes, can be inhibited by incorporation into the soil of biomass of oilseed radish and/or mustard. The mechanisms behind this inhibition have not been determined for each individual case, but one of the effects is conversion of the glucosinolates in the brassicas into isothiocyanates. It is extremely important that the biomass is thoroughly chopped and incorporated immediately.

The main hypotheses of this project are:

1) Chopping and incorporation of the biomass of an intercrop with a high glucosinolate content has a sanitising effect against soil-borne plant pathogens
2) The mechanisms behind this inhibition are either immediate conversion of glucosinolate into isothiocyanate or an indirect action as a result of transformations in the composition of the soil flora.



In this project we will be working with brassica intercrops containing high but also low concentrations of glucosinolates. We have decided to study four economically important diseases and the pathogens responsible: Pea root rot (*Aphanomyces euteiches*); potato spraing (tobacco rattle virus, TRV); stem canker (*Rhizoctonia solani*) and white rot (*Sclerotinia sclerotiorum*). We will grow the intercrops outdoors in large crates and incorporate the biomass at early flowering, add known amounts of pathogens at sowing and analyse any inhibition using biotests and DNA-based analytical methods. The effects of the crop on structure of the soil microflora will be analysed through DNA extraction of soil samples before and after biomass incorporation. The DNA in the soil samples will be analysed using e.g. T-RFLP, which gives the sample a DNA fingerprint and can therefore reveal changes in structure.

Utilisation of synergies between enhanced biological control through selective biodiversity and targeted crop rotation

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In this project we aim to develop a cropping system that provides the conditions to increase and then maintain high populations of natural enemies within the farm, while at the same time interrupting the development of pest populations through introduction of a targeted crop rotation. This will create good synergies for control of pest populations, increased production reliability and better economics for vegetable growers.

In order to increase and maintain high populations of natural enemies, there must be undisturbed habitats within the cultivated landscape that provide them with good access to food, shelter and overwintering sites.

The parasitic wasp *Trybliographa rapae* (*Hymenoptera: Figitidae*) is an important natural enemy of pests within the family *Delia*, which includes e.g. cabbage root fly (*D. radicum*) and onion fly (*D. antiqua*). The parasitic wasp lays its eggs in the fly larvae in the soil and from these a parasitic wasp then emerges instead of a pest fly. Adult *T. rapae* are reliant on available nectar of high quality and resting places. Unfortunately these are often lacking in the modern agricultural landscape. Increased availability of nectar can greatly improve the living conditions for parasitic wasps and their ability to parasitise pests.

Biological control by site-specific natural enemies has always been most successful in perennial crop systems. By imitating a perennial cropping system for the parasitic wasp through a crop rotation consisting of cabbage and onion, the wasp is provided with continuous access to its host *Delia spp*. from year to year. While pest populations are being disrupted annually through a new crop being cultivated, in addition the pest insect (*Delia spp*.) cannot multiply. Vegetable cultures will be co-cropped with strips of perennial flowers that act as a good source of nectar for the parasitic wasps. These strips of flowers will also act as good overwintering sites for other natural enemies of the pests. The choice of plants will be based on the results of behavioural and electrophysiological experiments to determine the attraction of the parasitic wasp species to colour and scent.

The knowledge we acquire in this project will also be very worthwhile in designing biological control programmes for other cropping systems and pests.

Organic milk production based on herbage and cereal feeding – effects on milk and methane production

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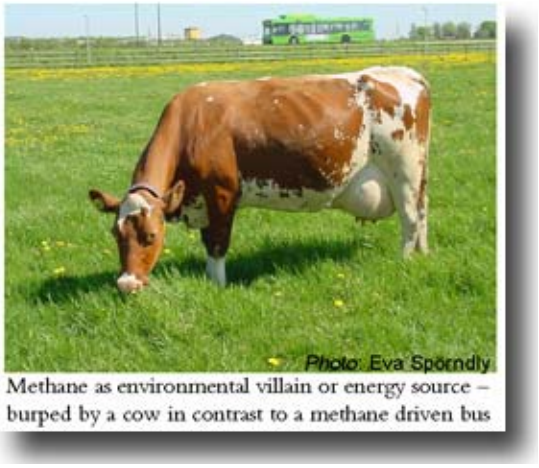

Methane as environmental villain or energy source – burped by a cow in contrast to a methane driven bus

Only few protein feeds fulfil the requirements and rules for feeding in organic milk production and these feeds are often high in price and limited in supply. Starting 2008, organic milk producers are required to supply the cows with 100% organically produced feed.

As organically produced feed is scarce on the market and holds a high price this new regulation makes it increasingly important for the organic producer to produce his/her own feed. It is therefore important to investigate if today's high quality roughage, combined with only cereals (all home grown feeds) can offer an economically interesting production alternative for the organic milk producer compared to the current rations based on a considerable amount of purchased organic protein supplements.

As protein may be a limiting factor in these forage/cereal rations, it is likely that the proportion of legumes in the forage will be an important factor for the production outcome. Clover has been shown to give high feed intakes and high milk yields and to influence the fatty acid composition of milk in a favourable way by increasing the levels of polyunsaturated fatty acids, especially α-linolenic acid.

Large quantities of forage in ruminant diets have been shown to increase the emission of the green-house gas methane but measurements performed on high producing dairy cows that are fed high quality roughage are scarce.

Therefore, measurements of the amount of methane gas emissions from cows on the three diets with different roughage levels are planned, in two methodological studies. These measurements will be performed in cooperation with the department of microbiology, who has recent experience in performing methane measurements in other projects.

The production experiment includes 40 cows during lactation week 1-20 and will take place during the indoor feeding period 2009/2010. It is planned as a factorial experiment with two types of forage:

- high (50%) and
- low (20%) proportion of clover

and two types of concentrates:

- only cereals (barley/wheat) or
- cereals (barley/wheat) in combination with peas and rape seed cake.

The concentrates are fed according to production in accordance with the rules of the Swedish organic control organisation "KRAV" and roughage will be fed *ad libitum* throughout the experiment. Measurements of the effects on milk production, milk composition and the processing qualities of the milk are planned.

Improving the nutritional value of forage to dairy and beef

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Forage ley is the crop occupying the greatest area in Sweden, 49% of agricultural land (16% grazing and 33% harvested ley). It is the largest feed ingredient in the diet of dairy and beef cattle, sheep, goats and horses.

During silage making, nutrients such as protein and fatty acid fractions are subjected to changes that lower their quality to some extent. The protein fraction is exposed to enzymatic degradation that results in its conversion to simple nitrogenous compounds. The fatty acid fraction is altered in a way that has repercussions for meat quality. It has been shown that the meat from grazing animals has a more positive fatty acid composition for humans than the meat from stall-fed animals.

During silage making the crop is first cut and then allowed to dry (wilt) from approx. 20% DM to 30-60% DM. The crop is then transported to air-tight silos of various designs. In Sweden, silage is made in tower silos, plane silos, round bales or tubes.

Wilting can take anything from a few hours to several days depending on the weather and the methods used for harvesting. Different methods for handling the newly cut silage can speed up the process. The actual mechanical treatment can also be expected to have an effect on the degree of decomposition that occurs in the cut crop and during the ensiling process.

The proposed study aims to determine in a systematic way how the protein and fatty acid fractions are altered during wilting and to characterise various quality parameters. This is essential for future technical development of harvesting systems that maintain quality during forage conservation.

In the first year, the effects of wilting and DM content will be studied in a red clover-timothy ley according to the timetable below.

DM content	Cut (wilting) time, hours			
(%)	0	12	24	48
20	×	×	×	×
40	-	×	×	×
60	-	-	×	×
80	-	-	-	×

In the second year the study will continue with fewer variables but with additional plant material in the form of:

- white clover
- birdsfoot trefoil
- sainfoin
- meadow fescue and
- ryegrass

Nitrogen management strategies in organic oilseed rape production - influence of precrop and site on yield

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Plant nutrient supply is a key question in organic production of winter oilseed rape (*Brassica napus* L.). The variation in practical cultivation is great and yield levels vary widely, while there is also a lack of knowledge regarding the need for, and profitability of, fertiliser inputs under different conditions, e.g. different precrops.

The aim of this project is to investigate the possibilities of, and to develop methods, for precrop- and site-adjusted nitrogen application in organic winter rape growing. This will be done in field trials where we investigate the effects of nitrogen levels under varying conditions in order to quantify basic yield, yield potential and nitrogen requirements in relation to soil parameters.

We intend to show how nitrogen uptake in winter rape is dependent on nitrogen mineralisation from the soil and to quantify the variation between sites. Factors affecting the amount of nitrogen uptake and soil mineralisation will be identified, documented and quantified. The objective will be to produce decision support data regarding nitrogen fertilisation of winter rape.

The study will consist of eight field trials per year for two years in southern and central Sweden, where nitrogen will be supplied in different amounts and strategies in the form of Vinasse, which has had good effects in the spring on autumn-sown crops.

- Various precrops (leys, cereals, peas, green manure leys, field beans),
- soil texture,
- row spacing and
- climate conditions

will be selected. The trials will be laid out in existing crops in order to ensure a uniform crop stand.

Each site will be documented with respect to:

- cropping history
- soil texture
- humus content and
- other soil parameters

The status of the crop stand in all plots will be determined in autumn and at the bud stage by hand-held nitrogen sensors and at each site crop samples will be cut on these occasions.

- Root crown diameter,
- maximum rooting depth and
- incidence of pests and diseases

will be monitored.

The content of mineral nitrogen in the 0-90 cm soil layer will be determined at sowing, in early spring and at harvest. Yield and seed quality, including nitrogen content, will be determined on a plot-wise basis at all sites.

Improving quality and storability of organic apples by picking at optimum harvest date, heating and ULO storage

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Several cultivars which have been chosen during last years to develop organic apple production in Sweden, had poor skin color at harvest and weak resistance to fungal decay and physiological disorders during storage.

The purpose of this work is to improve quality and storability of these cultivars by investigation of four possibilities:

- multi- orchard practice
- optimal harvesting date
- postharvest treatments and
- ULO storage.

Pruning the trees and covering the orchard ground with white materials improve fruit colour and storage potential due to better light distribution in the canopy, and more carbohydrate accumulation in the tree. An interaction between the effects of these two practices on the organic apples will be investigated.

Selection of the optimum harvesting date is one of the best ways to maintain fruit quality and minimize losses during storage. To make this selection accessible a maturity index for new cultivars that are produced in organic system will be developed.

Ultra low oxygen (ULO) storage is essentially based on delaying the natural ripening processes. Unfavorable ULO conditions can induce physiological disorders, enhance susceptibility to decay, and shorten shelf life. In this study, optimum levels of storage atmosphere composition for each cultivar will be estimated by keep fruits on four different oxygen and carbon dioxide percent for 16-20 weeks.

Heating which enhances the wound repair process, inhibits the synthesis of cell wall hydrolytic enzymes and changes skin structure has been used to control fungal decay and maintain fruit quality during storage. Ethanol is effective in reducing postharvest decay by disinfecting the fruit. These two postharvest treatments also will be investigated by immersing organic apples in hot water (different degrees and periods) or treating them with ethanol.