EKOFORSK

SLU Ekoforsk - field research on organic production

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

The aim is to improve the knowledge base for the development of crop cultivation, animal husbandry and the production of fruit, berries and vegetables. Projects should contribute to the development of a sustainable production in terms of environmental concerns, animal welfare, resource management, income level and productivity.

Projects 2020-2022 (project responsible within brackets)

Results from the projects are published at http://www.slu.se/ekoforsk
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Intermittent suckling

To decrease piglet mortality and increase piglet growth

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Abrupt weaning is practiced in all piglet farms. Although, weaning is a gradual process in pigs in the wild. Intermittent Suckling, (IS) means that the sows are kept away from their piglets several hours daily during the last week before weaning. Research shows that IS leads to less stress at weaning, better and evener growth of piglets, because they are starting to eat solid feed earlier and get successive adaptation to feed. Intermittent suckling also leads to less weaning diarrhea, fewer sick piglets and lower piglet mortality.

It is common for sows to lose weight during lactation. This weight loss could cause illness and decreased fertility. The weight loss is more severe among younger sows and in organic farms where lactation is longer than in conventional production. Intermittent suckling can prevent severe weight loss in sows during lactation.

Research shows that IS is working better with longer lactation. Therefore IS would probably work better in Swedish organic production, than in conventional farms with shorter lactation. We will explore the possibilities to adapt IS to Swedish organic farms.
Our hypothesis are:

- intermittent suckling will improved piglet survival and vitality,
- give more homogeneous piglet size,
- reduced need for antibiotics and zinc additives and
- improved piglet growth including better health and welfare in sows and piglets.

Intermittent suckling will increase the productivity and competitiveness for Swedish organic piglet producers.

Facts:

High piglet mortality is a major animal welfare problem in Sweden. In organic farms piglet mortality is higher than in conventional. An important cause of piglet mortality is post-weaning diarrhea that results from the sudden change of diet.

Within organic piglet production there is also a problem with large variation in piglet weights within litters and between litters of the same age. If the piglets in a litter are not of the same size, they cannot be moved at the same time. Pigs of different ages and different immune status will be mixed infections will spread easily among the pigs.

Grain legumes in the crop rotation

Species mixtures and varietal choice to prevent soil-borne diseases

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There is variability in the level of resistance to root rots among varieties of several legume species, however many species and varieties used in innovative cropping systems have not been characterized. Diversification by intercropping with non-host species has been shown to reduce root pathogen occurrence in some crop species but references are very scarce for grain legumes.

Moreover, it is not known if the combination of both strategies, *i.e.* using resistant legume varieties in mixtures with non-host species will lead to more efficient disease prevention than each strategy applied separately. Additional practical experience is required in order to give Northern European farmers clear recommendations.

This project will therefore investigate root diseases caused by *Aphanomyces euteiches*, *Fusarium* and *Phytophtora pisi* on different varieties of

- faba bean,
- vetch and
- pea

grown as sole crops and intercropped with non-host species. Measurements of pathogen occurrence and disease severity will be performed in one greenhouse screening and in two field experiments.

1. One field experiment compares two organic crop rotations differing in the frequency of legume species and the presence of crop mixtures.
2. The second field experiment focuses on a three-year sequence with a high frequency of legumes in order to assess the capacity of resistant varieties and species mixtures to prevent the build-up of inoculum and the disease symptoms.

The project is expected to generate results for direct implementation in design of organic cropping systems where legumes are included both as cash and cover crops, and thereby contribute with a large part of the nitrogen supply.

Facts:

There is a need for improved knowledge about management practices that prevent the build-up of soil-borne diseases in cropping systems that contain both grain legume main crops and legume cover crops. Combining the effects of varietal choice and species mixtures can be expected to be an efficient way to prevent diseases, but the combined strategy has not yet been evaluated for soil-borne legume diseases in Sweden.

Nitrogen strategies in organic milling winter wheat

Production of premium quality

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Application of fertilizers approved for organic farming can be hazardous, since the nitrogen may not be available for the crop in time before the end of nitrogen uptake. This could lead to not high enough protein content and a risk for nitrate leaching and nitrous oxide emissions to the environment. A strategy for application of organic fertilizers to achieve the desired protein levels and to avoid losses to the environment is therefore needed.

The objectives of this study are to evaluate different application strategies of organic fertilizers to obtain a high yield and bread quality in organic winter wheat production. Split application and different times for top dressing of selected organic fertilizers will be tested in field experiments, with and without irrigation.

Facts:

The demand for organically produced products are increasing, including bread wheat. However, the protein concentration in organically produced winter wheat is often too low to qualify for premium quality (>10.5%) and concentrations as low as 8% are not unusual. Higher protein content, preferably 12%, demands more nitrogen available for the crop during the later phases of nutrient uptake (GS37-50) and may require late application of N-fertilizers.

The dairy farm as a carbon sink

Added value from biochar

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In addition to being a carbon sink, there are indications that biochar possess several properties that may contribute to payoff for its inclusion in the chain feed-milk production-manure management-crop production. This could be either directly by improving production/saving costs, or indirectly by environmental benefits that gives acceptance for a higher consumer price or motivates some economical premium from society.

This project investigates and quantifies such effects on several key points in the feed chain of the organic dairy farm.

1. Biochar as a silage additive for improved nutritional value and safer ensiling. Ley crops are commonly wilted to facilitate ensiling and restrict fermentation so that more protein and carbohydrates remain intact after ensiling. The extent of wilting is limited by impaired packing properties, increased leaf loss and a larger weather dependence. Our hypothesis is that biochar addition by reducing water activity may give an effect similar to extensive wilting at lower dry matter concentration with retained packing properties and without leaf loss.
2. Biochar for reducing ruminal formation of methane and ammonia. Silage with biochar addition will be investigated in vitro under the hypothesis that methane formation and ruminal liquid ammonia concentration are reduced.
3. Biochar in the feed for more firm manure and cleaner animals. Silage with biochar addition will be fed to heifers. Manure consistency and animal cleanliness will be investigated under the hypothesis that biochar will give firmer manure and cleaner animals and that the effects are similar regardless if biochar is added at ensiling or prior to feeding.
4. Biochar to reduce formation of methane and ammonia during slurry storage.

Facts:

Biochar is produced from the heating of wood or other organic materials under oxygen restriction (pyrolysis). It has traditionally been produced as charcoal for use in iron processing and more recently for barbecues. It is nowadays also a by-product from heating facilities. If biochar is incorporated into soil following distribution on farmland, it is stable for a long period and hereby act as a carbon sink.

Improving pasture utilization

By using the natural variation in dairy cows' grazing behaviour and herbage nutrient content

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A well-managed pasture can be beneficial both economically and in animal welfare perspective. However, getting a well-functioning pasture can be challenging, as the cows are not always motivated to seek pasture. It is therefore important to take advantage of cow's daily grazing patterns.

Previous studies have reported that grazing at dusk provides the longest and most intense grazing of all grazing events seen throughout the day. An increase in milk production and increase in fat and protein yield has been observed in cows grazing in the afternoon compared to the morning, which might be due to the difference in the nutritional content of the pasture. The dry matter and soluble carbohydrate content increase during the day, while the content of structural carbohydrates and crude protein decreases. This indicates that the plant nutritional value is higher in the afternoon than in the morning due to a better balanced fermentation ratio of carbon / nitrogen, which might improve intake, milk yield and efficiency of utilization of the nitrogen in the feed.

By combining two natural processes,

1. the daily variation in the chemical composition of the grass and
2. the natural motivation of the cows to graze,

this project aims to stimulate increased grazing intake in dairy cows. We will compare, morning and afternoon grazing, and evaluate differences in

- milk production and composition,
- feed intake and nitrogen utilization,
- cow-activity,
- milking frequency and
- grazing behaviour.

A controlled study will be conducted year 1 at Lövsta Research Center, SLU, Uppsala. Year 2 study will be based on year 1 results, and three organic farms will be recruited to evaluate our results under commercial conditions.

Facts:

In organic milk production under the Swedish certificate KRAV, pasture plays an important role as roughages must represent more than 50 % of the diet and the cows must have access to pasture for at least 12 hours daily during the grazing period.

Strip-till establishment

Effective weed control and increased carbon sequestration through strip-till establishment in withered cover crops

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The goal in this project is to develop a strip-till cropping system for row sown crops in organic production, where the main crops are strip-tilled in withered cover crops to provide:

- low weed pressure,
- safe establishment in windy areas,
- good management of soil organic carbon and plant nutrients,
- and to maintain the economy for the grower.

The idea is to sow a frost sensitive autumn cover crop after harvest of a main crop. The cover crop will be sown at the same row distance as in the next year's main crop. The biomass from the frost sensitive cover crop remains in the field over the winter and the next main crop is sown between the remaining rows of "cover crop stubble". Weeds in the next main crop are controlled in a combination of mechanical, thermal and manual methods.

A strip-till cultivation system links to "Conservation Agriculture" (FAO, 2019) were minimized tillage and sowing in plant residues from cover crops is applied.

In the project, we will evaluate the weed control effect, the soil carbon sequestration and the nitrogen dynamic in the cropping system, when the organic field crops:

- onion,
- sugar beet and
- maize

are established through strip-till in withered autumn cover crops: oilseed radish, phacelia, buckwheat, Persian clover and oats. In future, we expect strip-till systems to reduce the climate impact via reduced CO_2 emissions, through reduced tillage of the soil, increased carbon sequestration from the roots of the cover crops, and by the possibility of harvesting the cover crops in late autumn as fodder or as a substrate for production of biogas and bio-digestate to organic plant production.

Facts:

Conservation Agriculture is a farming system that promotes maintenance of a permanent soil cover, minimum soil disturbance (i.e. no tillage), and diversification of plant species.

Weed management strategies in lupin and faba bean

Roller crimping in cultivation systems with reduced or no tillage

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Aims of this project are to develop and test weed management strategies for reduced- and no-tillage faba bean and lupin production. This will be achieved by the strategic use of biological characteristics of a cover crop and associated ecological mechanisms facilitating soil nitrogen management and weed suppression.

Field experiments will be set up at two sites with contrasting soils. A non-leguminous reference crop (buckwheat) will be included to account for N effects. Early flowering cultivars of green rye will be used as cover crop, providing rapid biomass production and hence strong competition for light, water and nutrients, suppressing weeds during autumn and early spring. Roller crimping will terminate and mulch the rye in spring.

The experiments comprise four main treatment combinations:

1. No cover crop, ploughing before sowing of grain legume/reference in spring, weed control with up to three hoeing passes (*inversion tillage/standard farmers practice*).
2. Ultra-shallow tillage of cover crops in spring followed by direct seeding of grain legumes/reference crop, mechanical weed control with up to three hoeing passes (*reduced tillage strategy with hoeing*).
3. Roller crimping of cover crop at anthesis in spring followed by direct seeding of grain legumes/reference crop, no additional mechanical weed control (*no-till strategy with roller crimping, late sowing*).
4. Interseeding of grain legumes/reference crop into standing cover crop followed by roller crimping shortly after emergence of the interseeded grain legume (*no-till interseeding strategy, with roller crimping, early sowing*).

Data collection:

- Biomass and C:N ratio of cover crop
- Soil temperature and soil moisture
- Soil total N and mineral N content
- N effect of the legumes and different management strategies on the subsequent crop.
- Nitrogen fixation
- Weed and crop density, phenological development and biomass accumulation

In two experiments, the rye crop is established during autumn 2020, lupin/faba bean/buckwheat in the spring 2021, and the residual effect is studied in a spring sown cereal 2022. Two more trials are established the autumn 2021.

Facts:

Reduced- or no-tillage practice can provide numerous benefits for agro-ecosystems, such as reduction in soil erosion, enhanced storage or retention of soil organic matter, improvement of soil health and reductions of energy consumption for crop production.

Weeds are a major yield limiting factor in organic agriculture in general and in grain legume production in particular. Perennial weed species like creeping thistle (*Cirsium arvense*), and sow thistle (*Sonchus arvensis*) or couch grass (*Elymus repens*) are in particular difficult to control in grain legume crops, why continuous no-till organic farming is regarded as impossible so far.

Welfare indicators

Improved welfare of pigs and cattle at slaughter – evaluation and development of animal welfare indicators and their association to meat quality

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Animal welfare, i.e. the subjective experience of the animal and its biological functioning and adaptation to its current environment, includes all parts of an animal's life. Although the time spent at the slaughterhouse is a relatively short period of livestock's life, it has a major influence on the welfare of the animals.

At a slaughterhouse, livestock are exposed to a number of novel stressful factors such as noises, odours and interactions with unfamiliar conspecifics and humans. Besides negative effects on animal welfare *per se*, stress in animals prior to slaughter has negative effects on meat and carcass quality. Although the relationships between suboptimal handling of animals, animal welfare and meat quality may seem at least partly self-evident, research in this area is lacking.

The long-term aim of this project is to improve welfare and meat quality of pigs and cattle from organic production systems. This three-year project will be conducted in three steps with the specific goals to

1. map and validate animal welfare indicators in animals from organically certified herds on the slaughter site and assess association to meat quality,
2. investigate how the welfare of the animals at slaughter and meat quality is affected by the rearing system, handling at transport and handling at the slaughterhouse and
3. develop a protocol for monitoring of animal welfare based on the results from steps 1 and 2.

Facts:

IFOAM and KRAV (the Swedish organic certification organisation) have their own standards and regulations on handling of organic animals at slaughter, while the EU:s regulations for organic production lack specific organic standards for the time of slaughter. There is an evident need of scientifically based development of animal welfare, and regulations for the welfare of animals from organic production systems at slaughter.

Winter oilseed rape

Increased nitrogen availability and biodiversity by intercropping annual frost sensitive legume plants

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Winter oilseed rape (WOR) demands high amounts of available soil N during the vegetative stages to achieve an adequate yield. Site specific N can increase by intercropping (IC) a legume companion crop frost-killed during winter. WOR is attacked by different insect pests early in the season as the turnip sawfly and cabbage stem flea beetle.

The aim is to develop a concept to improve nitrogen (N) management in WOR by IC nitrogen-fixating legume plants frost-killed during winter. The concept will stimulate growth of WOR and provide site specific N early in spring. The objectives are to provide a basis for selecting legume species appropriate to intercrop without outcompeting WOR and define the best techniques for establishing intercropped WOR and legume plants in different regions of Sweden.

The first year (2020)

- spring faba bean,
- field peas,
- field vetch,
- Persian clover,
- Berseem clover and
- a mixture of all legumes species

are investigated in growth conditions in Skåne, Östergötland, and Central Sweden. Three demonstrations are performed to develop seeding techniques and to find optimal time points of seeding. Row distances 12.5 and 50 cm are compared and legume crops are seeded simultaneously with the main crop and in between rows.

In 2021, field trials are performed in WOR in each geographical area. The best seeding practice evaluated in 2020 and the three best legume crops are chosen. Determination of

- N-uptake with sensor (N-sensor alt. Greenseeker) and
- soil-mineral N will be determined on separate occasions along with cutouts.
- Weed assessment is undertaken in spring and
- the influence of IC on insect pests is determined in late autumn.
- Root health of legume plants is assessed in autumn.

Facts:

By increasing the functional biodiversity intercropping legumes and oilseed rape an improved soil coverage and decreased prevalence of weeds is achieved and conditions are created to decrease attacks of insect pests in rapeseed crop. The concept developed in France is applied in about 10% of the French production of WOR and is reported to improve over wintering and lower prevalence of weeds and diseases.

Flower strips 2.0

Optimized biological control and pollination in organic strawberries

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Sowing nectar-rich flowers to support beneficial insects that consume pests is a promising plant protection method in Swedish horticulture. Strawberries are attacked by a number of pest insects where *e.g.* strawberry tortrix, weevils and thrips can cause extensive damage. The goal of this project is to provide better knowledge for designing effective flower strips for increased biological control of pest insects and increased pollination in organic strawberry cultivation without simultaneously aggravating problems with fungal diseases such as gray mold and plant-parasitic nematodes.

We do this by

- 1) identifying which are the best flowering plants to support natural enemies and pollinators without favoring pests and diseases aboveground, and
- 2) identifying which are the best flowering plants to support a healthy soil without favoring plant-parasitic organisms.

25 different flowering plants will be sown in separate plots in a field trial to test their individual effect on beneficial insects, pollinators, pest insects and aboveground fungal diseases as well as soil organisms (nematodes and decomposition). The plant species that will be investigated in this field trial are determined in collaboration with extension officers. Based on these results, we will then

- 3) design optimal flower mixtures to maximize biological control of pest insects and pollination and evaluate them in organic strawberry cultivation.

Facts:

Organic strawberries are in great demand by consumers, but only about 2% of all strawberry cultivation in Sweden today is organic. In order to increase the proportion of organic strawberries, new and better organic plant protection methods need to be developed, *e.g.* based on biological control.