Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Mistra Biotech

Mistra Biotech
Annual Report 2012




MISTRA Biotech

Mistra Biotech, Annual Report 2012

Production
Project leader: Anna Lehrman
Graphic design: Viktor Wrange
Photographers: Anna Lehrman, Jenny Svennås-Gillner, Viktor Wrange, Johan Roland & Alex Giacomini
Illustrations: Fredrik Saarkoppel, Kobolt Media AB
Print: Repro, Ultuna.

Contents

FUNDED BY

MISTRA

The Swedish Foundation for
Strategic Environmental Research

The world faces major challenges associated with our environment, human use of natural resources and our impact on our surroundings. The Swedish Foundation for Strategic Environmental Research (Mistra) plays an active part in meeting these challenges by investing in the kind of research that helps to bring about sustainable development of society.

This is done by investing in various initiatives in which researchers and users make joint contributions to solving key environmental problems. Mistra's programmes cut across disciplinary boundaries, and the results are intended to find practical applications in companies, public agencies and non-governmental organizations. For more information, vistit www.mistra.org.

Inger Andersson, Director General at The National Food Administration (Livsmedelsverket).

Chair's preface

Food concerns us all. In my daily work as Director-General of the National Food Agency I am reminded of this all the time. Our primary responsibility is to oversee the healthiness and safety of food, and to provide information to consumers, but public concerns cover a wide range of additional issues, including environmental, social, and ethical aspects of food production. Any proposal to change the food production and distribution system will have to take this larger picture into account. Knowledge of food chemistry and biology is important but far from sufficient.

One of reasons I find the Mistra Biotech programme so interesting and promising is that it takes the broad approach that we need. The programme contains plant and animal breeders, ecologists and other natural scientists, but also economists, consumer researchers, ethicists and scientists specializing in the agricultural production system. Judging by the reports of the scientists to the Board, research in Mistra Biotech can contribute substantially to improvements to the Swedish food production system in ways that will benefit both consumers and farmers. To mention just a few examples, the programme is studying how nitrogen leakage in agriculture can be reduced, how pesticide use can be reduced with resistance breeding, and how plant breeding can make it possible for farmers to produce healthier foodstuff.

Swedish farmers are under great pressure today and operate in harsh economic conditions. At the same time, consumers rightly demand both high quality products and environmental sustainability. We need a thriving Swedish agriculture, and therefore we need researchers like those in Mistra Biotech who are committed to the discovery of ways to combine economic and environmental sustainability.

Inger Andersson
Chair of the Board

Sven Ove Hansson, Professor in Philosophy at the Royal Institute of Technology (KTH) and Guest Professor at the Department of Crop Production Ecology, SLU.

Director's view

It began one and a half years ago. Mistra had announced a call for proposals for a new research programme. The topic was whether biotechnology (in a broad sense) can be used to achieve something positive for the environment, and in particular whether it can deliver more sustainable agriculture. I remember asking a colleague at Mistra's information meeting: "Do you want to compete or cooperate with me?" "Cooperate" he said. "Fine", I said, "so do I".

Many such conversations later, a group of researchers met at Krusenberg, outside Uppsala, to finalize a programme proposal. Mistra wanted a broad approach involving the collaboration of natural scientists, social scientists, and ethicists. And so did we. But it was a tough task to put together a full research proposal, with all the elements in place and effective plans for cross-disciplinary cooperation.

We soon learned that we had two competitors. Of course we were convinced that our proposal was the better one, but what would the evaluators say?

We won! And then followed new meetings, new discussions, and of course lots of work in labs and greenhouses and at computers. Now it is time to summarize the first year. Two things are particularly gratifying for me personally. First, the enthusiasm for cooperation across disciplines that was expressed at Krusenberg has withstood the transition from preparation to execution. Our cross-disciplinary working groups are very productive, and it is especially pleasing to see the willingness of young scientists to take part in them. Secondly, our external communication activities have attracted a lot of attention, and we have found our commitment to a balanced, science-based discussion to be both respected and shared by the stakeholders we have spoken to.

With only one year behind us, we have most of the work in front of us. As you will see in the following pages, we already have a lot of interesting results to report, but the best is yet to come!

Sven Ove Hansson
Programme Director

Field cress (*Lepidium campestre*), a potential new oil crop.

Why breeding?

Domestication of plants and animals has a long history. Plant breeding began about 8000 B.C. when instead of just collecting seeds from wild plants, people started to sow seeds. Surviving plants that gave many seeds were the ones that got their seed re-sown, and by that, natural selection turned into selection guided by human interests. In animals, genetically transmitted changes in behaviour were an important part of domestication. The first animal to be domesticated was the dog, some 10 000 years ago. When humans developed from nomads to village inhabitants who cultivated plants, hunting in the vicinity of the villages eroded wild animal populations and motivated people to explore the husbandry of mammals and poultry. Selection for production and reproduction traits resulted in dairy cows, laying hens and other farm animals. Today's farm animals and cultivated crops have come a long way from their wild relatives.

During the 19th century, Darwin explained evolution and Mendel discovered the basic rules of inheritance. With an increased knowledge about the heritability of traits, and the discovery of chromosomes and genes, we have gone from unintentional selection to advanced breeding programmes where more and more knowledge of the mechanisms behind different traits is used to tailor the sources of our food. Thanks to breeding we have access to healthier livestock and crops, producing milk, meat and grain at levels our ancestors could only have dreamt of. However, the evolution of insect pests and disease-causing microbes continues, and this means breeding for resistant crops is a never-ending project. Certain unfavourable genetic correlations between production traits and other traits have meant that breeding for increased production results in health problems in farm animals, and these problems also have to be handled by improved breeding programmes.

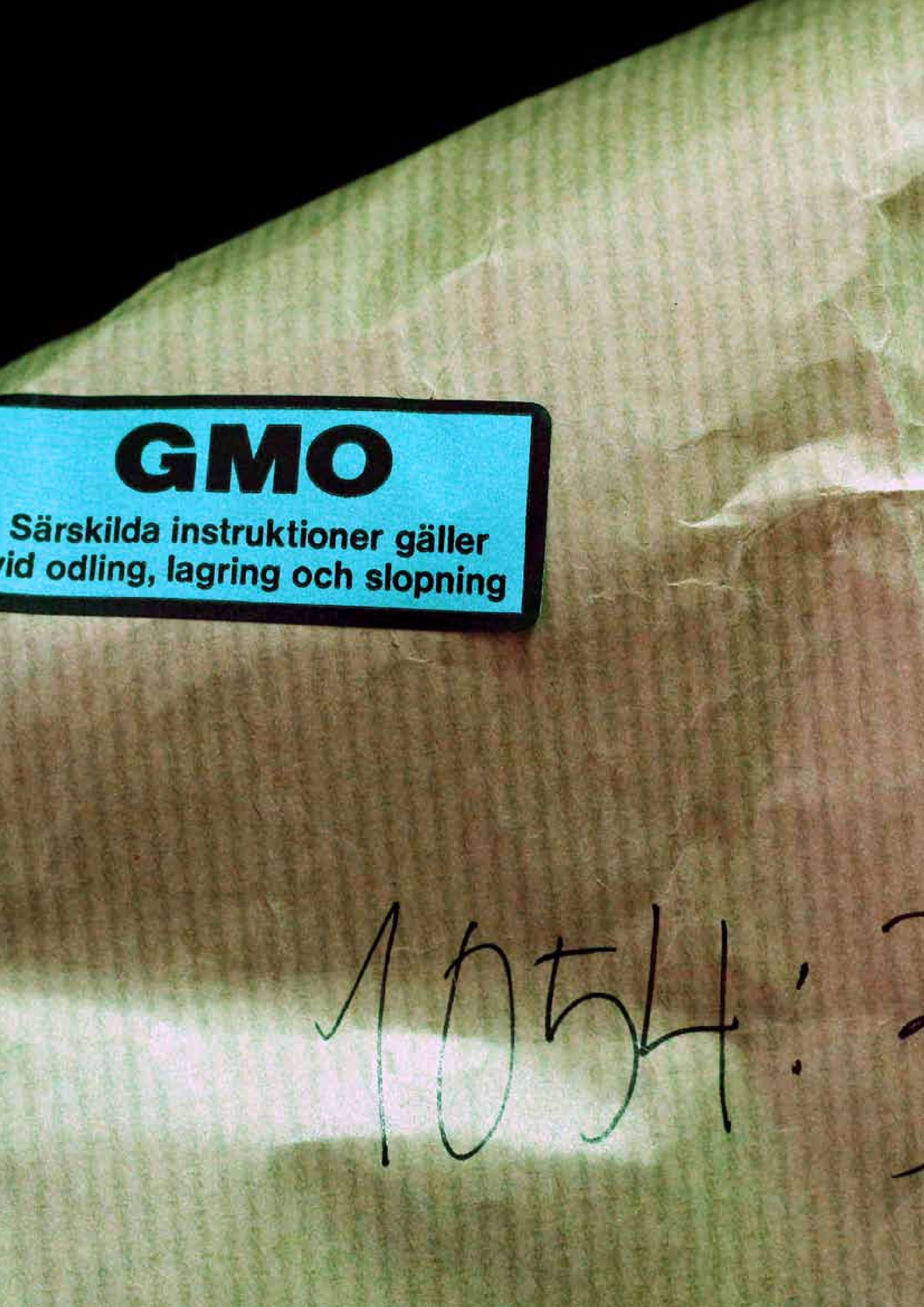
The negative impacts of agriculture on the environment have to be reduced. Agriculture accounts for almost 20% of the greenhouse gas emissions in Sweden, and for around 40% of the Swedish nitrogen and phosphorous load entering the Baltic and the North Sea. On top of this, as we live longer, more people have to be fed in the world, while fossil fuels need to be replaced and food production has to adapt to climate change. New genotypes and production systems have to be developed in response to the changing climatic conditions, not least to the new pests and diseases that can be expected.

Like evolution, breeding is dependent on genetic diversity and the recombination of genes. But the genetic variation, or "gene pool", can be more or less restricted. If all individuals belong to the same family there is limited variation. Also, a desirable trait, such as growth rate, may be closely linked to undesirable traits, and therefore selection for one trait can result in negative changes in others. This explains why different ways to increase genetic diversity have been explored – by increasing the mutation rate, bringing about crossings that would hardly occur in nature, and even by merging cells from different species. Growing biological knowledge and technological development now enables us to turn genes on or off, or to move genes between individuals. And our knowledge of gene functions and traits in different species, in combination with statistics, also gives us the ability to select individuals on the basis not only of specific genes, but entire individual genetic set up. The toolbox used for modern breeding includes a large variety of tools, such as tissue culture, artificial insemination, genomic selection and genetic modification (GM).

Following the first introduction of GM crops 30 years ago many countries adopted GM technology extensively – at any rate, where plants were concerned. Others took a more restrictive approach. GM animals are important for medical research, but so far they have not been used for food production in any country.

Mistra Biotech is an interdisciplinary research programme focusing on the use of biotechnology to secure sustainable and competitive agriculture and food systems. The overall goal is to help to create production systems that are sustainable from ecological, social and economic perspectives.

We use the term "biotechnology" in a wide sense that includes (but is not limited to) the use of genomic technologies, selective breeding, biomolecular markers and genetic modification, as well as technologies for cell and tissue culture, and for animal cloning.


GMO
Särskilda instruktioner gäller
vid odling, lagring och slopning
1054:

Mistra Biotech
– cross-disciplinary research on the edge

The use of biotechnology in crop and animal breeding, especially genetic modification, attracts a great deal of attention today. In the 1970s and 1980s, debate over GM food products was led mainly by the scientists themselves, and there was little divergence between Europe and the US. This changed in the 1990s with intensified public discussion. At that time different regulatory frameworks emerged in Europe and the US, leading to a transatlantic divide. In the EU, a heated debate between stakeholders in the second half of the 1990s resulted in a moratorium on the approval of new GM crops and foods that was not lifted until 2004. Although they were less heated, similar debates occurred in the Asia-Pacific region in the first years of the new millennium and are now taking place in developing regions.

The criticism has many angles and often relates to the applications brought forward by large, multinational companies, and farmers' growing dependence on these companies when it comes to seeds. Questions are also raised about ethical acceptability, and about the health and environmental impacts. A general aversion to what is often referred to as the "industrialisation" of agriculture, and to "unnaturalness", also emerges in the debate. Therefore, economics and social science are as important as natural science to the study of our usage of biotechnology.

In economic terms, Swedish agriculture faces competitiveness problems, and the number of farms and farmers is decreasing rapidly as the result of poor profitability. On the other hand, Swedish agriculture is in a strong position given its abundant access to arable land, water and technical competence. At the same time Swedish consumers are taking the lead in demanding healthy food produced in an ethically sound way.

Sweden has the opportunity to be a path-breaker in the development of sustainable agriculture and food systems. For this potential to be realized close cooperation between research, industry and the public sector is needed, and it will be necessary to take an interdisciplinary approach. In Mistra Biotech we are taking the lead in developing biotechnology that helps us to meet the difficult challenges concerning sustainability in agriculture. Such an undertaking has to be conducted collaboratively, with natural scientists, ethicists and social scientists all involved. Can biotechnology be used to improve crops which mitigate climate change or benefit the environment? What potential is there to commercialise such a crop? How would the consumers react to products made from it? Can breeding technology be improved further? Why does the market for genetically improved plant and animal material look the way it does? What ethical concerns does the use of biotechnology raise? And how do all these issues feed into future agricultural systems? To answer these questions, Mistra Biotech's ethicists, social and natural scientists work together in five different component projects. The results are integrated in the synthesis project called the Centre for Agriculture and Food Systems Analysis and Synthesis (AgriSA).

In Mistra Biotech, we aim to develop...

…new elite plant lines that have benefits for consumers, farmers, the food industry, and the environment.

…biotechnology tools that can be used to achieve new product qualities, healthier livestock and crops, and to solve environmental problems related to agriculture.

…a basis for sustainable production systems that contributes to increased competitiveness in Swedish agriculture and food production.

…tools for ethical scrutiny of agricultural biotechnology that combine high standards of safety with the encouragement of innovation.

…a basis for improved regulatory approaches and private-public relationships.

Jan Eksvärd, Senior Expert in Sustainable Development at the Federation of Swedish Farmers (LRF).

Mistra Biotech reflects a complex reality

Jan Eksvärd is Senior Expert in sustainable development at the Federation of Swedish Farmers (LRF). He has extensive experience of working with environmental issues in agriculture. He has been engaged in several Mistra Biotech events during this first year of the research programme.

– I believe that the research in this programme will benefit Swedish agriculture in many ways. Breeding is crucial if we are going to provide healthy, high-yielding and resource efficient crops to farmers. Today the commercial breeders have slimmed down their investments to relatively few varieties, applicable to a broad market. However, Swedish farmers need varieties tailored to suit various cropping, soil and environmental conditions.

Sustainable agriculture is of great concern to Jan. To solve this complex problem he thinks scientists and breeders will need to use all the tools in the toolbox.

– I think we need to focus on the traits. In a given variety, there are traits like pest resistance, nitrogen efficiency, cadmium uptake, oxygen deficiency tolerance, etc. Since a number of old and new techniques can be used to get the desired features, the breeders should have the opportunity to choose the most appropriate method. Of course, health and environmental safety should be assessed independently of the tool used.

– We are looking forward to seeing the work of AgriSA, the synthesis project in Mistra Biotech, which we hope will develop sustainability criteria for varieties and cropping systems.

The value of agricultural production in Sweden has decreased since 1985, and far from the total production capacity is used. This is a result of many factors, but one thing is clear: if we wish to secure Swedish food production we need to increase the competitiveness of Swedish farmers.

– From our point of view, we are looking forward to seeing results of a research programme that takes several issues in to account, including technology development, the assessment of sustainability, legislation, consumer attitudes, the economy, and production systems. This reflects the reality that farmers encounter every day.

Emelie Ivarson, PhD student at the Department of Plant Breeding at SLU in Alnarp.

Biologist with a mission

Emelie Ivarson has been interested in biology as long as she can remember. In high school she chose the Natural Sciences Programme, and she has a Master in Biology from the Horticultural Science Programme at SLU. Now Emelie has a position as a PhD student in the Department of Plant Breeding at SLU, based in Alnarp, working with the wild plant field cress, or field pepperweed (*Lepidium campestre*). The goal is to develop it into a catch crop that produces healthy oil.

– Field cress can give a really healthy food oil, and if it is grown together with barley nutrient leakage, which is a problem if the soil is left bare, can be avoided.

But to get there many traits have to be improved for example increased oil content, altered oil composition and reduced pod shattering. To achieve this, Emelie does such things as shutting down existing genes and inserting new genes into the plants. Does that not feel strange, to move genes around?

– No, it does not feel strange at all. Genetic engineering is no more unnatural than causing changes (mutations) by radiation or the application of chemicals, which is done in conventional breeding. We are only moving a few genes, and it's what the genes do that matters.

Being part of a large research programme is interesting, especially if you are a young scientist.

– The projects within Mistra Biotech all aim to find solutions to big and important problems of today. The work also gives me many opportunities to meet other researchers working in the field.

Ashkan Pakseresht, PhD student at the Department of Economics at SLU in Uppsala.

An agricultural economist with an interest in behavioural factors

Ashkan Pakseresht's interest lies in behavioural and experimental economics, and his broad background gives him a good understanding of the business world. After he graduated from the Azad University in Agricultural Engineering he started to work at the agribusiness cooperative Moeen Ghaleh. Later he moved to the Kaleh Dairy in Tehran. During this time Ashkan started his first Masters degree in business administration, after which he worked as a marketing manager and brand manager at Pakshoo. Now he also has a Masters in Business Administration from SLU and holds a PhD position in the Department of Economics at SLU, Uppsala.

Ashkan is studying the drivers of consumer attitudes and the behaviour consumers adopt in response to the use of agro-biotechnology in food.

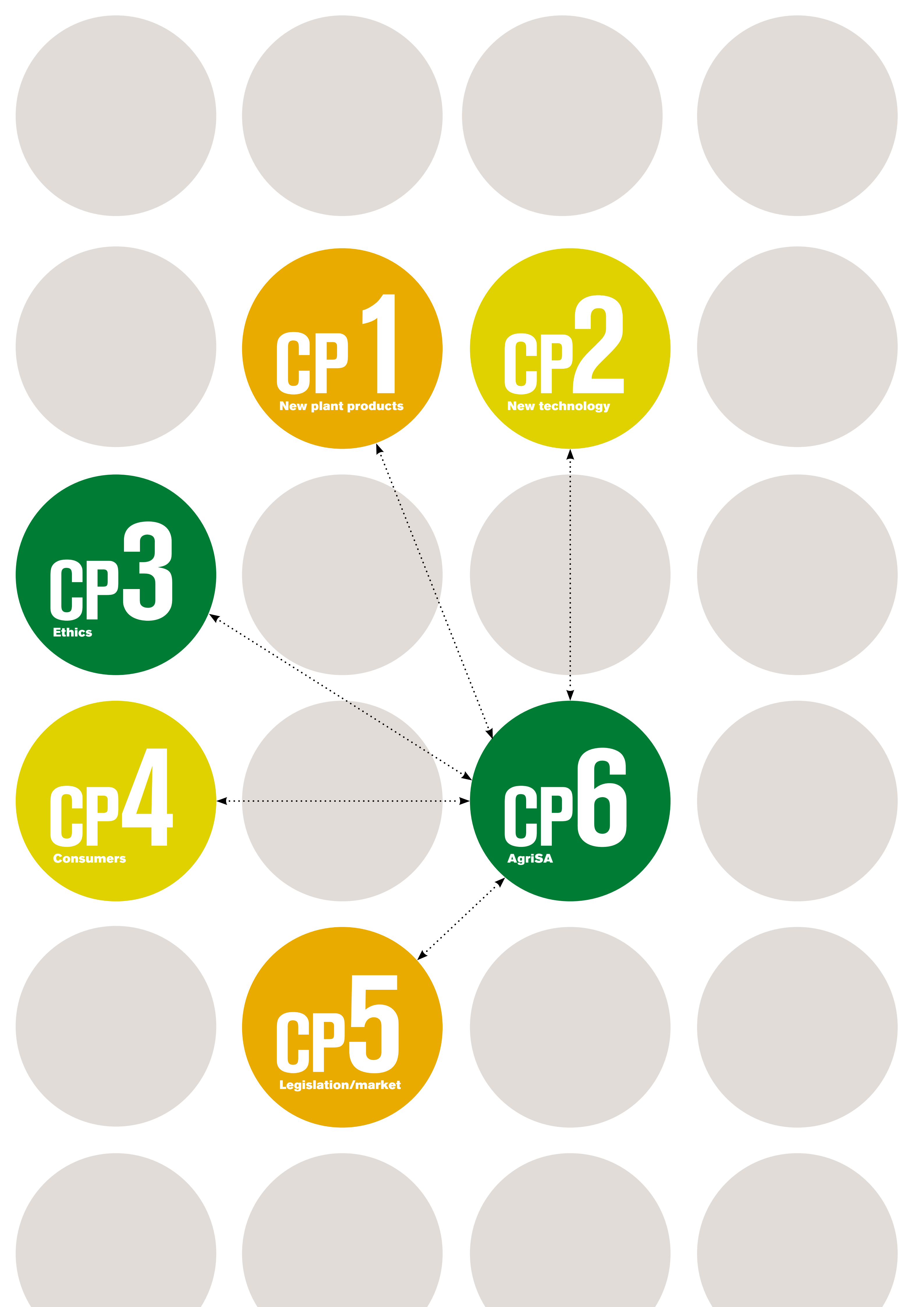
– My aim is to shed light on the ways in which different agents in the food chain make decisions about gene technology. My research will address the question how the risk responsibility connected with agricultural biotechnology is distributed across different target groups, such as consumers, producers, retailers and government.

An understanding of behavioural and attitudinal trends in society also helps food researchers and producers to anticipate the needs society will have in the future.

– A key challenge in meeting these future needs is to understand the potential public response to new technologies in food and crops, and specifically biotechnology.

The cross-disciplinary approach in Mistra Biotech is something Ashkan appreciates.

– It's a great opportunity for me to get into the networks of high-profile researchers in different areas of agribusiness and agricultural biotechnology.


CP1
New plant products
CP2
New technology
CP3
Ethics
CP4
Consumers
CP5
Legislation/market
CP6
AgriSA

Research in the making
– the first year of Mistra Biotech

The research in Mistra Biotech is organised into six component projects (CPs). Five of these focus on separate research areas: new plant products, new technology, ethics, consumer attitudes, and legislation/markets. The results from these CPs are integrated in the sixth CP called the Centre for Agriculture and Food Systems Analysis and Synthesis (AgriSA).
In the following pages you can read about what has been going on in the different projects during our first year. Some managed to kick-start their research. Others devoted time to the recruitment of researchers. We also follow the standard procedure in science of not announcing our results in public before they are published in scientific journals. Keep an eye on our homepage if you are curious!

Mistra Biotech involves over 50 researchers. Most are at SLU, while some work at KTH, Lund University and other academic institutions. The programme includes international cooperation with, among other institutions, Aarhus University and the University of Edinburgh. Mistra Biotech is funded by Mistra with 10 million SEK per year. SLU co-funds the programme, matching the Mistra funding with a further 10 million SEK. This funding is provided at three levels: central SLU, the four faculties and all departments with researchers active in the programme. Many companies, agencies and organisations also support the programme with their knowledge, experience and valuable feedback. Lantmännen SW Seed AB also contributes financially with a sum of 50 000 SEK per year.

Programme kick-off 2012 at Wik Castle.

Plant biotechnology for innovative products

CP 1
component project

In this project we will develop the biennial wild species *Lepidium campestre* (field cress, also known as field pepperweed) into an oil and catch crop with the aim of reducing soil tillage and mitigating nutrient leaching. We will also make nitrogen use more efficient and improve pathogen resistance in barley and potato to reduce reliance on fertilizers and pesticides. Finally, we shall focus on health issues concerning starch. We aim to will develop a potato with a low glycemic index (GI), and to analyse the structure and properties of the starch amylopectin from different types of barley.

FIELD CRESS – A NEW OIL CROP

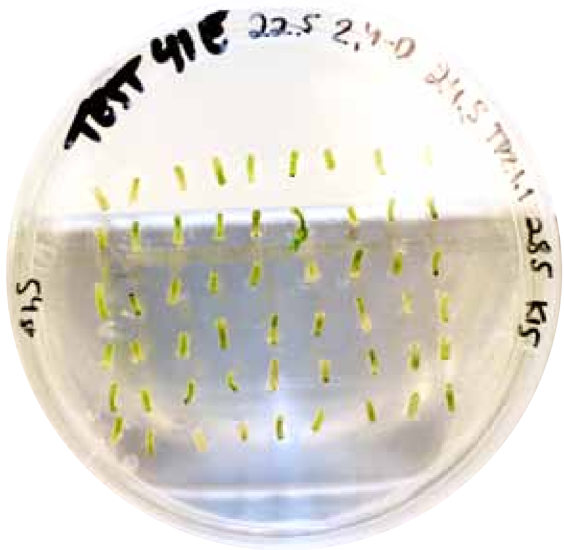
In the work with field cress we have used both genetic modification and non-GM techniques. This enables us to compare the breeding method's effects on the improvement of important agronomic traits. The main targeted traits are: oil content, oil quality, yield and pod shattering. Pod shattering (i.e. seed drop before harvest) cause huge losses in yield.

To improve oil content we transferred a gene, proven to increase oil content, from *Arabidopsis* (rock cress) into the field cress. Over 20 transgenic lines were recovered and planted in the greenhouse. Some have been harvested, and preliminary results suggest the oil content has increased. However, more transgenic lines and generations are needed to verify this. Some lines have been planted in the greenhouse to produce the subsequent generation of seeds for analysis. Meanwhile, three haemoglobin genes from *Arabidopsis*, sugar beet and a bacterium were also transferred into field cress, but here the results have yet to be analysed.

The DNA looks like a spiralling ladder. In this ladder every step is made up of base pairs of A, G, C and T. An A is always adjacent to a T, and a C is always adjacent to a G, so the two strands of the ladder is a mirror of each other. The order of the bases determines the amino acid they code for (the code is made up of three bases).

We are also trying to increase levels of the healthy oleic acid (omega-9), which is a monosaturated fatty acid, by turning off the genes coding for specific enzymes that otherwise make longer chains of fatty acids, which are less healthy. This is done using so-called RNA interference (RNAi) technique. When part of a target gene sequence that produces RNA complementing the plant's own single-stranded RNA is inserted the RNA becomes double-stranded. This double-stranded RNA is cut into small pieces by a specific RNA-cleaving enzyme, which results in gene silencing. Here we used the sequences of two genes from the field cress itself to make RNAi. As yet, however, the oil content analysis has not yet been carried out. We have also used the RNAi technique to reduce pod shattering. Here we use a gene from field mustard (*Brassica rapa*) which has been shown to down-regulate the pod-shatter gene in *Arabidopsis*. We have also tried to use the equivalent gene in field cress for the same purpose, but it is too early to draw any conclusions about the outcome.

In the non-GM approach we searched for field cress plants with desirable traits in all of the regions of Sweden where field cress is reported to grow, from the southern tip of the country up to Gävle, as well as from the west coast to the east coast, including Öland and Gotland. Representative samples of these newly collected populations are now planted in the greenhouse for characterization and evaluation. Field evaluation of 1600 individual plants – a collection including selected genotypes from the 2012 field evaluation and the newly collected populations – is performed to identify less pod-shattering genotypes and genotypes that are resistant to major diseases and pests. Other major traits that we are working on include seed yield, seed size and weight, synchronised maturity and root growth. Synchronised maturity is crucial in crops; it enables the farmer to harvest as much high quality seed as possible. A good root system enables the plant to compete for water and nutrition, and is especially important in a biennial (two-year) crop because the root establishment in year one determines how much energy can be allocated to flowering and seed-setting in year two. A good root system also reduces nutrient leaching. Promising field cress genotypes have now been selected for the second round of screening and breeding.
Our goal is to increase the oil content in field cress



One way to insert new genes into a plant is to use the soil bacteria *Agrobacterium tumefaciens*, that normally insert its own genes, to carry "our" genes. Here pieces of the first shoot emerging from the field cress seeds are infected with the bacteria. When new shoots start to develop they are moved to a selection medium where only plants containing the new genes can grow.

seeds to over 30%. Over 300 plants from the ones known to have a relatively high oil content were both selfed and crossed. A preliminary study of their oil content and fatty acid composition shows wide variation in oil content. Linolenic acid (polyunsaturated) was the highest of all the individual fatty acids. Among the monounsaturated fatty acids, erucic acid was dominant, followed by oleic acid. In general we found very small variations in fatty acid composition among different plants. Although the oils contain a high level of polyunsaturated fatty acids, there is a good resistance to oxidation. This is possibly due to other minor components in the oils, such as tocopherols, which have high vitamin E activity and function as antioxidants. The level of cholesterol was remarkably high relative to that in other known vegetable oils.

We also attempted to improve important traits by crossing field cress, which is *Lepidium campestre*, with *Lepidium heterophyllum*. The hybrid plants do have desirable traits, such as high yield, larger seed size and perenniality. These hybrids are now being crossed to create substantial genetic variation in the second generation which will be used to map genes. A large number of crosses were also made between *Lepidium campestre* and *Lepidium graminifolium* to transfer high oil content genes from the latter to the former through backcross breeding. However, although the crosses appeared to be successful at an early stage, the developing seeds collapsed after few days, so no viable hybrid seeds have been obtained so far. We will try to overcome this problem using embryo-rescue methods.

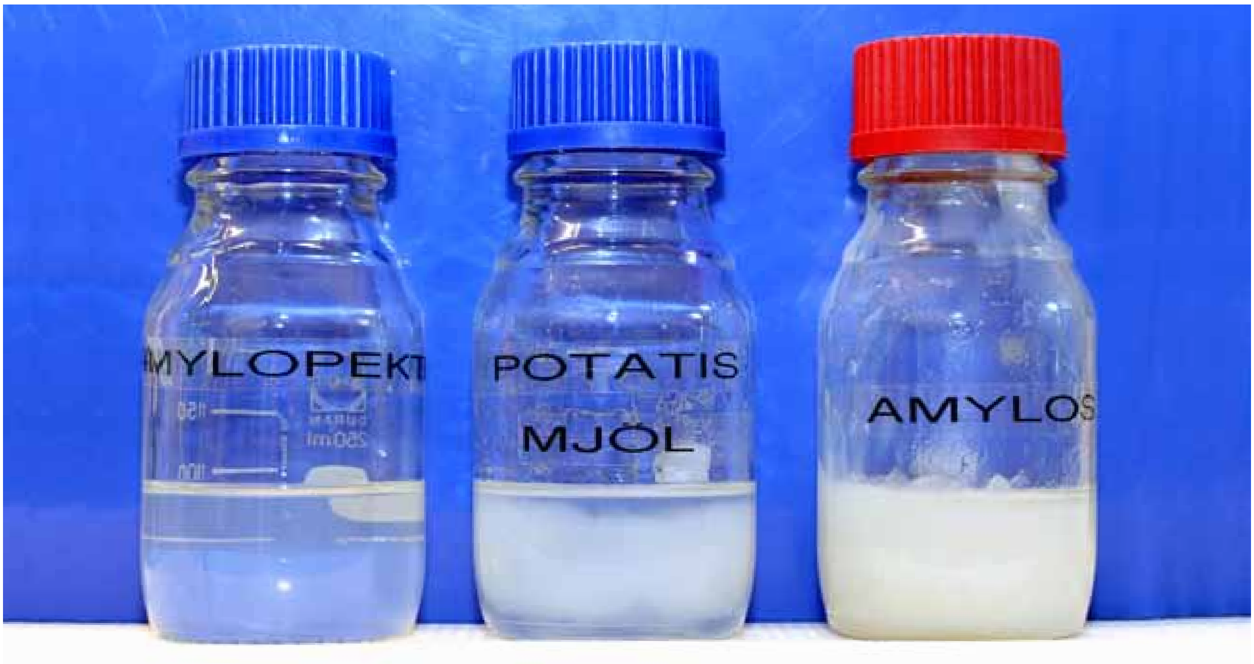
From gene to protein: the DNA unfolds, exposing the strand to be copied by the transcription machinery to messenger RNA, using the coding DNA strand as a template. The mRNA is translated, in accordance with the code, into a long row of amino acids, which then are folded into a protein.

DNA samples from diverse field cress material are ready to be sent for sequencing; and the RNA of promising plants will soon be extracted and sent for transcriptome analysis. In this type of analysis we obtain sequence information on all the RNA, enabling us to tell which genes are actually active in that specific individual. This gives a better picture of which genes affect a specific trait, taking us beyond mere knowledge of which genes an individual is carrying.

From this project we provide DNA and RNA from desirable field cress plants to the component project working with the development of genomic breeding tools: CP2. We also provide field cress seeds for field trials: CP6.

IMPROVING BARLEY AND POTATO

Here we have been focusing on improving nitrogen uptake and pathogen resistance using various gene technologies. The first step was to establish a protocol for barley transformation. We have tested two selec-



Five per cent potato starch heated in water. Usually it is made up by 25% amylose and 75% amylopectin (the jar in the middle) but by turning of specific genes those proportions can be changed. The difference between amylopectin and amylose is clearly visible to the naked eye.

tive agents, kanamycin and hygromycin, for choosing individuals with successful insertion of the target gene. It appears that shoot regeneration is quicker with hygromycin than it is with kanamycin. However, final conclusions cannot be drawn at this stage. We have now selected two Swedish commercial varieties of barley which will be transformed.

One fairly new and promising-looking method of controlling the expression of genes is so-called site directed mutagenesis. This consists of a number of techniques including TALEN (i.e. transcription activator-like effector nuclease). We shall be using the TALEN method to improve disease resistance in barley and potato. In this method, you use an artificial restriction enzyme (nuclease) which cuts DNA strands to mutate a small part of a target gene at a specific position – creating a targeted mutation. In doing this, we change the gene sequence, and thus the gene expression, while leaving no foreign DNA in the organism's offspring. So far we have synthesised four nucleases for potato, and the enzyme sequence is under evaluation for its correctness. We will use two scaffolds (the part that binds to the correct site) for TALEN to ensure the TALENs to work in our target species. We also need to establish effective technique for delivering TALENs into potato cells, and here a protocol is currently in progress. When we have established the technique in diploid potatoes, we will continue to work on disease resistance in their tetraploid cousins. After effecting site-directed mutagenesis in the diploid potato, we will establish the technique in barley for powdery mildew resistance.

In our work on improving nitrogen uptake we have focused principally on a GM barley field trial where we investigate the influence of two introduced genes responsible for root uptake of amino acids: one for the uptake of alkaline amino acids, and the other for the uptake of neutral and acidic amino acids. We have also characterised GM barley and GM rapeseed carrying the same genes, and have just started working with potato lines as well. Three GM barley lines were selected for a field trial in which we injected solutions of labelled amino acids into the field plot. In this way we could measure the amino acid uptake. The test gave inconclusive results: essentially, no difference was detected in above-ground biomass of wild types and GM lines. Interestingly, however, the lines transformed with the gene for uptake of alkaline amino acids showed some differences in seed weight as well as in seed nitrogen content. This may be down to a relatively small trial size, but the possible impact on seed properties is interesting and will be investigated further. In view of the inconclusive results, we are planning to make new transformations with a focus on strong expression of genes in the roots. We will also look at soil properties, and at non-GM barley growth on green manure (clover mix).

STARCH – OUR MOST COMMON CARBOHYDRATE

The quality of starch is of great importance in both human food and animal feed. But the starch can have different properties depending on granular size distribution, composition and the chemical structure of the individual starch components, amylose and amylopetin. When starch is heated in water the bonds between the starch molecules are broken down and the starch binds more water. This is called gelatinization. High amylose content in the starch is expected to influence starch gelatinization, and also to affect what happens when the starch cools again, i.e. retrogradation. Retrograda-


tion occurs when the starch thickens, turning into a gel, due to its rearrangement into more crystalline structure. The boiling of high amylose starch is expected to result in a high degree of starch crystallization. The resulting retrograded amylose is unavailable for digestion and should therefore give a low glycemic index (GI). We have investigated the fine molecular structure of the amylopectin isolated in various genotypes of barley. We found that a mutation linked to starch biosynthesis results in a modified amylopectin structure. We are now investigating how different molecular units in the amylopectin are interconnected in these barley samples. A certain category of glucose chains, building up the amylopectin molecule, is thought to play a role in cluster interconnection, and thereby in the compiling of domains. Other categories of shorter chain-lengths are believed to interconnect smaller amylopectin building blocks. More information on the fine structure of amylopectin will improve our understanding of the relations between starch structure and several functional properties. These relations will be studied during the coming year.

THE GI-POTATO

Potato starch is usually made up by 25% amylose and 75% amylopectin. By turning off two genes that code for enzymes involved in the building of amylopectin, we can increase the ratio of amylose. More amylose and less amylopectin results in a lower glycemic index, and thus a healthier potato. Six high-amylose potato lines (GM) and three parental varieties (non-GM) were grown in a field trial to measure the amylose/amylopectin ratio, the starch content, and the tuber yield. Results from the trial show that potatoes with high amylose content had lowered starch content. There were minor variations in tuber yield – a result of greenhouse-propagated seed potatoes of varying size. We found an increase in tuber yield in the line with the highest amylose content, which somewhat compensates for the severe decrease in the total starch content in that line. It was not easy to extract starch from this potato, owing to the small starch granules (a phenotypic feature associated with the high amylose trait). We extracted starch from three lines with preliminary amylose contents of 35–70%.

We have now begun studies into ways of circumventing the starch yield drag. The research will be focused on the unknown mechanism behind the extraordinarily high starch content of the potato variety Verba. This variety will be crossed with our high amylose potato. We will also do transcriptome analyses in order to compare their gene expressions, and find out which genes are affected in the high-amylose line and thus responsible for the severe starch yield drag, and which genes are responsible for the high starch content of Verba. Interesting genes will then be isolated and transferred into the high amylose line.

Collaborations

Lyckeby Stärkelsen.

Swedish Rural Economy and Agricultural Societies, Kristianstad.

The GenePool Ashworth Laboratories, University of Edinburgh.

Prof. Lars Østergaard, John Innes Centre, UK.

Prof. Thordal-Christensen's group, Copenhagen University.

Novel molecular breeding tools

CP2
component project

The majority of economically important traits in crops and livestock, whether we are talking about product yield, product quality, or disease resistance, are so-called complex traits governed by many genes and environmental factors. Traditional breeding approaches have used pedigree information and statistical tools to estimate the proportion of variation that is due to heritable factors, but treated the genome as a "black box". Today new technologies facilitate the sequencing at a fraction of the original costs. We will be providing methods and tools for the use of whole genome sequence data in breeding – that is, where you select your plants and animals using information about their entire DNA instead of looking at specific genes. Additionally, we will be investigating the potential to use information about proteins, the genetic product, in breeding. The gain here is the ability to screen for, and select, suitable plants and animals at an early stage in the breeding process.

MOLECULAR BREEDING USING THE COMPLETE CODE

Genomic selection in crops

The theory that the accuracy of selection can be predicted using a method called genomic selection has been shown to work well in dairy cattle breeding. However, many breeding programmes for other species have characteristics, such as the extended use of crossbreeding, which will make any application of genomic selection more complex. Additionally, traits in plant species are often largely dependent on environmental factors. The need to implement these differences into selection tools presents challenges for molecular breeding, but the challenges will also provide new opportunities for improved use of molecular breeding tools in dairy cattle. We have conducted an extensive literature survey to assess the current state of molecular breeding in crops. We discovered that although a great deal of work had been published on statistical methodology, little is known about practical application strategies. Many large companies are currently working on strategies for the implementation of genomic selection, but their results are often not yet presented fully in the public domain. We will continue to evaluate the opportunities for genomic selection in crops. We will also evaluate the use of the technology in a pilot study of oats.

Molecular breeding in Swedish Red cattle

At present more than 15 000 dairy cattle bulls of the Nordic Red breed have been genotyped via high-throughput arrays for 50 000 or even 700 000 so-called "single nucleotide polymorphism" (SNP) in a series of collaborative projects involving Sweden, Denmark and Finland. An SNP is a difference in a single nucleotide (A, T, C or G) between two individuals of the same species. SNPs can be found in large numbers throughout genomes. And this variation can be used as marker for different traits. It is especially useful when it comes to traits that are affected by several genes. Traditionally the genetic merit of an individual (which has a significant impact on phenotypic features, such as body size or milk yield, of its offspring) is determined by information on relationships and trait measured on relatives. In genomic selection the genetic merit of an individual is determined on the basis of the genome-wide SNPs using sophisticated modelling techniques. Information on SNPs has facilitated a revolution in dairy cattle breeding, where traditional family-based selection has now been improved by genomic selection.

New techniques, such as the sequencing of the whole genome at relatively low cost, have also been applied in the Nordic Red breed. The first step for this analysis was to identify which bulls to select for re-sequencing. Using a pedigree analysis, we calculated the relative contribution of all bulls to the current bull population in Sweden, Denmark and Finland, and then selected 16 bulls for sequencing. In a joint effort with other research groups, a total of 65 bulls (key ancestors) have been sequenced. We know from studies of Holstein bulls that more than 20 million SNPs can be expected to be identified across these bulls. Together with colleagues in Finland and Denmark we will exploit this novel data through a number of joint research activities. Our focus will be on the translation of information on these millions of SNPs into an understanding of all genotyped bulls. A method called "imputation" will use knowledge of genomic structure from SNP information and replace the missing data in the datasets of 50 000 or 700 000 SNPs with substituted values from genetic relationships among the millions of SNPs. We

Genomic selection is used in the breeding of dairy cattle worldwide and is also a very active area of research for other livestock and crop species.

are hoping to have statistically estimated datasets for more than 20 million SNPs for all Nordic Red bulls genotyped using the high-throughput arrays. The sequence and imputed SNP information will then be used to identify important individual mutations related to economically important traits (such as milk yield) and assist further efforts to improve genomic selection. Additionally we will join an international collaboration which aims to collect full genome sequences from 1000 bulls. This is likely assist to improve our knowledge of important genes in the genome of dairy cattle.

INTRODUCING MOLECULAR BREEDING IN NOVEL SPECIES – APPLICATION TO FIELD CRESS

The technological development of high-throughput sequencing (or next-generation sequencing) enables us to study the genome of any species of interest. This means that we might be able to apply genomic selection more quickly in species which are currently domesticated or where selective breeding will be newly applied.

Among the many methodologies for next-generation sequencing, RAD (Restriction site Associated DNA) sequencing is well suited for the whole-genome sequencing of species where little knowledge of the genome structure is available. For the sequencing of field cress, we began by identifying plants with the most promising traits (such as seed size, yield and low pod-shattering) in collaboration with CP1. After two generations of trait recoding and selection we were able to select the most promising plants. DNA was extracted from leaves of all plants and a total of 10 plants were selected for sequencing. We are currently improving the DNA extraction protocols to provide the best possible material for RAD sequencing, and to limit contamination by non-plant DNA. At the same time, seeds from selected plants are being replanted for an extended recoding of their traits and to provide additional DNA material for future experiments.

PRECISION BREEDING USING PROTEINS

Proteomics is when you study the proteins in an organism. It compares with genomics, where you look at all the DNA. You might say that you study the cake rather than the recipe.

We will develop assays for measuring the levels of specific proteins. Potentially the assays could be used to predict the features of different crosses in breeding programmes, as an alternative or complement to genomic markers.

In the method used, complex protein samples are first digested to yield peptides (i.e. small proteins) using a

The small field cress (*Lepidium campestre*) plants are nurtured until they are big enough to be planted in pots with soil.


Field cress have the potential to become a new oilcrop. One trait that needs to be improved is pod shattering, well illustrated in the righthand photo.

specific enzyme. The peptide mixture is then separated using liquid chromatography, and the levels of specific peptides are measured using mass spectrometry. High performance measurements can be achieved by using a targeted mass spectrometry technique, called selected reaction monitoring (SRM). With SRM technology a set of a few hundred peptides can be measured in a sample, but the first task is to select the peptides to measure. We have developed a strategy to select the most appropriate peptides to measure in the potato. The selection is based on previous analyses using protein measurements where potential indicators of resistance to the disease causing water mould *Phytophthora* in potato have been detected. We selected groups of peptides which were either differentially expressed in susceptible and resistant potato varieties, or differentially expressed during infection, or specific to certain gene variants, or always expressed. When developing the SRM assays for the peptides we used real samples, and in cases where the peptide identities were not certain synthetic reference peptides were also used for comparison. In total we developed SRM assays, targeting 273 unique peptides, which have been used to measure the peptide levels in three potato varieties, both uninfected and during *Phytophthora* infection. The goal is to develop assays for field cress and dairy cattle as well.

Collaborations

Lantmännen, SW Seed AB.

SciLife Laboratory, Uppsala.

Aarhus University, Denmark.

MTT Agrifood Research, Finland.

GenePool Ashworth Laboratories, University of Edinburgh, UK.

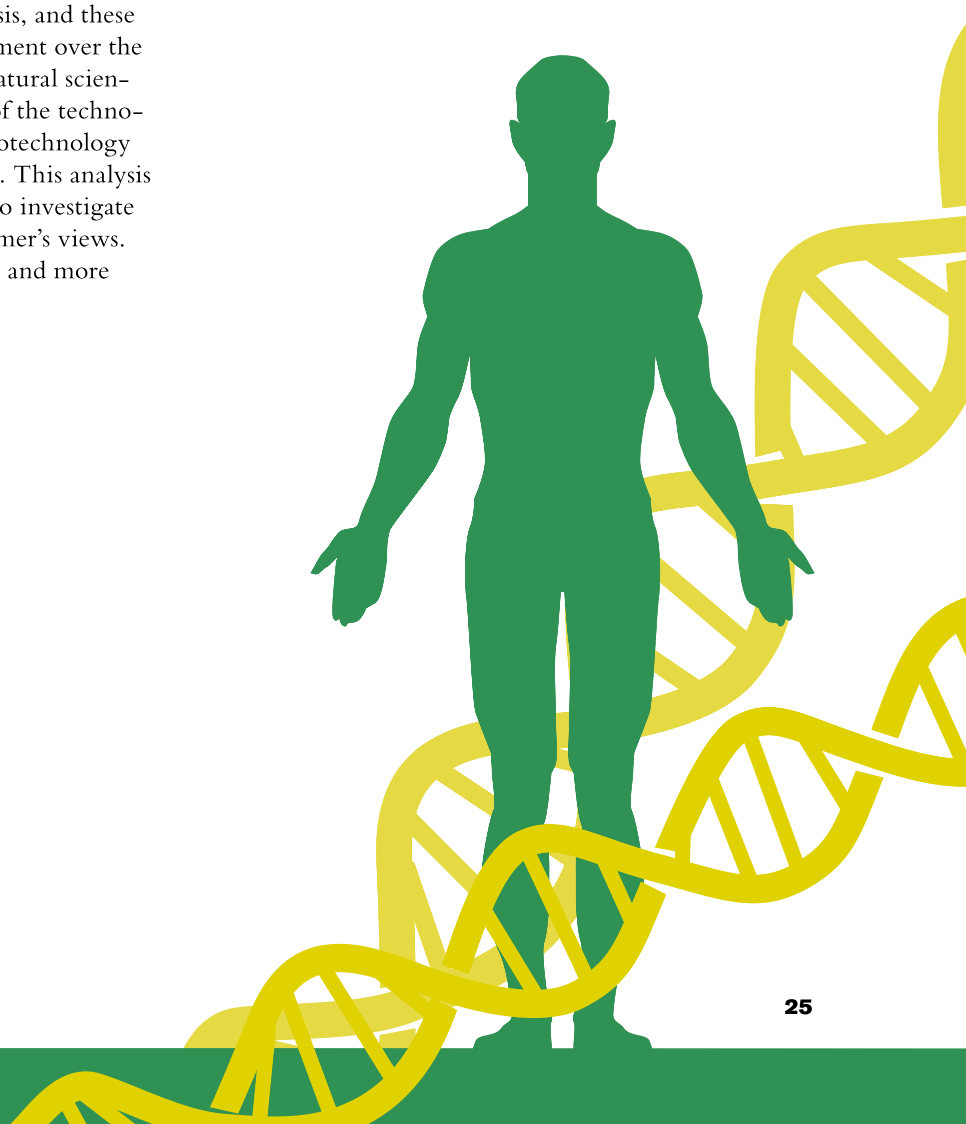
CP3
component project

Ethics

The debate about ethical issues in biotechnology and its applications is very polarized – some people are against, some in favour, and these views are often very firmly held. Despite the large literature on ethics of technology in general, there is a shortage of studies carried out in close collaboration with the scientists developing actual technologies. Therefore, much of the debate is insufficiently informed by recent developments and rather sweeping in character. Also, few applications of ethical technology assessment involve new biotechnologies, and even fewer take into account the potentially positive environmental and health impacts of agricultural applications of biotechnology in a systematic way. We hope to provide a structured method of making this debate less polarized, allowing everyone to better understand each other's arguments.

There is a set of method-developing tools such as checklists and matrices for ethical analysis, and these methods have undergone rapid development over the last decade. In close cooperation with natural scientists we will undertake a close analysis of the technological and use-related dimensions of biotechnology that may influence its ethical assessment. This analysis will also be used in consumer research to investigate the impact of different factors on consumer's views. The cooperative approach provides new and more precise knowledge of the factors that influence ethical appraisals of agricultural biotechnology, and we are working on an ethics toolbox.

We also will investigate what a "precautionary" approach might involve in the context of agricultural biotechnology, and we will study some concepts that are common in the public debate, but which are sometimes cursorily treated in the scholarly discourse, such as naturalness and sustainability. The latter is now being analysed in a joint working group as part of CP6.



CP4
component project

Consumer attitudes

Why do consumers – you and I – act as we do? What are the driving forces behind attitudes and behaviours when it comes to food produced using agricultural biotechnology? What is our perception of risks and trust? We hope to reach a better understanding of the underlying consumer-related issues that will play an essential role in the uptake and use of any application of agricultural biotechnology in Sweden.

WHAT DOES THE LITERATURE REALLY SAY ABOUT CONSUMER ACCEPTANCE OF BIOTECHNOLOGY?

Social science research on GM crops and foods has diversified remarkably. While most of the early researchers perceived themselves as conducting a technology assessment, there was a shift in the late 1990s towards interdisciplinary consumer research. Research became more academically ambitious, much of it focusing on psychological as well as the behavioural foundations of technology acceptance among members of the general public. There is already an extensive research literature on attitudes to biotechnology in food production and food products. We have collected and categorized the available literature on consumer evaluation of biotechnology in food production and food products. This collection now includes approximately 1200 scientific publications from more than 20 databases. The data in the literature had to be re-scored for the outcome variables as original studies reported results using a range of scales. The data will function as the dependent variable in further estimations of a meta-model.

We have now combined information from 1673 individual survey questions about attitudes to biotechnology in food products. These questions come from 214 (of the 1200) studies, covering 58 different geographical regions. In total, the information in this meta-survey is based on responses from more than 200 000 respondents. We make the working assumption that all survey questions in our dataset capture aspects of the underlying psychological factor "attitude". Therefore, we will identify the way differences in the rescaled mean response rate (that is, our empirical representation of "attitude") can be explained by food product characteristics and the relevant biotechnologies, but also by the information provided during a survey. We also tested if, and to what extent, regional differences regarding consumer attitudes exist, and whether peer review affected reported findings within our literature sample.

Soon we will also have results from a second meta-analysis in which we use an economic measure as the dependent variable. The idea is to examine the extent to which economics research, on the one hand, and alternative forms of social science research, on the other, have been able to provide consistent results on consumer acceptance of biotechnology in food.

Another task in the near future is to demonstrate that the discrepancy between what consumers say and what they actually do (i.e. between declared and revealed preferences) where biotechnologies are concerned is in part due to behavioural costs – that is, the costs of adhering to a certain attitude or belief. We will integrate the aspects of attitudes as behavioural costs and consumer perceptions of risks and benefits. A more ambitious aim will be to demonstrate that change in the real or perceived behavioural costs of accepting or rejecting biotechnologies can in fact change behaviour motivated by attitude. Additionally, the likelihood of engaging in any food-related biotech action depends not only on the strength of a person's attitude to biotechnology, but also the severity of the risk.


EKSTRÖMS
Frasvåfflor
FRASVÅFFLOR
KANELBULLAR
VILL DU SMAKA PÅ ANDRA BULLAR?

CP5
component project

Swedish competitiveness

The economic and regulatory environment in which firms operate has a direct effect on their ability to produce and to adopt new technologies. Firms will produce innovations when they have the ability to commercialize, to sell a product or service at a profit. The profitability of an innovation depends on the degree to which they are able to capture the economic rents generated by their innovations.

We analyse the structure and governance of the Swedish agri-food system and the national and international regulatory environments. We also explore Sweden's capacity to produce and distribute innovative products and processes, constraints on this capacity, and the impact of all this on the Swedish economy. We plan to provide a synthesis which will be part of the basis for discussion of policy recommendations. The results will be relevant to actors in the primary agriculture sector, the biotech industry, and other stakeholders in the processing and distribution agri-food industry.

INDUSTRY STRUCTURE AND GOVERNANCE

We are investigating the vertical and horizontal structure of the Swedish agri-food industry. The analysis of market power along the agri-food value chain is critical for the adoption of GM crops, because firms with market power upstream (biotech firms) or downstream (processors and retailers) can be the beneficiaries of many of the gains generated by the adoption of GM crops. The analysis is going to be limited. Adequate data are not available, and we are using mainly secondary data from published sources.

We are also reviewing literature on theories and methods for the study on governance between firms and farms in the agri-food value chain. More specifically, we shall provide a basic understanding of the analysis of governance including contractual arrangements, alliances, clusters, and network formations in the oilseed, cereal and potato industries. Property rights, incentives and information are key factors for this study. Additionally we are analysing networks in the biotech and agri-food industry, and we are investigating how the various network measurements, including centrality, determine innovation activity and firm profitability. The unit of analysis in this study is the "relationship" between firms.

POLICY AND REGULATIONS

To what extent does the EU regulatory framework on biotechnology function as a trade barrier? Does it enhance competitiveness and innovation? How does it contribute to the management of a globalised policy? How do existing institutions involved in biotechnology help, or inhibit, further developments in research, business development and policy? These are some of the questions investigated in this part of the research. At present, we are reviewing the literature on these issues.

We will also study the overall competitiveness of the Swedish biotech and agri-food industry using a synthetic model that integrates the agri-food and biotech industries into the Swedish economy as a whole, including imports and exports.

Centre for Agriculture and Food Systems Analysis and Synthesis (AgriSA)

The work in AgriSA focuses on whole production systems and stretches across disciplines within the human, agricultural, natural, and social sciences. The aim of this work is to understand and facilitate the implementation of sustainable food production using biotechnology as a tool. AgriSA is the hub where the information and results from all Mistra Biotech projects are processed and where overall syntheses are made and communicated to stakeholder groups.

In AgriSA scientists from all the Mistra Biotech projects will be working together with stakeholders and experts on food production systems and methods of system analysis. They will be focusing on, among other things, scenario development, lifecycle assessment, and cost-benefit analysis.

At the moment we are discussing the following issues within AgriSA:
1) What is included in the concept of sustainability in relation to green biotechnology?
2) Ecological and evolutionary consequences of plant biotechnology.
3) Consequences of the biotechnology regulation system.
4) Field trials, communication and relations with producers and consumers.
5) The sustainability assessment of different production systems.

Researchers from the other Mistra Biotech projects and researchers involved exclusively in AgriSA are now collaborating in three working groups:

Inventory of plant and animal breeding – methods, products and industry
This group of about 10 people is preparing a popular science booklet that will stimulate interest in genetics and also serve as a common base for all participants in Mistra Biotech. It will incorporate texts on: today's plant and animal breeding; the way domestic species have developed; breeding methods; contemporary production using GM plants and livestock; rules and regulations for breeding and for production based on genetic modification; the economic value of genetic improvement; and ethical views on breeding. We will use the booklet in our work with schools, stakeholders and colleagues in other areas.

Ecological and evolutionary consequences of biotechnology in plant and animal production
Nine researchers are working on the ecological and evolutionary consequences of using biotechnology in plant and animal production. They are performing a literature review covering crops, husbandry and microorganisms, and including aspects of production, greenhouse gas emissions, nutrient cycling, carbon sequestration, biodiversity, and pest regulation.

Analysis of the sustainability concept
The members of this group are analysing the sustainability concept, particularly in relation to green biotechnology. Discussions that took place at a workshop in January 2013 will be used in a synthesis article that this group is writing.

FIELD TRIALS WITH NOVEL CROPS AND CROPPING SYSTEMS

AgriSA is responsible for the field trials in Mistra Biotech. The idea with a catch crop like two-year field cress is that it can be sown together with a cereal, and then, after the cereal is harvested, it prevents nutrients leaching during the winter and is harvested the following year. During 2012 we established several field trials with field cress sown in with barley. Unfortunately only two of these were successful. The reasons for these problems were probably a combination of low vitality in the seeds and unfavourable weather at the sowing sites. Observation plots sown exclusively with field cress were sown in autumn 2012 so that we could monitor winter hardiness. Two other on-going field studies are focusing on nutrient leaching.

In autumn 2012 barley was harvested in two trials to study the effect of field cress. The barley yield was similar in both trials, and no significant effect of the undersown field cress was observed. It is known that barley is allelopathic – that is, it can influence neighbouring plants negatively. There is a risk that the barley

Field cress form rosettes during the first year and is therefore not damaged when the barley is harvested. Next year, the plants will flower and produce oil-rich seeds.

cultivar used, Quench, was too competitive with the field cress. Both germination and growth of field cress was low when it was sown with Quench. However, cultivars differ, and so to find a less allelopathic plant we tested five barley and five wheat cultivars looking at germination and root growth inhibition on field cress. The test revealed that germination was reduced by 10–20% and root growth by 35-60%, depending on the cultivar. The lowest inhibition was observed when the field cress was grown together with some of the wheat cultivars. Interestingly, the barley cultivar Barbro showed low allelopathic activity close to that of the wheat cultivars. Thus, in the trials next year Barbro will be used instead of Quench. We will also include the wheat cultivar Bagett, since this displayed remarkably low allelopathic activity.

Field trials with GM barley with high nitrogen utilisation efficiency and GM potato with high amylose content were also performed during the summer 2012, with results that can be read about in CP1.

Collaborations

Lantmännen SW Seed.

Department of Biology, Lund University.

Swedish Rural Economy and Agricultural Societies Stockholm, Uppsala, Södermanland and Kristianstad.

The GM barley and potato were in focus when media was invited to see the field trials.

Programme Director Sven Ove Hansson at the KSLA seminar day "Sustainable agriculture – does it need modern biotech?"

Li Feng, postdoc in CP5, at the "SciTech Europe 2012" conference in Brussels.

Erik Andreasson, researcher in CP1, informing about Mistra Biotech at the agricultural fair "Borgeby Fältdagar".

Panel discussion at the seminar day "The Future of Plant Biotechnology in Europe". Tina d'Hertefeldt Lund University, Sven Ove Hansson Mistra Biotech, Huw Jones Rothamstead Res./EFSA, Jan Eksvärd LRF and Frank Hartung JKI/EPSO.

Activities

20/3: Li-Hua Zhu presented the Mistra Biotech program in the meeting on modern gene technology for food production held by "GMO-nätverket".

9-10/6: Mistra Biotech was represented by the communicator at "Ekohjulet" - public meet researchers and experts, organised by Antonia Ax:son Johnson's Foundation for the environment.

8-13/7 Emelie Ivarson, Sten Stymne, Li-Hua Zhu (and others) presented a poster at the 20th International Symposium on Plant Lipids, Sevilla, Spain.

16/8: Li-Hua Zhu was invited by the president of the Huazhong Agricultural University, Wuhan, China, where she presented the field cress project for 120 PhD students.

27-28/6: Representatives from Mistra Biotech attended in the joint SLU stand at "Borgeby Fältdagar", one of northern Europe's largest agricultural fairs, attracting 300 exhibitors and nearly 17 000 visitors from all the Nordic countries as well as Germany.

27/8: Press information and field demonstration organised together with PlantLink, TC4F and ICON, research projects that, together with Mistra Biotech, have filed trials with biotech crops at HIR outside Kristianstad.

29/8: The Gene Technology Advisory Board were taken on a field excursion at the GM field trials in Kristianstad and got informed about CP1.

30/8: Sten Stymne, Sven Ove Hansson and Jan Bengtsson all gave presentations at the KSLA seminar day "Sustainable agriculture – does it need modern biotech?", which rendered some media coverage. All participants also received information material about Mistra Biotech.

31/8: Lunch seminar with Prof. Pamela Ronald (Genome Centre, University of California) organised in collaboration with Future Agriculture and Linnean Centre for Plant Biology.
25/9: Participation at the conference "Klimatanpassning Sverige 2012". Anna Lehrman gave a presentaion about biotechnology as a tool in adapting agriculture to climate change, and Mistra Biotech.

5/10: Students from Rosendals gymnasium visited Ultuna and got short information about Mistra Biotech and a lecture with Jens Sundström on gene technology.

11/10: Sven Ove Hansson presented Mistra Biotech to The Swedish Gene Technology Advisory Board.

17/10: Participation at the Future Agriculture day "Lantbruket är vad du äter".

7/11: Seminar day "The future of plant biotechnology in Europe – emerging technologies and policy making" organised in collaboration with Plant Link and Partnerskap Alnarp.

22/11: Participation with a shared stand (with the Dep. of Crop Production Ecology) at the conference SciTech Europe 2012 in Brussels.

26/11: Sven Ove Hansson presented the research in Mistra Biotech to Lantmännen.

The Mistra Biotech Newsletter reach over 1000 Swedish and international recipients, informing about our reserach and upcoming events. Do you want to join? Send an e-mail to mistrabiotech@slu.se.

Media

NEWSPAPERS:
Articles published in relation to activities or research in Mistra Biotech (or researchers involved in the program).

"Phytophthora infestans och svältkatastrofen på Irland" Ny Teknik 18/4

"Genmodiferad potatis orsakar biflytt" Kristianstads-bladet 31/5

"Populistisk miljörörelse demoniserar gentekniken" DN Debatt (Sten Stymne and Jens Sundström) 2/6

"Genmodifierade livsmedel motverkar ett hållbart jordbruk" DN Debatt reply (P. Eriksson, head of Greenpeace Sweden) 7/6

"Forskningen visar att gentekniken i sig inte utgör någon speciell risk" DN Debatt (final comment, Stymne and Sundström) 8/6

"Orimlig syn på GM-grödor" Di debatt (Dixelius, Fagerström and Sundström) 8/6

"Försök med grön olja kan tvingas flytta" Kristian-stadsbladet 29/8

"Gränsvärdet för GMO-grödor i mat ingen hälso-fråga" Kristianstadsbladet 29/8

"Delade meningar om genteknik" Norra Skåne 29/8

"Gmo även för ekoodlare?" ATL 31/8

"Genteknik för viktig för att väljas bort" ATL 3/9

"Europa lever i en bubbla" Lantmannen nr 10

"Eko-bönder öppnar för GMO" Miljöforskning, September

"Fem GMO-projekt för att skapa förnybara råvaror och hållbarare jordbruk" Jordbruksaktuellt 28/9

"Ett hållbart jordbruk behöver GMO" Lantbrukets affärer 4/10

RADIO:
20/3: Li-Hua Zhu on Radio Sweden: Swedish scepticism blocks GMO crop expansion.

18/4: Sten Stymne in Ekot, on Swedish public radio, about "oljekål" *Crambe abyssinica*.

4/5: About the need for nets preventing insects from spreading GM-pollen. Ekot, on Swedish public radio.

5/12: Per Sandin and Tina d'Hertefeldt gave their view on "Genmodifierade grödor - hot eller möjlighet?" in the OBS on Swedish public radio.

TV:
28/8: Feature with Sten Stymne and Li-Hua Zhu about the GM field trials, Aktuellt (Swedish Television). Following debate between Stefan Jansson and Mikael Kalsson (SSNC).

19/9: *Mistra Biotech in TV4 News Vetenskap.* Mariette Andersson talks about her work with the starch potato.

Mariette Andersson at the potato field trial.

Publications

SCIENTIFIC JOURNALS

de Koning, D. J., and McIntyre, L. 2012. Setting the standard: A special focus on genomic selection in GENETICS and G3. *G3-Genes Genomes Genetics* 2: 423.

Forabosco, F., and Rydhmer, L. 2012. The current status and future prospects of genetically modified farm animals in Europe. *Genomics and Quantitative Genetics 5*: 1-4.

Hansson, S.O., and Joelsson, K. 2012. Crop Biotechnology for the Environment? *Journal of Agricultural and Environmental Ethics*. DOI: 10.1007/s10806-012-9405-z.

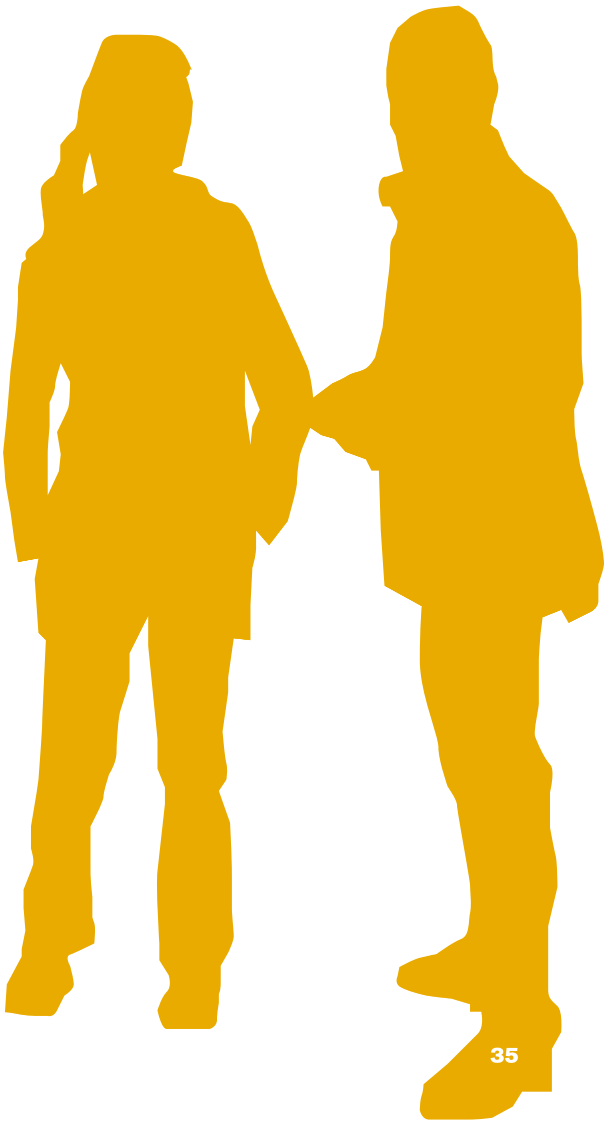
OTHER PUBLICATIONS

Lehrman, A. Från förädling till konsument. 2012. Resurs 3: 14.

Weih, M. 2012. Independent science for sustainable solutions in agriculture. Public service review: European Science & Technology 17, 72.

The Mistra Biotech homepage was first published in May at www.slu.se/mistrabiotech. The site is continuously developed and relevant articles are shared on the site every week. During 2012 we had visitors not only from Sweden, but also UK, Finland, Malaysia, Brazil, Australia, Belgium, Germany, Denmark, India, Netherlands, Philippines, USA, South Africa...

www.slu.se/mistrabiotech



Researchers

EMPLOYED AND ASSOCIATED RESEARCHERS

CP1: Plant biotechnology for innovative products		Department
Alessandro Nicolia	Researcher	Plant Breeding, SLU
Camila Cambui	Post-Doc	Forest Genetics and Plant Physiology, SLU
Emelie Ivarson	PhD student	Plant Breeding, SLU
Erik Andreasson	Deputy project leader	Plant Protection Biology, SLU
Henrik Svennerstam	Researcher	Forest Genetics and Plant Physiology, SLU
Iftikahar Ahmad	PhD student	Forest Genetics and Plant Physiology, SLU
Inger Åhman	Researcher	Plant Breeding, SLU
Kristine Koch	Researcher	Food Science, SLU
Li Hua Zhu	Project leader	Plant Breeding, SLU
Mariette Andersson	Researcher	Plant Breeding, SLU
Mattias Holmlund	Research engineer	Forest Genetics and Plant Physiology, SLU
Mulatu Dida Geleta	Researcher	Plant Breeding, SLU
Paresh Dutta	Researcher	Food Science, SLU
Per Åman	Researcher	Food Science, SLU
Samanthi Madawala	PhD student	Food Science, SLU
Sandra Jämtgård	Post-Doc	Forest Ecology and Management, SLU
Sten Stymne	Researcher	Plant Breeding, SLU
Torgny Näsholm	Researcher	Forest Ecology and Management, SLU
Ulrika Ganeteg	Researcher	Forest Genetics and Plant Physiology, SLU

CP2: Novel molecular breeding tools		
Aakash Chawade	Post-Doc	Immunotechnology, Lund University
Christina Dixelius	Researcher	Plant Biology and Forest Genetics, SLU
Dirk-Jan de Koning	Project leader	Animal Breeding and Genetics, SLU
Elisabeth Jonas	Post-Doc	Animal Breeding and Genetics, SLU
Erik Bongcam-Rudloff	Researcher	Animal Breeding and Genetics, SLU
Fernando Lopes Pinto	Post-Doc	Animal Breeding and Genetics, SLU
Fredrik Levander	Researcher	Immunotechnology, Lund University
Lars Rönnegård	Deputy project leader	Animal Breeding and Genetics, SLU
Mulatu Dida Geleta	Researcher	Plant Breeding, SLU
Patrice Humblot	Researcher	Clinical Sciences, SLU
Zeratsion Abera	Researcher	Plant Breeding, SLU
Örjan Carlborg	Researcher	Clinical Sciences, SLU

CP3: Ethics		
Helena Röcklinsberg	Researcher	Animal Environment and Health, SLU
Karin Edvardsson Björnberg	Project leader	Philosophy and History of Technology, KTH*
Payam Moula	PhD student	Philosophy and History of Technology, KTH*
Per Sandin	Deputy project leader	Crop Production Ecology, SLU

CP4: Consumer attitudes towards biotechnology		
Ashkan Pakseresht	PhD student	Economics, SLU
Carl-Johan Lagerkvist	Project leader	Economics, SLU
Jacob Lund Orquin	Post-Doc	Business Administration, Aarhus University, DK
Joachim Scholderer	Researcher	Business Administration, Aarhus University, DK
Klaus G Grunert	Researcher	Business Administration, Aarhus University, DK
Sebastian Hess	Researcher	Economics, SLU

CP5: Swedish competitiveness

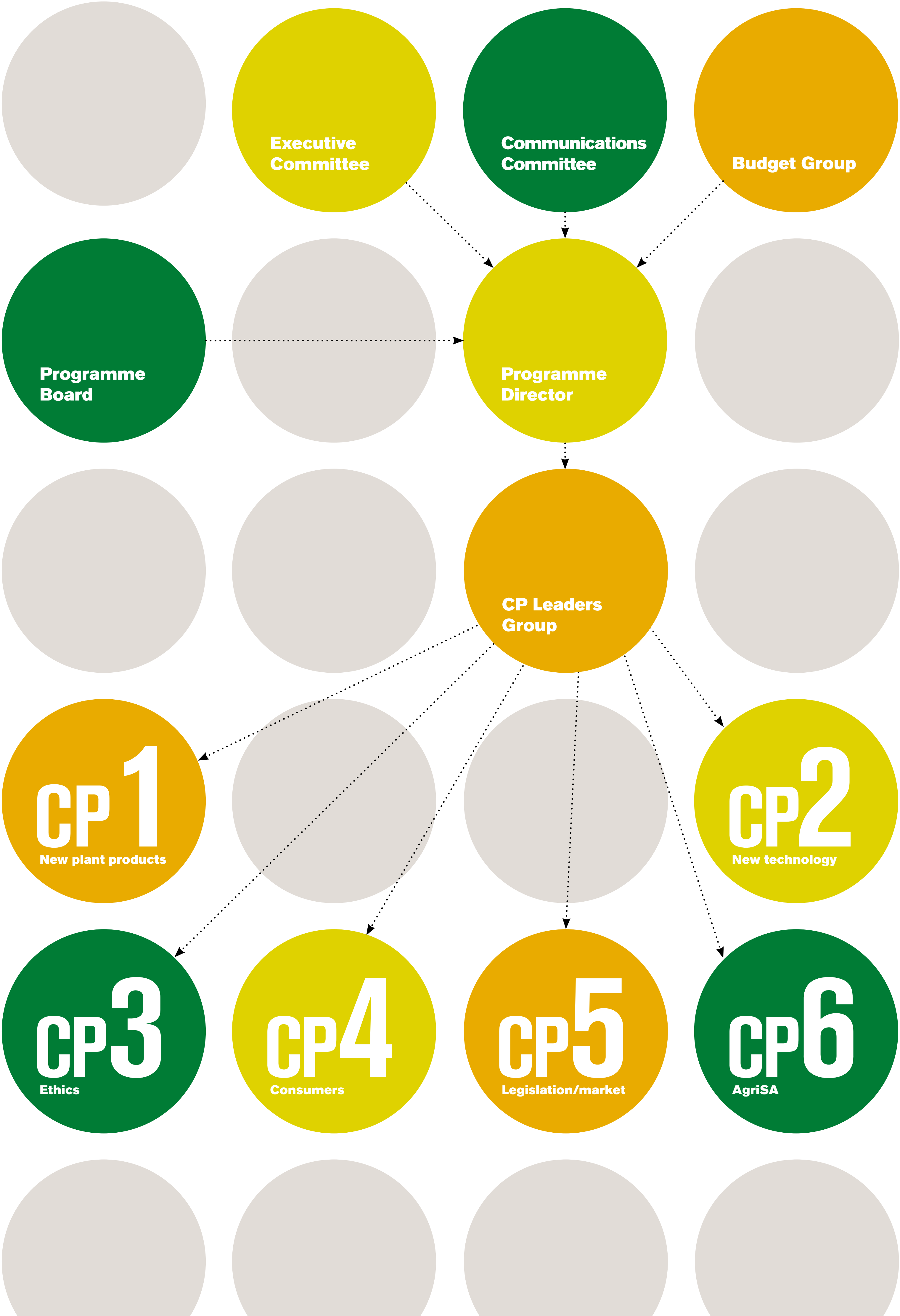
Christopher Kevin Ansell	Researcher	Political Science, University of California, USA
Konstantinos Karantininis	Project leader	Economics, SLU
Li Feng	Post-Doc	Economics, SLU
Sevasti Chatzopoulou	Researcher	Society and Globalisation, Roskilde University, DK
Torbjörn Jansson	Researcher	Economics, SLU

CP6: AgriSA - Centre for agriculture and food systems analysis and synthesis

Alessandro Nicolia	Researcher CP1	Plant Breeding, SLU
Anna Lehrman	Communicator	Crop Production Ecology, SLU
Anna Wallenbeck	Researcher	Animal Breeding and Genetics, SLU
Anna-Karin Kolseth	Researcher	Crop Production Ecology, SLU
Barbro Ulén	Researcher	Soil and Environment, SLU
Christina Dixelius	Researcher CP2	Plant Biology and Forest Genetics, SLU
Elisabeth Jonas	Post-Doc CP2	Animal Breeding and Genetics, SLU
Flavio Forabosco	Researcher	Animal Breeding and Genetics, SLU
Håkan Marstorp	Researcher	Soil and Environment, SLU
Ingrid Öborn	Researcher	Crop Production ecology, SLU
Jan Bengtsson	Researcher	Ecology, SLU
Jens Sundström	Researcher	Plant Biology and Forest Genetics, SLU
Karin Edvardsson Björnberg	Project leader CP3	Philosophy and History of Technology, KTH*
Konstantinos Karantininis	Researcher CP5	Economics, SLU
Li Feng	Researcher CP5	Economics, SLU
Li Hua Zhu	Project leader CP1	Plant Breeding, SLU
Linnea Asplund	PhD student	Crop production ecology, SLU
Lotta Rydhmer	Project leader	Animal Breeding and Genetics, SLU
Maren Emmerich	Post-Doc	Microbiology, SLU
Mariette Andersson	Researcher CP1	Plant Breeding, SLU
Martin Weih	Researcher	Crop Production Ecology, SLU
Mulatu Dida Geleta	Researcher CP1/CP2	Plant Breeding, SLU
Nils-Ove Bertholdsson	Researcher	Plant Breeding, SLU
Payam Moula	PhD student CP3	Philosophy and History of Technology, KTH*
Pernilla Tidåker	Researcher	Crop Production Ecology, SLU
Per Sandin	Researcher CP3	Crop Production Ecology, SLU
Sara Hallin	Researcher	Microbiology, SLU
Stefan Marklund	Researcher	Clinical Sciences, SLU
Sten Stymne	Researcher CP1	Plant Breeding, SLU
Sven Ove Hansson	Programme director	Crop Production Ecology, SLU & KTH*
Tina D'Hertefeldt	Researcher	Biology, Lund University
Torgny Näsholm	Researcher CP1	Forest Ecology and Management, SLU

** Royal Institute of Technology (KTH)*

SLU
KTH VETENSKAP OCH KONST ROYAL INSTITUTE OF TECHNOLOGY
LUND UNIVERSITY
AARHUS UNIVERSITY


Executive Committee
Communications Committee
Budget Group
Programme Board
Programme Director
CP Leaders Group
CP1
New plant products
CP2
New technology
CP3
Ethics
CP4
Consumers
CP5
Legislation/market
CP6
AgriSA

MISTRA
Biotech

MISTRA Biotech