



Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Mistra Biotech

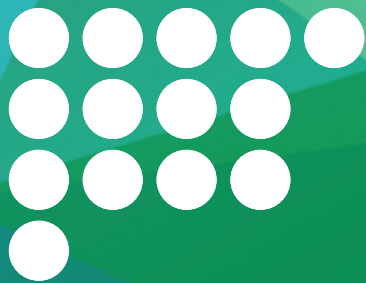
Report from phase 1

2012-2016



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Mistra Biotech
Report from phase 1
2012-2016



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Project leader: Lisa Beste

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Monika Johansson, Mårten Svensson, Kristin Thored
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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, visit www.mistra.org.





Chair's preface

Mistra Biotech is now entering, literally, a new phase. The first phase was based on a four-year grant. Like other Mistra programmes we were invited to apply for funding for four additional years. Writing that application has been a long and very interesting process. Let me tell you what it looked like from my perspective as chair of the programme board.

We had our first discussions on the coming application on a board meeting in October 2013. In December that same year we continued this discussion and clarified both our own role in the process and that of the researchers in the programme. This meeting was also the starting-point for our discussions with SLU on their co-funding of the programme in its second phase.

We continued our discussions on various aspects of the application at board meetings in March and May 2014. On the latter of these meetings we decided to invite all researchers in the programme to submit a memo on how they wanted to develop Mistra Biotech in a second phase. The project leaders were specially invited to write memos on possible continuations of their respective projects.

When we met in October 2014 we had eighteen such memos on the table, containing a large number of high-quality research proposals. After a thorough discussion of these proposals, we decided on a synopsis for the application, a new structure for the programme, and a preliminary distribution of the budget between its major research areas (expressed in percentages since we did not know the total amount). We also asked for brief texts describing the research to be performed. At a board meeting in November, these texts were accepted with some modifications. Now it was time for the researchers to write a complete application.

When the board met in March 2015 we had an almost complete draft of the application on our table. Based on the feedback from this meeting, the researchers produced a complete and much more

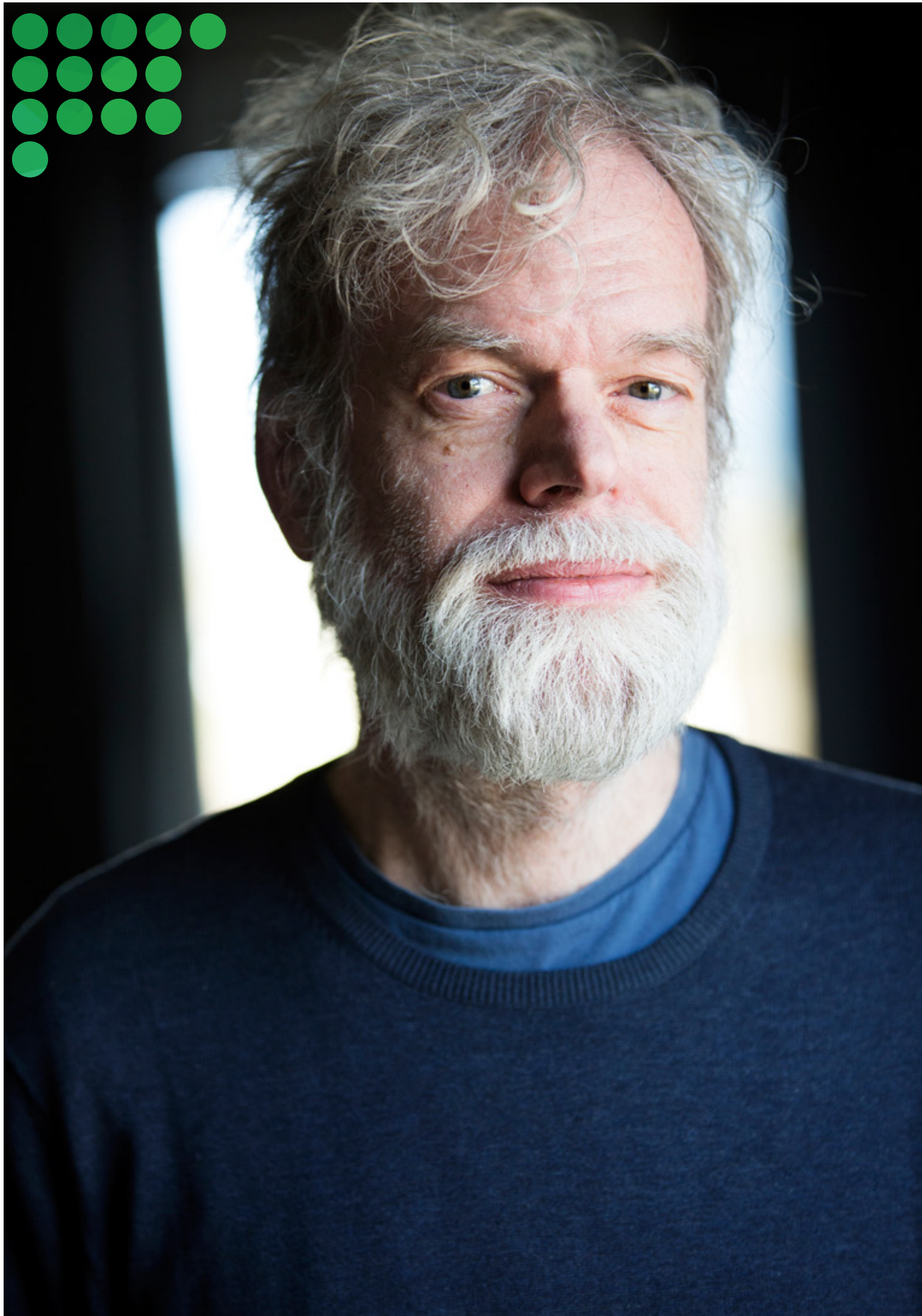
polished version of the application for our meeting in June. At that meeting the application was approved with some minor modifications. A few days later it was submitted to Mistra.

Mistra appointed a group of external reviewers to assess our application. Their report was very positive but it also contained many detailed proposals for improvement. This report was the main topic of our board meeting in October 2015. After that, the researchers produced a revised version of the application that took the reviewers' comments into account. The new version was approved by the board in early November, and sent to Mistra a few days later. In December 2015 we received a message from Mistra telling us that our revised application had been approved. Four more years of Mistra Biotech!

You often hear of researchers writing a big application in a very short time, often finishing it in the last few hours before it has to be submitted. Our process for the phase 2 application was the very opposite of this. In fact it took about two years from our first discussions to the final submission. This had the advantage that we have all had the time to think more than once about our priorities. I also believe that this way of working contributed much to the interdisciplinarity of the programme. The researchers in the programme discussed each other's proposals, and the opportunities for co-operation, on many occasions during this process. The board also repeatedly discussed co-operations and integration in the programme. As a result of this, we have a programme plan that contains many co-operations between widely different disciplines. We have four very exciting years ahead of us!

Inger Andersson
Chair of the Board

« Inger Andersson, Former Director General of the Swedish National Food Agency.





Organic or conventional farming?

Not long ago we had a debate in Swedish newspapers on organic versus conventional farming. Some of the participants expressed their conviction that the environmental problems in agriculture will be solved if all farmers adopt organic farming. Their opponents in this debate claimed instead that conventional agriculture has solved the major environmental problems, without jeopardizing high yields.

As far as I can see, both sides are wrong. Farming, whether organic or conventional, has serious negative environmental effects. Both types of farming use fertilizers that give rise to eutrophication and contribute to the greenhouse effect. They also both till the soil frequently, which gives rise to soil erosion that aggravates eutrophication. Both types of farming burn large amounts of fossil fuels in their tractors and other machines, with the consequent greenhouse gas emissions. Both types of farming use large land areas, thereby removing extensive areas of natural habitats and threatening biodiversity.

In addition to these shared problems, each type of farming has problems of its own. Conventional farming makes use of synthetic herbicides and pesticides, some which have substantial negative effects on the environment. Organic farming has on average lower yields, which means that a larger area has to be cultivated in order to obtain the same amount of food. A larger cultivated area means less area for wilderness. (Needless to say, both pesticide use and encroachment into wilderness are much more serious problems in Third World countries than in Europe.)

In summary: Agriculture has serious environmental problems that cannot be solved by choosing one of the already existing forms of farming. In order to substantially reduce the negative environmental impact, we need to take a much more innovative approach. For

this purpose, much research is needed. One of the most promising approaches is to develop new crops and varieties that reduce the need for agricultural practices that are negatively impacting the environment. Modern plant breeding has the capacity to provide for instance:

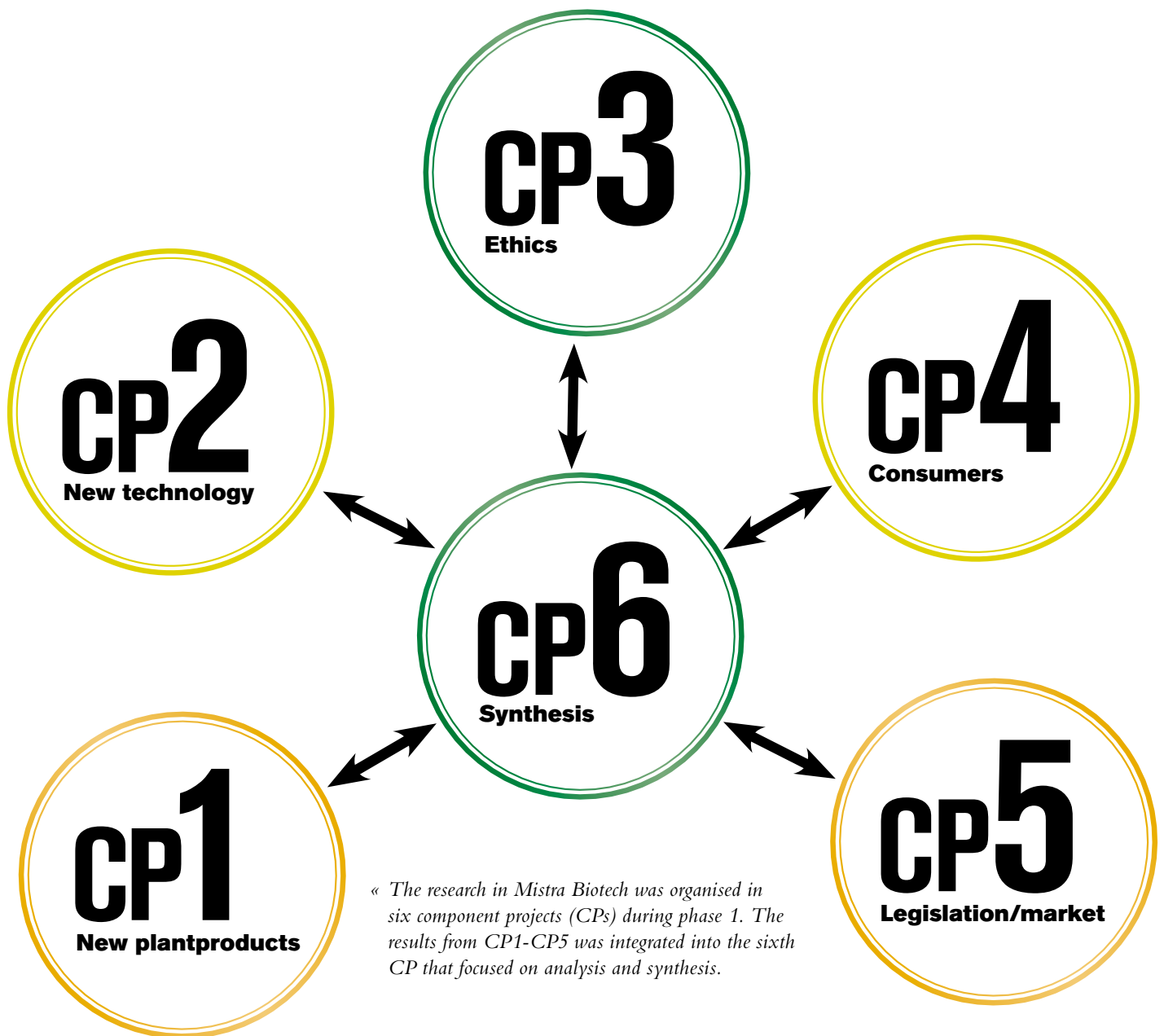
- Pest-resistant crops that reduce or eliminate the need for pesticides.
- Plants with improved mineral nutrient uptake that reduces the need for fertilizers.
- Biennial or perennial crops that reduce the need for tilling.
- Drought-tolerant crops that reduce the need for irrigation.

All of this is within reach, and urgently needed. What we lack is sufficient resources for the research and development that is required to realize it.

I began by asking: Organic or conventional farming? The answer is: Neither is good enough in its present form. We need new forms of farming that are better for the environment than either of them. And we need plant breeding, along with other branches of agricultural and ecological research, to develop these new forms of agriculture.

Sven Ove Hansson
Programme director

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





Mistra Biotech

Mistra Biotech is an interdisciplinary research programme focusing on the use of biotechnology for sustainable and competitive agriculture and food systems. Our vision is to contribute to the processes that will enable the Swedish agricultural and food sector to produce an increased amount of high-quality, healthy food at moderate costs with less input, decreased environmental impacts, and healthier crops and livestock. The goal is sustainable production systems from ecological, social, and economic perspectives. We perform research in both the natural and the social sciences.

Our research in the natural sciences is aimed at utilizing the potential of agricultural biotechnology to contribute to a more sustainable food production with healthier products and reduced environmental impacts. With ability comes responsibility, and we take the concerns that have been raised about potential negative effects of biotechnological products on human health and the environment very seriously. For us, safety, control, and transparency are essential regardless of which technology is used.

Our research in the social sciences has its focus on the social, economic, and ethical aspects of the use of biotechnology in agricultural production. We study consumer attitudes and behaviours related to the use of agricultural biotechnology for food products and investigate issues related to governance and regulation in the Swedish agri-food system. Our social research has a strong focus on sustainability issues and on the perspectives of stakeholders in the food production systems. In its first phase Mistra Biotech had six component projects (CPs). Five of these have focused on the following research areas: new plant products, new technologies, ethics, consumer attitudes, and legislations/markets. The results from these CPs have been integrated into the sixth CP that focuses on analysis and synthesis. This is the final report from the first phase of Mistra Biotech. The second phase of our research programme started in April 2016.

We use the term “biotechnology”

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

Mistra Biotech involves over 70 researchers. Most are at SLU, but some work at KTH, Lund University, and other academic institutions. The programme also includes international collaborations with Aarhus University, the University of Edinburgh, and other institutions. Mistra Biotech was funded by Mistra, 10 million SEK per year during the years 2012 to 2015. SLU co-funded the

first phase of the programme by matching the Mistra funding with a further 10 million SEK per year. Many companies, agencies, and organisations also support the programme with their knowledge, experience, and valuable feedback.

Lantmännen SW Seed AB also contributed financially with a sum of 50,000 SEK per year during the first phase. The programme has now received phase-two funding from Mistra and SLU for four more years of research.



Component projects

CP1 PLANT BIOTECHNOLOGY FOR INNOVATIVE PRODUCTS

A major task in this project is to domesticate the wild biennial species *Lepidium campestre* (field cress, also known as field pepperweed) as an oil and catch crop. A catch crop is one that is sown under cereal crops during the spring with the aim of reducing soil tillage and mitigating nutrient leaching. Using both genetic modification (GM) and non-GM techniques enables us to compare the effects of different breeding methods on the improvement of important agronomic traits, as well as to speed up the breeding process. The main targeted traits in field cress are increased oil content and quality, increased seed yield, and reduced pod shattering (i.e., seed drop before harvest, which causes huge losses in seed yield).

To reduce reliance on fertilizers and pesticides in barley and potatoes, our work focuses on making nitrogen use more efficient and on improving pathogen resistance. We are focusing on health issues by developing a potato with a low glycaemic index, breeding for high oleic acid oil in field cress, and analysing the structure and properties of starch from different types of barley. 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.

Contact: Li-Hua Zhu, li-hua.zhu@slu.se

Collaborations:

Lantmännen, SW Seed AB
Lyckeby Starch
Swedish Rural Economy and Agricultural Societies, Kristianstad
The GenePool Ashworth Laboratories, University of Edinburgh
Prof. Lars Østergaard, John Innes Centre, UK
Prof. Leif Bülow, Dept of Pure and Applied Biochemistry, Lund University
Prof. Thordal-Christensen's group, Copenhagen University
Ass. Prof. Robert S. Brueggeman, North Dakota State University

CP2 NOVEL MOLECULAR BREEDING TOOLS

Most economically important traits in crops and livestock that influence either product yield or disease resistance are complex traits governed by many genes and their interactions with environmental factors. Traditional breeding approaches use pedigree information and statistical tools to estimate the proportion of variation that is due to heritable factors, but these methods treat the genome as a “black box”. Today's new technologies facilitate genome sequencing at a fraction of the original costs only a few years ago, and we are developing methods and tools for the use of whole genome sequence data in breeding, that is, selecting plants and animals based on information about the entirety of their DNA instead of just looking at specific genes. Because traits in plants are often largely dependent on environmental factors, the need to implement these factors into selection tools presents challenges for molecular breeding. Similar challenges also provide opportunities for improved use of molecular breeding tools in cattle. We are also investigating the potential to use information about proteins – the products of the genome – in breeding in order to screen for and select suitable plants and animals at an early stage in the breeding process.

Contact: Dirk-Jan de Koning, dj.de-koning@slu.se

Collaborations:

Lantmännen, SW Seed AB
Viking Genetics, Skara
SciLife Laboratory, Uppsala
Aarhus University, Denmark
LUKE (former Agrifood Research), Finland
Edinburgh Genomics, University of Edinburgh, UK



CP3 ETHICS

The debate about ethical issues in biotechnology and its applications is deeply polarized. Despite extensive literature on the ethics of technology in general, there is a shortage of studies carried out in close collaboration with the scientists who actually develop these technologies. Therefore, much of the debate is insufficiently informed by recent developments and is rather sweeping in character. Also, few ethical assessments of the applications of technology have dealt with 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 for making this debate less polarized so as to allow everyone to better understand each other's arguments.

Contact: Karin Edvardsson Björnberg, karin.bjornberg@abe.kth.se or Per Sandin, per.sandin@slu.se

CP4 CONSUMER ATTITUDES

Why do consumers act as they 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 acceptance and use of agricultural biotechnology in Sweden. The research in this component project has focused on in-depth studies of the driving forces behind consumer attitudes and behaviours related to the use of agricultural biotechnology for food products. This project explores the psychological foundations of technology acceptance, risk perceptions, choice, and trust among members of the general public in their roles as consumers.

Contact: Carl Johan Lagerkvist, carl-johan.lagerkvist@slu.se

CP5 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 make innovations when they have the ability to commercialize their products or services at a profit, and the profitability of an innovation depends on the degree to which firms are able to capture the economic benefits generated by their innovations. We analysed the structure and governance of the Swedish agri-food system and the national and international regulatory environments. We also explored Sweden's capacity to produce and distribute innovative products and processes, the constraints on this capacity, and the impact of all of this on the Swedish economy.

Contact: Konstantinos Karantininis, karantininis.konstantinos@slu.se

CP6 CENTRE FOR AGRICULTURE AND FOOD SYSTEMS ANALYSIS AND SYNTHESIS, AgriSA

The work in this project has been focused on whole production systems and stretches across disciplines within the human, agricultural, natural, and social sciences. AgriSA has been a hub where the information and results from all Mistra Biotech projects has been processed and where overall syntheses were made and communicated to stakeholder groups. The project was also a platform for collaboration between researchers involved in Mistra Biotech's CPs and other researchers. The aim of this work has been to understand and facilitate the implementation of sustainable food production using biotechnology as a tool.

Contact: Lotta Rydhmer, lotta.rydhmer@slu.se





Will the scepticism end?

In 1996 the National Food Agency in Sweden published a special issue of the journal *Vår Föda* devoted to biotechnology. Scientists predicted that in the near future there would be genetically modified foods from about 40 plant species. Twenty years later, only six plant species have been genetically engineered for the European market – maize, canola, cotton, soybean, potato, and sugar beet. The statistics not only illustrate the difference between the researchers' hopes and the current reality, but they also illustrate the strong winds blowing against the use of genetic engineering in a food context.

The food crisis in the nineties, especially the outbreak of mad cow disease, made it clear to politicians that scientific risk assessment must be separated from the political management of food risks. The same persons who had investigated the scientific risks of using animal bone meal as feed had also decided on how the risks of the product would be handled. A specific EU agency, the European Food Safety Authority (EFSA), was established to organise the scientific risk assessments. The EFSA GMO panel, composed of independent scientific experts, was instituted and wrote guidelines for the GMO risk assessments. Since May 2003, the GMO panel has reviewed the applications to get permission to market GMOs in the EU. The EFSA has also established channels for EU member states to give input on scientific issues during the risk assessment phase. Based on the opinions of the EFSA GMO panel and other legitimate factors, the European Commission and the member states are responsible for the GMO risk management.

It soon became clear, however, that politicians active in the area of the environment were not happy with the risk assessment and risk management being separated. In December 2008, during the French presidency of the EU, the Environment Council urged the European Commission to take action to strengthen the risk assessment of GMOs. One of the projects of the Commission was to turn the guidelines into legal text. The scientific language was translated into legal language, and the wishes of particular member states were integrated. Within the European Commission, political consensus seemed to be more important than good scientific practice. An implementing law on GMO risk assessment entered into force in 2013. Sweden had voted against it.

During the years 2005–2008, it took on average just over a year for the GMO panel to give its opinion on an application. In 2009–2012 it took them about 2½ years, mainly due to the increased number of applications. Now it takes more than four years.

A total of 128 applications concerning genetically modified food and feed had been received by the EFSA at the end of 2015. Twenty of these involved cultivation of genetically modified crops in the EU, and the rest were solely requesting the use of GMOs as food and feed.

The authorisation process has taken an unexpectedly long time, and this is a problem. Seventeen of the cultivation applications have been withdrawn. A new variety of a crop is a perishable commodity, and it might be useful in the market for only 10–20 years, after which it will need to be replaced by better varieties. If varieties produced through genetic engineering are delayed for too long in the approval process, their potential time on the market will be reduced. The biotech industry group EuropaBio has been complaining loudly about the time and the costs for the risk evaluation phase. Only the multinational giants survive, and this raises the question of whether we care about the future in the right way.

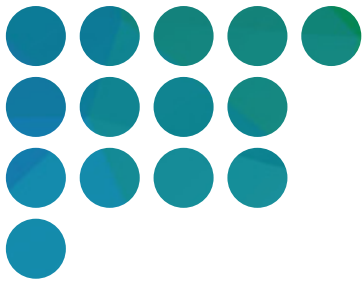
Apparently a concern has recently been raised within the Swedish government that the EFSA does not review the GMO risk assessments properly. In November 2015, the Ministry of Enterprise and Innovation (*Näringsdepartementet*) mandated the Board of Agriculture (*Jordbruksverket*) to review how the risk assessment of GMOs is organised in Sweden and how the EFSA GMO Panel has dealt with comments from Sweden. Comparing the risk assessment comments delivered by the Swedish National Food Agency (*Livsmedelsverket*) to the EFSA GMO Panel during their risk assessment of applications, and the way the GMO Panel has used the comments, it became clear that 91.2% of Sweden's comments related to food safety were used by the Panel to request further information from the applicants. The conclusion is that the EFSA GMO Panel has listened to Swedish experts' opinions.

Now that I am retiring, the time has come for me to leave the battlefield and merely become a spectator, but one who is now allowed to express my personal views on the GMO debate. I note that the anti-intellectual approach to modern biotechnology in the food area remains. I thought it would fade away when information on the safety of GMO products was piled high enough.

Christer Andersson

Associated Professor in Genetics, Risk and Benefit Assessor, National Food Agency, Sweden.

« Christer Andersson, Associated Professor in Genetics, Risk and Benefit Assessor, National Food Agency, Sweden.

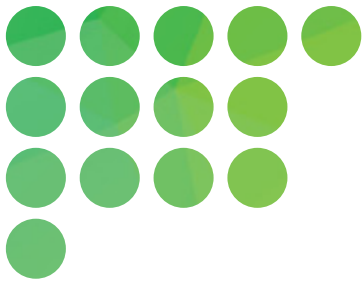




MISTRA BIOTECH

WHAT HAVE WE LEARNT...

Four eventful years have passed since the beginning of the Mistra Biotech programme. Natural and social scientists have been working together, contributing their expertise to achieving our overarching goals. Let's ask some of our researchers what they have learnt about domestication, resistant breeding, starch composition, ethics, decision-making, production systems and other areas of research, during the first phase of Mistra Biotech.



WHAT HAVE WE LEARNT ABOUT

Domesticating field cress?

Through domestication of the plant species *Lepidium campestre* (field cress) we have learnt that 1) The genetic resources and genetic diversity of this species, and related species, are important for improving important agronomic traits. 2) Domestication is a long process that cannot be finished within a short period of time. We need to utilize both conventional and modern breeding methods to speed up the process. 3) Modern breeding tools, such as genetic engineering, are important for precise and efficient breeding, particularly for some traits that are difficult to improve upon with traditional breeding methods. 4) The interdisciplinary programme Mistra Biotech enables us not only to solve the scientific problems related to genetic improvements of the species, but also allows us, through a close collaboration between natural and social scientists working within the programme, to learn more about issues such as ethical, social, and economic aspects associated with the introduction of genetically modified varieties or a new species into agricultural production.

We have obtained a number of breeding lines of *L. campestre* that have improved seed oil composition with health benefits, reduced pod shatter, increased oil content, or increased seed yield. However, most of the improved traits reside in single breeding lines alone, and in the next step we will seek to combine these traits in the same breeding lines.

Our ultimate aim is to develop *L. campestre* into a novel oilseed crop with extreme winter hardiness suitable for being used as a cover crop to reduce nutrient leaching and to minimise tillage. The species naturally has some good agronomic traits, but it also has some serious problems, and these have been the main targets for improvement in this program.

Li-Hua Zhu

Professor in Plant Breeding, SLU





WHAT HAVE WE LEARNT ABOUT

Late blight resistance in potato?



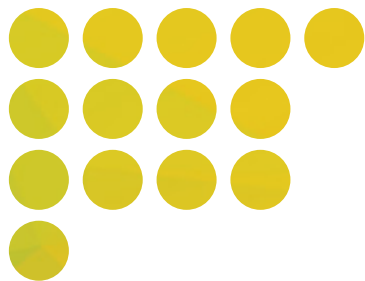
It has previously been shown that a breeding clone of potato (SW93-1015) is resistant to the disease late blight (*Phytophthora infestans*) under field conditions in Sweden. To understand the molecular mechanism behind this resistance, we crossed this clone with a susceptible potato clone. Analysis of the potato progenies showed that this breeding line has a simple genotype for the disease-resistant trait. We cloned eight candidate resistance gene homologs from this line, but only one of them was shown to be functional. We also developed a DNA marker for this trait, and this marker is now used together with other markers in the Swedish potato breeding programme to identify late blight-resistant potato clones.

We have performed studies using protein levels as a tool to select for resistance against late blight and tuber blight because proteins are closer to the phenotype than DNA. We established a framework for the selection of potato breeding candidates based on protein profiles using mass spectrometry. We tested different mass spectrometry-based workflows and developed robust data processing methods. Mass spectrometry-based protein assays were developed for leaf proteins from potato, and we were able to predict resistance to late blight and tuber blight.

We have also gained insights into new putative ways to control the pathogen *P. infestans* itself. We studied the genes of *P. infestans* and learned about how these genes are regulated by short RNAs and through specific phosphorylation.

Erik Andreasson

Professor in Resistance Biology, SLU



WHAT HAVE WE LEARNT ABOUT

Changing starch composition?

Through molecular genetics, we have turned off the enzymes making the branched structure of amylopectin in potato. As we expected, this led to potatoes with more amylose and less amylopectin.

Amylose and amylopectin are the two different components of starch, the most common carbohydrate consumed by humans. The ratio between these two components is in most crops approximately 1:4. Both of the starch components are products of linked sugar molecules, differing in that amylopectin is a branched component with short chains and amylose is long-chained and mostly linear.

However, we found that the molecular modification did not completely delete the amylopectin component. Instead, the molecular structure of amylopectin was found to be altered and more like the structure of amylose, i.e. the amylopectin molecules had longer unbranched chains than branched chains – like a tree with fewer and longer branches.

This new amylopectin structure has been found to be useful when producing thin barrier films for food packaging. It is also expected to have a positive impact for human consumption because the long chains give the starch a low glycaemic index (GI).

Amylopectin is believed to be the largest molecule in nature with up to several millions sugar units linked to each other. Eating starch-rich food often contributes to a high GI because the branched short-chain amylopectin is easily degraded in our bodies. The GI level can be decreased by eating starchy crops or food products with a lower content of amylopectin.

Mariette Andersson

Researcher in Plant breeding, SLU

Kristine Koch

Researcher in Food Science, SLU





WHAT HAVE WE LEARNT ABOUT

Genome-wide association in animals?

By sequencing the DNA from a total of 25 Swedish Red bulls, we were able to join an international consortium that aims to put together a large collection of genomes from a large number of breeds. This 1000 bull genomes consortium now has sequenced well over 1100 genomes. When we have a population of cows or bulls that we wish to study genetically, we can now use the information from the 1000 bull genomes consortium to

estimate the whole genome sequence for these animals using a process called imputation.

At the start of Mistra Biotech, it was already commonplace for the main livestock species to genotype a large number of individual animals for tens- or hundreds of thousands of DNA variants using so-called SNP-chips. Researchers could search for DNA variants with a pronounced effect on a trait of interest in a so-called genome-wide association study (GWAS).

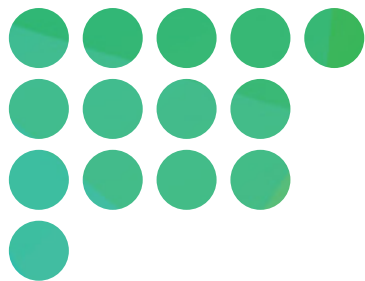
The potential use of imputed, whole genome sequence data in GWAS was met with a lot of enthusiasm because the causal DNA variant will be among our genotypes. In our work for Mistra Biotech, we have used imputed genome sequences to fine-map genome regions affecting growth in dairy bulls and milk properties in Swedish Red cows. In both cases, the use of sequence data showed a marked improvement of the test statistic, thus providing more evidence for an effect in the DNA region. However, in each case there were many highly significant signals in the region, and it was not possible to pinpoint a single putative causal variant.

Earlier simulation studies have shown that using whole genome sequence data can improve the accuracy of selecting animals by somewhere between 2% and 30%. The first results using real data suggest that the increase is closer to 2% than 30%. We have learnt that when using sequence data in genomic selection it is important to use statistical approaches that differentiate among all the DNA variants because the vast majority of variants will have no effect on the trait of interest at all. The 'variable-selection' approaches perform even better if we can a priori differentiate between the expected effects of DNA variants on the basis of their location in the genome.



Dirk-Jan de Koning

Professor in Animal Breeding, SLU



WHAT HAVE WE LEARNT ABOUT

Genomic selection in crops and livestock?

From the point of view of a livestock breeder like me, a lot has been learned about the potential of genomic selection in crop breeding. Breeding of crops is, despite the opinion of many livestock breeders and geneticists, neither easier nor faster than the breeding of livestock species. The interval until a new breeding stock has been selected requires many years in both crop and livestock populations. Breeding of many livestock species is difficult because of the small number of offspring per female and year. Crop breeding, on the other hand, is highly impacted by the environment and the need for uniform plants in the field.

The potential of genomic selection was studied by the SLU Departments of Plant Breeding in Alnarp and Animal Breeding and Genetics in Uppsala in cooperation during the Mistra Biotech project. We concluded from literature reviews that the implementation of genomic selection has been tested in many crop populations. While some achievements have been seen, results have often not reached the initially predicted successes.

In many livestock populations, selections are made based on estimated breeding values and use information from individuals and pedigrees. In contrast, we learned that the first cycles of selection in many crop populations are focussed on a phenotypic evaluation of plants in field plots.

Challenges in the application of genomic selection in crop breeding include the dependency on the environment and genotype-by-environment interactions. Other difficulties with genomic selection concern multiple generation crossing schemes, hybrid or inbred populations, complex genome structures, and costs for the recording of phenotypes.

We learned during the first phase of the Mistra Biotech project that the introduction of genomic selection in crop breeding is complex. Novel approaches need to be tested in the continuation of the project,

and the approaches developed in collaboration between the two departments will hopefully lead to applicable solutions for implementing genomic selection in selected crop populations.

Lisa Jonas

Associate Professor in Animal Breeding, SLU





WHAT HAVE WE LEARNT ABOUT

Genomic selection in plant breeding for different crops?



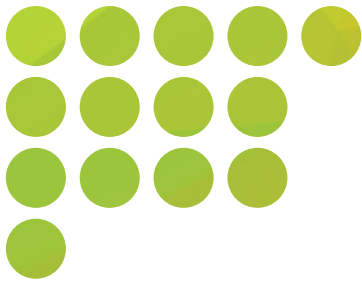
First of all, we were able to learn that techniques established in animal breeding, like genomic selection (GS), are difficult to apply directly in plant breeding. The nature of population structures, particularly in inbreeding plant species, is a major barrier to implementing GS in the breeding of crops. Likewise, the accuracy level achieved in GS lacks a simple biological interpretation. A literature review on GS models revealed that model performance, sample size, sample relatedness, marker density, gene effects, heritability, and genetic architecture are factors that affect prediction accuracy. Further in-depth research should focus on the incorporation of plant genotype \times environment interactions into models to determine if GS could be suitable for predicting plant performance in new environments.

Although the estimated genetic gain per year of applying GS is several times higher than that of conventional breeding, many programmes worldwide are still struggling to identify the best strategy for the implementation of GS. A literature review was used to develop breeder-oriented considerations on the practical applications of GS in wheat, which includes potential breeding schemes for GS, genotyping considerations, and methods for effective design of the training population. The components of selection intensity, progress toward inbreeding in half- or full-sibs recurrent schemes, and the generation of selection were also determined. Each breeding scheme has its advantages and disadvantages, and the best will be the most suitable to “transform the words reported therein into more food for humanity.”

Currently we are learning more about the genome of the biennial plant species *Lepidium campestre* in order to elucidate key traits for domesticating this Brassicaceae species and to develop a molecular toolbox that will speed up its domestication.

Rodomiro Ortiz

Professor in Plant Breeding, SLU



WHAT HAVE WE LEARNT ABOUT

Agricultural sustainability and GMOs?

Although key actors in the Swedish food supply chain share the same view of what agricultural sustainability is, there is less explicit consensus in the view of how the concept of agricultural sustainability should be put into practice and what role biotechnology should play in creating more sustainable food production systems. This was shown in an analysis of the sustainability policies of five organisations active in the producing, processing, or retailing of food in Sweden. Interview data furthermore suggested that the prevalent agricultural sustainability discourse in the Swedish food supply chain has been largely shaped by consumer attitudes and pressure from strong environmental organisations. However, susceptibility to external pressure in the form of campaigns against genetically modified organisms (anti-GMO campaigns) varies along the supply chain from production to retailing, with the food retailers being the most sensitive.

Based on a reading of 99 peer-reviewed journal articles about the social impacts of genetically modified (GM) crops published in 2004–2014, a number of conclusions were drawn. Economic impact studies currently dominate the literature about social impacts of GM crops and mainly report on the benefits of using GM crops. Other social impacts are less well studied but present a more complex picture, and the social benefits of GM crops vary significantly depending on the political and regulatory setting. Well-being has been frequently discussed in the literature, but rarely investigated empirically. Social impact studies from the global North are virtually non-existent. Moreover, two-thirds of the reviewed publications are based on previously published empirical evidence, indicating a need for new empirical investigations into the social impacts of GM crop cultivation.

Karin Edvardsson Björnberg

Associate Professor in Environmental Philosophy, at the Royal Institute of Technology (KTH), Stockholm





WHAT HAVE WE LEARNT ABOUT

Ethics of biotechnology?

During the programme, we have learned that there is a considerable number of ‘ethical tools’ that all aim to facilitate ethical deliberation and decision making, but there is a lack of well worked-out ideas about precisely what it is that makes such a tool a good one. New evaluation criteria should be developed, and we suggest that the most important criterion is how well the purpose of the tool is achieved. This is because ethical tools have different purposes – some aim at including members

of the public in technology assessment as a means of making sure that decisions are legitimate, while others are designed to ensure that a decision maker does not overlook ethically significant aspects.

Some common criticisms of biotechnology in agriculture are based on the idea that such technology amounts to hubris or man’s ‘playing God’. We have argued that such criticisms are misdirected because they are based on a misunderstanding of the degree to which agriculture is a technological endeavour.

We have been reminded that despite repeated debunking, the category of ‘the natural’ keeps recurring, in particular in the context of food. Any number of food products is labelled with ‘all natural ingredients’ or something similar. However, because naturalness is not one concept, but several, this should somehow be reflected in the labels, and we outline what such labels might look like.

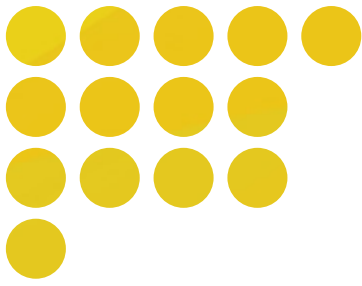
A particular case of agricultural biotechnology is genetically modified (GM) crops, the most common examples of which are the insect-resistant Bt crops and glyphosate-resistant crops (‘Roundup ready’). In addition to health, agronomical, and environmental consequences, the social impacts of such crops have been studied.

There are often calls for precautionary measures in the application of biotechnology, not only in agriculture. The precautionary principle is usually invoked, but there has been considerable disagreement over the years regarding the meaning and reasonableness of this principle. We argue that one way of looking at it is to regard the precautionary principle as a moral mid-level principle rather than as a narrowly rational one.

Per Sandin

Associate Professor in Philosophy, SLU





WHAT HAVE WE LEARNT ABOUT

Consumers' decision-making?

Over the last decade, a consumer orientation of “from fork-to-farm” food-value chains has emerged in which consumers together with retailers have acted as driving forces. However, previous consumer studies on genetically modified (GM) food have been characterised by an oversimplified perspective that does not take into account that in real life decisions are based on complex interactions between different type of actors. Consumer behaviour does not take place in a vacuum; instead, other stakeholders' views and choices provide inputs that influence their decision-making process.

The application of biotechnology in food production has been a contentious issue in Europe over the last decades and is a topic of worldwide controversy. Because of the controversies on GM technology and its applications, any regulatory action or commercialisation strategy to approve or market GM food requires regulators and food value chain actors to have a consumer behavioural perspective as one point of departure.

In one of our studies, a so-called artefactual field experiment was used to examine the acceptance decisions taken by consumers that were conditional upon decisions taken by farmers, the food industry, and retailers. Our experiment was designed to reveal consumers' acceptance decisions associated with both direct and indirect product and production benefits in relation to a GM potato. The experiment sessions were designed under four randomised policy scenarios: (A) GM is banned, (B) GM is allowed in research and development, (C) GM is allowed in imported products, and finally (D) GM is allowed in full commercialisation. The results show that consumers were more in opposition towards the GM potato in the two most restrictive policy options (A and B). In the less restrictive scenarios (C and D), a considerable fraction of consumers was neutral to the GM food. Furthermore, consumers' acceptance of the GM product was higher under mandatory labelling.

Moreover, our results show that consumer choices were statistically related to the decisions taken by the other actors in the food value chain. The decisions taken by farmers and retailers were the most decisive in determining the decisions taken by consumers.

Carl Johan Lagerkvist

Professor in Business Economics, SLU





WHAT HAVE WE LEARNT ABOUT **EU GMO regulation?**

Following the EU Single Market in the 1980s, regulatory policy competences were transferred from the national level to the EU, particularly in policy areas related to the free movement of goods. These competences then expanded to transportation, packaging, food, chemicals, etc.

As a Mistra Biotech researcher studying the EU regulatory framework on biotechnology, I have expanded and deepened my academic knowledge on the role of the EU as a regulator within policy areas that rely on science and the significance of not taking 'science' for granted. During this period, I have interacted extensively with the European Commission, the European Food Safety Authority, the legal service at the European Parliament, and various non-governmental actors. Through these interactions, I have been able to confirm that institutions and politics also matter in science-based policymaking, and it is important to study them so as to explain the emergence of new policy areas and decisions.

I now understand better the role of informal politics and informal actors, i.e. the organised interests. Close study of the policy process taught me that what is presented in the media is not necessarily well founded, and certain actors are often attributed roles they do not have in reality. Moreover, more work needs to be done on the formation of a broader public opinion based on science. I hope I will have the opportunity to conduct such work in the future.

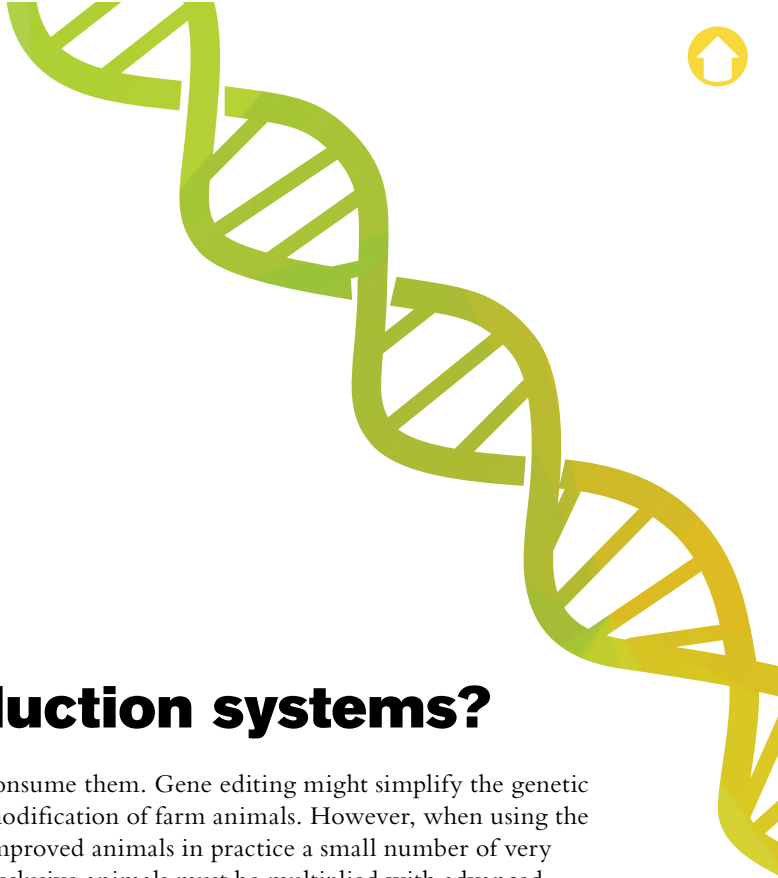
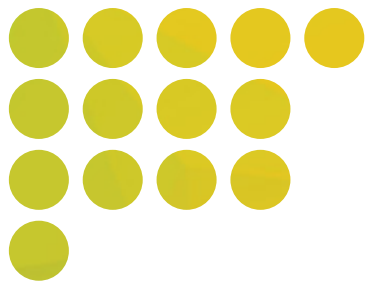
The Mistra Biotech project created the opportunity for a diverse group of academics to work in an interdisciplinary manner. The great diversity of researchers has been challenging in terms of understanding the different scientific terms, methods, and theories.

The role of politics has not been particularly emphasised in the project. Nevertheless, I learned and confirmed once again the importance of interdisciplinary interactions and the way we can help each other across disciplines by providing different points of view and sharing our diverse enthusiasms that we experience separately in our research.

Sevasti Chatzopoulou

*Associate Professor in EU Politics and Policies,
Roskilde University, Denmark*





WHAT HAVE WE LEARNT ABOUT

GMOs and whole production systems?

We have learnt that most effects of genetically modified organisms on ecosystem processes are indirect, and that ecological consequences of production systems with ‘new’ organisms are important to study regardless of the technique used to modify the organism. Such studies of production systems are, however, still rare. Meanwhile, simulation studies can show how genetically improved plants influence the environment.

We simulated a new barley variety with improved nitrogen uptake efficiency and showed how it reduced greenhouse gas emissions and nitrogen leaching involved in its farming. According to the simulation, these reductions are highly dependent on weather conditions, showing the need for field trials.

The trials with potato and *Lepidium campestre* have demonstrated the importance of testing new varieties in the field, since the performance can be very different in the field as compared to the greenhouse. Furthermore, new varieties must be tested in various environments over several years; a plant variety can perform differently at different locations and from one year to another. Field trials are thus time consuming, especially if studying the whole production system.

Field trials with *L. campestre* have shown that this new oil crop is winter hardy and as a catch crop it has the ability to reduce nitrogen leaching. The genetically unimproved varieties that we have studied so far have a low ability to compete with weed. This trait needs to be genetically improved before this plant species can be introduced in any production system. In a future production system including *L. campestre*, both oil and seed cake (a by-product from oil production) will be produced. The digestibility of the seed cake is also a trait that should be genetically improved. We have tested the seed cake on growing pigs in a pilot study and found that the pigs are willing to eat this feed.

Different types of GM farm animals have been developed by researchers outside Sweden, with the aim of improving production, reproduction and the health of the animals or the health of the humans who

consume them. Gene editing might simplify the genetic modification of farm animals. However, when using the improved animals in practice a small number of very exclusive animals must be multiplied with advanced reproduction techniques. This raises ethical questions, some of them related to success rate.

Lotta Rydhmer

Professor in Animal Breeding, SLU





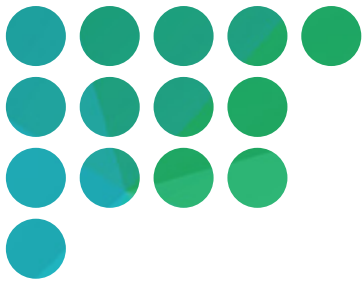
WHAT HAVE WE LEARNT ABOUT GMOs in ecosystems?

When keeping in mind that genetically modified organisms (GMOs) have now been used for more than two decades, surprisingly few studies have been published with a clear focus on the ecological consequences of biotechnology on agro-ecosystems. There is a particular lack of field studies at the landscape scale covering time periods longer than five years. In the few available studies, we see that most of the effects of GMOs on ecosystem processes are indirect, which means that they are not the result of the GMOs themselves, but rather result from associated changes in management strategies. For example, it might not be a specific property of an herbicide-tolerant crop that affects the ecosystem, but rather the associated changes in terms of more spraying and less soil tillage that might influence biodiversity and CO₂ emissions. The Mistra Biotech programme focuses strongly on crop breeding, but it is often difficult to link ecological impact assessment and plant breeding because major targets for ecological impact assessment are quantities at the ecosystem level, while the targets for plant breeding are individual plant traits. Irrespective of the technology used for crop improvement, our knowledge on the mechanistic links between individual plant traits and agro-ecosystem processes is poor and needs to be investigated further in the future. In this context, it is interesting to note that biotechnology might provide a unique tool for gaining insights into the links between plant traits and ecosystem processes when such technology is integrated into the toolbox used in basic ecological research. A major focus of this research should be on the specific traits of modified organisms and their possible ecological consequences rather than on the technologies used to modify those traits. In particular, field studies carried out over longer time scales are needed for evaluating the effects of the modified traits.

Martin Weih

*Professor in Plant Ecology and Eco-physiology of
Agricultural Crops, SLU*





WHAT HAVE WE LEARNT ABOUT

Communicating gene technology?

When we launched Mistra Biotech four years ago, we were well aware of the unfortunate mix of misinformation, lack of knowledge, and polarisation between different non-governmental organisations (NGOs), researchers, institutions, and private interests concerning GMOs.

Is gene technology as such the whole issue? No. In our dialogue with NGOs and the public, it has become very clear that the benefits from breeding crops and livestock in general are very unclear to most people. In fact, not many people are aware of the gigantic changes our crops and livestock have gone through and what those changes have meant for improving human life. "Can't things just be like they used to be?" No, in

agriculture they can't. Both plant and animal breeding are important continuous processes in our quest for better animal breeds and crop varieties to meet environmental changes and to reach sustainability goals. Before talking about the pros and cons of using gene technology in our food production, it is important to clarify the purpose of such technology in the first place. Otherwise, the communication will not be fruitful.

It is also striking just how strongly public scepticism towards GMOs is linked to the widespread aversion to the company Monsanto, even though there are many other seed companies and research institutes developing GM crops.

In talking to the public about gene technology, we have learnt that people can be sceptical and curious at the same time. I have especially noticed this when talking to students at schools and universities. Over the past years, there has been a positive change in how gene technology is discussed. In the comments sections of blog posts and news articles on the web, there seems to be a shift where more people acknowledge genetic modification as just one more technique among other breeding techniques. More and more comments about GMOs in social media refer to scientific facts, and the focus has been shifting from the technologies as such towards their application. This might be a result of the rapid developments in biotechnology that have blurred the boundaries of what can be called a GMO and made some of the arguments against the technology lose their value.

Anna Lehrman

Communication Officer at Mistra Biotech









The first four years

The first phase of Mistra Biotech began in January 2012. Thanks to successful cooperation between researchers from different scientific disciplines, a strong knowledge base about the opportunities and problems surrounding the use of modern biotechnology for sustainability in agriculture has been established during the first four years of the research programme.

In our own plant breeding projects, both genetic modifications (GM) and non-GM methods have been used to improve crops and to domesticate a wild plant species. The biotechnological work includes genetic modification, site directed mutagenesis and the use of genetic information for selective breeding.

The research programme has taken considerable steps towards the domestication of the biennial wild plant species, *Lepidium campestre* (field cress), into a novel oil-seed and catch crop suitable for northern conditions.

In the non-GM approach, *L. campestre* accessions have been selected and crossed based on phenotypes for the target traits of oil content, pod shatter, seed yield, and synchronised maturity.

In the GM approach, experimental protocols for genetic transformation and some molecular analysis methods have been established. Genes with known functions to improve specific traits (oil content, pod shatter, and oil composition) were targeted. Several *L. campestre* breeding lines with a single improved trait have been evaluated for phenotypical, biochemical, and molecular characteristics, and these improved traits will be combined in future breeding lines.

Potato breeding work has been performed to improve pathogen resistance, increase the nitrogen use efficiency, and enhance the nutritional value by increasing the amylose content. Both high-amylose potato clones and clones for resistance against late blight were produced using genetic transformation. The high-amylose potato was tested both in the greenhouse and the field, and the potato developed for pathogen resistance was tested in the greenhouse and found to be resistant against late blight. A marker for this resistant trait was identified, and it is now used in the Swedish potato breeding programme.

Furthermore, novel methods for the description of starch structures have been developed, as well as new applications and quality evaluations of processed starch. The potato variety 'Verba' was identified as a superior gene source for increased starch content in the new

high-amylose potato, but crossings between Verba and a high-amylose potato did not show the expected general increase in starch content in the field trial as was indicated in the greenhouse.

Two amino acid transporter genes were introduced into potato to improve the nitrogen uptake efficiency but these did not show the expected increased amino acid uptake in greenhouse experiments.

A protocol for genetic transformation of barley was established and two amino acid transporter genes were also introduced into this crop to improve the nitrogen use efficiency. The transgenic barley lines were tested in the greenhouse and the field, but the amino acid uptake was not clearly affected in this crop either. Another identified candidate gene for increased nitrogen use efficiency will be targeted in Mistra Biotech phase 2.

Novel molecular tools for breeders, in particular tools for genome-wide association studies, genomic selection and proteomics, have been developed within Mistra Biotech. The new tools will make it possible to respond more quickly to new challenges such as new pathogens without taking recourse to pesticides and medication. The tools have been, or will be, used both on plants (*L. campestre*, potato, and oats) and animals (Swedish Red Breed cattle). A close methodological cooperation between crop and livestock breeders is essential for the efficient development of these molecular methods, and Mistra Biotech has taken the lead in developing such cooperation.

We have initiated the establishment of a single-nucleotide polymorphism (SNP) genotyping platform for *L. campestre*. Furthermore, we have generated several resource populations for genetic mapping and training data for the genomic selection of *L. campestre*. These will be used for genetic linkage and quantitative trait locus (QTL) mapping in the future.

We have used proteomics to identify peptide markers to select for resistance against *Phytophthora infestans*, the pathogen causing late blight in potato. We have also started the development of peptide markers for bull fertility using seminal fluid from candidate breeding bulls at VikingGenetics. Our contribution to the international 1000 bull genomes consortium will provide invaluable genetic information for cattle breeding internationally as well as in Sweden.



Along with the novel molecular tools, new statistical tools for breeding have been developed and implemented as well as simulation models for the different target species. For genomic selection in outcrossing species, methodologies have been developed for modelling non-additive effects as well as models that can handle repeated observations from related individuals.

Potential scenarios for the implementation of genomic selection in oats (which is a selfing crop) have been evaluated in cooperation with Lantmännen.

The ethics research undertaken within the programme has resulted in important insights on ethical approaches to biotechnology, insights on arguments for and against genetically modified organisms, e.g. the hubris argument, and clarification of the concepts of agricultural sustainability, precaution, and naturalness.

An analysis of the meaning and the normative foundations of the term “agricultural sustainability” and the various conceptions of it that exist among actors in the food supply chain help to clarify the role of biotechnology in creating sustainable agricultural production systems. This work also provides approaches to make the debate less polarised and more accessible to a broad audience.

An initial in-depth review of the scholarly literature showed that the number of already existing ethical tools was greater than anticipated. Therefore, the need for developing new specific tools was less than envisaged at the outset of the project. It was noted, however, that the literature lacked a clear discussion of the criteria for the appropriateness of the various tools. Thus the research in this part of the project focused on critically



reviewing proposed suggestions for how ethical tools are to be evaluated. We propose a set of criteria for the assessment of ethical decision tools, including comprehensiveness, user-friendliness, and transparency. The argument is that ethical tools ought to be evaluated based on their purpose, and we distinguish three types of tools and discuss quality criteria for the different types. We also provide an overview of relevant parts of the literature on ethical tools that can guide potential users, including developers, regulators, policy-makers and retailers.

Consumer attitudes to biotechnology and GMO labelling have been studied in-depth and this has provided knowledge about the psychological foundations of technology acceptance. Our findings suggest that consumers are susceptible to information provision and that the way the information is provided is of importance. The effects of negative framing on product choice were shown to be stronger than those of positive framing. Our research also showed that when people are not presented with a positive or negative information frame, labelling is likely to go unnoticed and to have no effect. Understanding consumer responses to agricultural biotechnology is essential for the use of the technology in food production.

By combining research results from several scientific areas we have provided a better understanding of which aspects are most influential in directing consumer behaviour in relation to genetically modified food as well as whether, and under which circumstances, consumers trust the available information regarding the possible environmental, food safety and public health effects of consuming such food.

Furthermore, we have identified the interplay between top-down and bottom-up cognitive processing that governs how much attention consumers pay to biotechnology information. We have provided new results on the mental processes by which consumers learn and associate in relation to a novel (biotech) food label.

Additionally we have identified the importance of the major risk-related concerns of Swedish and German consumers and how these concerns influence their attributions of risk responsibility among the main actors within the food and bioenergy sectors. Perceived risk is dominated by health and environmental concerns, while ethical and socio-economic risks are of less importance. Policy makers are the group to which most responsibility is attributed. Consumers, however, also assign non-trivial levels of risk responsibility to themselves as well as to other actors in the food sector.

Swedish competitiveness and the regulatory framework for agricultural biotechnology and GM crops in the European Union and globally have been investigated within Mistra Biotech. We have studied the governance of the Swedish agri-food system and the regulatory environments in Sweden in relation to potential uses of GMOs, and we have explored the potential for the adoption of new biotechnologies by the commercial agri-food value chain. We found that the duration of illegal cartels in Europe is longer for agriculture than other sectors. The simultaneous presence of throughput mechanisms contributes to the overall legitimacy of regulatory food governance in the EU, and the impact of the adventitious presence of GMO products differs in vertically oligopolistic markets.

Additionally the capacity and constraints to produce and distribute innovative products and processes were studied, as were the impacts that the introduction of these products can have on the Swedish economy. Site directed mutagenesis techniques might reduce the entry cost and might increase the competition in the GMO market, and GMO products that save on fertiliser use and reduce carbon emissions can be used on the market for carbon quotas to make the application of such techniques more economical for farmers.

We analysed the media coverage of biotechnology topics in the US and UK from 2011 to 2013 by examining two leading newspapers – The Washington Post and The Guardian. We found that the two newspapers differed in their intensity of reporting on GMO issues but were alike in their content about GMOs. On both sides of the Atlantic, the central actors were scientists and non governmental organisations (NGOs) who argued mostly about agricultural applications of biotechnology. We found the debate to be locked in a stalemate of potential risks against potential benefits, with neither of the two positions clearly dominating the discourse.

Production systems, ecological aspects, and how social sustainability can be affected by biotechnology in agriculture have been analysed within Mistra Biotech. The focus has been on environmental, economic, and social sustainability of agricultural production systems and how such systems can be improved. Natural and social scientists within Mistra Biotech have worked together with other researchers, stakeholders, and experts on food production systems and methods for systems analyses on this task. One conclusion is that effects of GMOs on ecosystem processes are indirect, and ecological consequences of production systems with ‘new’ organisms are important to study, regardless of the technique used to modify the organism.



Field trials have been conducted to evaluate the winter hardiness, nitrogen uptake efficiency, pathogen resistance, and product quality of new and improved crop varieties developed within Mistra Biotech.

Ecological and social consequences of using GMOs in agriculture have been reviewed in extensive literature studies. Simulation studies and life cycle assessment have pointed out the effects on production, greenhouse gas emissions and nitrogen leaching of growing GM barley with increased nitrogen uptake efficiency in Sweden.

Nordic potato breeding has been described and possibilities for a potato breeding strategy based on cooperation between the Nordic countries have been identified. Constraints for marketing GM products have been identified and discussed from a sustainability perspective. Ethical and breeding issues related to GM farm animals have been also been reviewed.

The communication activities have been performed in order to ensure that the relevant stakeholders are integrated in the programme and that our results are made known and put to use. We have also tried to provide general information and facts regarding our research area.

Our website presents our research, programme organisation, participants, publications, events, and links to relevant news articles and opinion pieces. The digital newsletter presenting our publications, workshops, and seminars reaches over 1100 subscribers (in Sweden and globally). The website and the newsletter have grown into important sources of information about agricultural biotechnology that are used by academics, policy-makers, industry, media, and the general public.

Our book “Shaping our food – an overview of crop and livestock breeding”, published in 2014, has likewise attracted many kinds of readers from high school students to politicians and government officials.

Our seminars and workshops have attracted broad audiences, from undergraduate students to senior researchers, representatives from NGOs, different branches of the agricultural and food industry, governmental institutions and the media. An international symposium about knowledge gaps concerning GM farm animals is one example of our outreach. National and international workshops about consumers’ attitudes and choices are other examples.

Visits to our field trials have been successful communication activities that have received significant coverage in the media. We have organised a recurring

Mistra Biotech-day for college students where our researchers give lectures and discuss their research with students. Mistra Biotech has also been part of the SLU stand at the annual agricultural fair Borgeby Fältdagar.

In summary, we believe that our external communication activities have contributed to providing the public with a much more complete and accurate picture of modern biotechnologies than what they usually receive.

The interdisciplinary approach within Mistra Biotech has provided a platform for direct and close interaction and co-operation between natural and social scientists. Our focus has been to understand each other’s research methodologies across the scientific disciplines and to learn from each other.

The researchers within the programme have been kept up-to-date with what is going on in the programme through meetings and through an internal newsletter.

Natural scientists have gained a better understanding of how the general public and consumers perceive the information about the modern technology-aided products in regard to ethical, social and economic aspects through in-depth discussions with the social scientists and ethicists. This has helped them to better understand the importance of taking ethical and social issues into consideration when communicating about the new biotechnological approaches. Meanwhile, social scientists have also made use of the competence of natural scientists to better understand the potential contribution of biotechnology to developing sustainable agriculture in Sweden.







How phase two differs from phase one

Large parts of our research in phase 2 of Mistra Biotech will be a continuation of our work in phase 1. This applies in particular to the plant breeding work included in the programme. Since plant breeding has longer time frames than most other research activities, it usually has to follow a long-term planning. Therefore it is not surprising that we continue to work with the species we have in phase 1, but in phase 2 we will focus mainly on *Lepidium campestre*, the new oil and catch crop that we are domesticating, and potato. For potato breeding we will focus in particular on disease resistance (late blight). Moreover, we will work with improving starch quality and increasing nitrogen use efficiency in potato, and resistance breeding of barley (leaf blotch) and oats (*Fusarium*).

We will continue to use both conventional and modern breeding methods to speed up the plant breeding process. We have worked hard to adapt the latest modern breeding tools such as genome editing technique CRISPR/Cas9 in phase 1 and will continue to do so for plant breeding in phase 2. We will follow the latest developments in genomics and proteomics and continuously evaluate what we can learn from work by others in these rapidly developing areas. We will apply genomics and proteomics both to our plant breeding projects and to animal breeding (bull fertility). Furthermore, we will continue to work on the further refinement of methods for genomic selection with a focus on livestock.

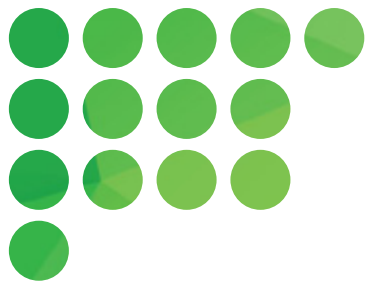
Our research in ethics and the social sciences will have a much strengthened emphasis on regulation and legislation in phase 2. We will also perform two in-depth studies of the possible introduction of biotech products in Swedish agriculture. In one of these studies we will investigate the various issues surrounding the introduction of *L. campestre* in Swedish agriculture. This will include legal, practical, ethical and economic aspects of the introduction. In the other of these studies, we will investigate the issues arising when biotechnology is applied to animals.

The programme has been reorganized into three research areas (RA) in phase 2 instead of the six component projects (CP) of phase 1. The first research area (RA1) contains the plant breeding activities from the previous CP1, and the second area (RA2) continues

the work with breeding methodology from the previous CP2. We merge the remaining four component projects into the third research area (RA3) that contains social science and ethics, as well as contributions from the natural sciences to the programme synthesis. We have replaced the terminology “component project” (CP) by “research area” (RA) in order to emphasize the more integrated, less project-bound way in which we intend to conduct our research in phase 2.

Our communication work will be strengthened, and we will have two communicators. We will create two new interdisciplinary working groups, one for *L. campestre* and one for potato. They will coordinate our work on these two crops and make sure that all the projects concerning the respective crop receive inputs from the various disciplines that can contribute to them. We will also have an Implementation Committee whose task is to develop and implement plans for bringing the results from Mistra Biotech to practical use.

In brief: We will focus more on regulation, implementation, synthesis and communication.



A sunny day in August 2012 Mistra Biotech arranged a demonstration of field trials with genetically modified barley and potato outside Kristianstad. The press was invited to a presentation about the research programme and the tested crops. The journalists had the opportunity to have a closer look at the plants, and make personal interviews with our researchers. The press viewing rendered articles in newspapers and spots in the Swedish national TV, one of which was followed by a debate on genetically modified crops between a representative of the Swedish Society for Nature Conservation and Stefan Jansson, professor at Umeå university and member of the Mistra Biotech board. This was one of our early successful outreach activities.



Activities

2012

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 presentation 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.

2013

14/1 E. Ivarsson talked about her work with transgenic plants in Mistra Biotech at the college Spyken, in Lund.

23/1 Mistra Biotech workshop "Sustainability in future food production systems - Can biotechnology make a difference?" at SLU, Ultuna.

13/2 Mistra Biotech was represented at the seminar "Växtförädling – en livsviktig verksamhet" at the Swedish Parliament.

18/2 Presentation of Mistra Biotech when the Thai delegation (Department of Rice, The Ministry of Agriculture and Cooperatives) visited SLU, Ultuna.



Activities

27/2 S. Stymne gave a presentation and provided information about Mistra Biotech at "Jordbruks och trädgårdskonferensen" at SLU, Alnarp.

13/3 S. Stymne was invited as speaker at the conference "Rachel Carson & Ruth Harrison 50 years on" at the Biodiversity Institute in Oxford, UK.

14/3 L. Rydhmer and J. Sundström were invited to talk about genetic alteration of livestock and genetically modified crops, respectively at Skara Senior University.

11/4 P. Sandin presented "Mistra Biotech - de etiska aspekterna av genteknik vid livsmedelsproduktion" at the Swedish network for GMO and food.

17/4 P. Sandin was invited to give a presentation "Biotek-grödor och verktyg för etisk analys" at the Swedish Genetechnology Advisory Board.

25/4 P. Sandin presented "Etiken, politiken och tekniken" at The Royal Swedish Academy of Agriculture and Forestry seminar "Växtförädling 3.0 – ny teknik och gamla lagar".

29/4 P. Sandin presented "Två kulturer, eller att samtala om risker – erfarenheter av möten med studenter från olika discipliner" at The Swedish Risk Academy, Stockholm. (Per was awarded The Swedish Risk Academy's Special Prize to Promising Junior Researchers 2013.)

28/4-1/5 Poster "Fatty acid profile and minor lipid components in the oil of some selected germplasms of *Lepidium campestre*" presented by S. Madawala et al., at the 104th American Oil Chemists' Society Annual Meeting & Expo, Montréal, Canada.

14/5 I. Åhman lectured about the gene revolution at the network for medical laboratory scientist in Skåne.

14/5 Mistra Biotech Nutrition Workshop for project leaders and invited researchers working on food, nutrition, and human health, discussed possibilities for breeding for healthier food.

18/5 Participation and information material at the Fascination of Plant's day in Lund.

10-13/6 Poster "Genetic improvement of *Lepidium campestre* using gene technology" presentation by E. Ivarson et al., at the European Plant Genetic Resources Conference, NordGen, Alnarp.

14-16/6 P. Moula presented "Hubris and the promethean sin in discussions on nature and technology". P. Sandin presented "What environmental ethicists can learn from bioethics: professions and 'killer apps'", and K. Edvardsson Björnberg gave a keynote presentation "From Hausväterliteratur to modern agricultural biotechnology: Past, present and future directions in environmental philosophy" at the Swedish Congress of Philosophy, Stockholm.

26-27/6 Mistra Biotech was represented in the SLU stand at the agricultural fair Borgeby Fältdagar.

17/7 C.J. Lagerkvist presented the results from "Consumers' Evaluation of Biotechnology in Food Products: New Evidence from a Meta-Survey" at the International Summer Labs at the Hochschule Osnabrück, Germany.

4-6/8 S. Hess presented "Consumers' Evaluation of Biotechnology in Food Products: New Evidence from a Meta-Survey" at the Annual Meeting of the Agricultural and Applied Economics Association (AAEA) in Washington D.C.

28-30/8 M. Dida Geleta presented "Development of *Lepidium campestre* as a perennial oil crop through domestication" at the FAO Expert Workshop on Perennial Crops for Food Security, Rome.

5/9 C.J. Lagerkvist presented the results from the meta-study and Klaus Grunert gave a talk about "Consumer concern about food processing: When and why?" at a seminar on consumer acceptance of food processing technologies at the University of Copenhagen.

4-7/9 K. Karantininis and S. Hess' paper "Cross-Atlantic differences in GMOs: A Media Content Analysis" was presented at the conference European Consortium for Political Research, Bordeaux.

4/10 Mistra Biotech lunch seminar with Nicholas Kalaitzandonakes in collaboration with Future Agriculture "The evolving structure of the global agrifood biotech industry and implications for future innovation" at SLU, Ultuna.

10/10 Mistra Biotech workshop "A never ending battle – understanding resistance biology for sustainable agriculture" in collaboration with Plant Link, SLU, Alnarp.

16/10 M. Andersson presented her work on the amylose-potato and discussed GMO legislation at the Gene Technology Advisory Board.



31/10-1/11 C.J. Lagerkvist presented the results from the meta-study at the Nordic-Baltic GMO workshop “Socioeconomic impacts of GM-cultivation” in Riga.

6/11 Mistra Biotech lunch seminar with Anita Lundström, Swedish Environmental Protection Agency, in collaboration with Future Agriculture, “Generationsmålet och miljö kvalitetsmålen - hur lyckas vi?” at SLU, Ultuna.

14/11 S.O. Hansson presented “Reglering av bioteknik ur etisk synvinkel” and S. Stymne “Bioteknologi för bättre miljö” on the theme “Bioteknologi för Miljö och hälsa” at The Royal Swedish Academy of Engineering Sciences (IVA).

18/11 C.J. Lagerkvist and Per Sandin gave talks at Lantmännen’s internal theme day “GMO – Attityder och Etik” in Stockholm.

19-20/11 Visit by Mikayla Keen from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) including meetings at the Swedish Radio, Mistra and the Gene Technology Advisory Board.

28-30/11 P. Moula gave a talk “The hubris in claiming hubris” at the Asia-Pacific Society for Food and Agricultural Ethics (APSAFE) Conference, Bangkok.

2014

11-15/1 “Genome wide association using imputed sequence data in dairy cattle with the 1000 bull genomes project data set” by D.J. de Koning et al., was presented at the Plant & Animal Genome XXII Conference in San Diego. At the same conference DJ and F. Lopes Pinto (et al.), presented “Oligoreef – Generation of primers for complex polymerase chain reactions”.

19-20/1 A. Lehrman (and others) met with Mikayla Keen, communicator at CSIRO, and visited Swedish Radio, Mistra, and the Gene Technology Advisory Board.

22/1 S.O. Hansson participated in a panel discussion at the launching event of “Growing Voices” online platform organised by EuropaBio in Brussels.

23-25/1 P. Sandin and S.O. Hansson gave talks at the workshop New Technologies and Social Experiments, Technical University of Delft, Netherlands: “Responsible social experimentation – fiddling with a trope or a way forward?” and “Experiments – Why and how?”.

6/2 S. Stymne talked about GMO and Mistra Biotech at a symposium for chicken producers arranged by Stiftelsen Svenska Kycklinguppfödare and SLU.

9-13/2 Oral presentations by U. Ganeteg “Root uptake of amino acids at naturally occurring concentrations”, H. Svennerstam “Root-shoot allocation of biomass depends on nitrogen source”, and S. Jämtgård “Organic nitrogen in agricultural soil”. The International Workshop on Organic Nitrogen and Plant Nutrition – from Molecular Mechanisms to Ecosystems. Centro Stefano Franscini, Switzerland.

20/3 P. Sandin gave a presentation “Animal feed – ethical aspects” at the Swedish Association of Veterinary Feed Control.

1/4 Mistra Biotech-day for high school students. Lectures by Studentpoolen, J. Sundström, L. Rydhmer, K. Koch, A. Pakseresht, P. Sandin, T. Jansson, K. Jäderkvist, and A-K Kolseth.

13/5 Forskningens samhällsansvar Kungl. Fysiografiska Sällskapet in Lund. S. Stymne gave a talk on “Är motståndet mot gentekniken på växter ett brott mot mänskligheten?”.

16/5 KSLA seminar: A changing climate – how does it affect Swedish possibilities for green economic growth? L. Rydhmer presented Mistra Biotech in a talk “Breeding plants and animals for mitigation and adaption to a changed climate in the Nordic countries”.

21/5 GMO GenEtik - Hur skapar vi framtidens mat? at Lund University. P. Sandin was the moderator and S. Stymne gave a short talk and took part in the debate. Organised by PlantLink and Alnarp Student Union.

23/5 Mistra Biotech workshop arranged by CP5: Regulatory challenges for agricultural biotechnology in the EU. S.O. Hansson and C.J. gave presentations.

2/6 Visit to SLU Uppsala by the Department of International Trade Policy of the Swedish Foreign Ministry. A. Lehrman gave a presentation “GMO – forskning, framtid och farhågor”.

4-6/6 K. Karantininis was a key-note speaker in the session “Integrating industry, academia and politics innovation agenda's to increase the sustainability and competitiveness of the European agrifood industry” at the 11th Wageningen International Conference on Chain and Network Management, Capri, Italy.



Activities

24-25/6 Mistra Biotech symposium and workshop: Breeding genetically modified animals for food production arranged by CP2, 3 and 6.

25-27/6 S. Chatzopoulou presented the paper "The challenges of the transnational regulatory governance of the food chain standards" at the 5th European Community Studies Association Regulatory Governance Conference, Barcelona, Spain.

6-11/7 L.H. Zhu gave a talk "Development of a new oilseed crop *Lepidium campestre*", and E. Ivarson presented a poster "Alteration of seed oil composition in *Lepidium campestre*" at the 21st International Symposium on Plant Lipids at the University of Guelph, Canada.

17-22/8 D.J. de Koning participated at the 10th World Congress on Genetics Applied to Livestock Production, where several of his project were presented.

9/9 A. Lehrman was invited speaker (on science journalism) at Sveriges Radio's 40 year anniversary celebration of the radio show Vetandets Värld.

13/9 A. Lehrman gave a presentation on "GMO – forskning, framtid och farhågor" at the open house day at the Ecology Centre, SLU, Uppsala.

23/9 A. Lehrman gave a presentation on "GMO – forskning, framtid och farhågor" at the Faculty of Natural Resources and Agricultural Sciences-day, SLU, Uppsala.

25-27/9 S. Chatzopoulou presented the paper "The contested politics of the EU regulatory governance of GMOs" at the Danish European Community Studies Association's Annual Conference, Aarhus University, Denmark.

13-15/10 The Mistra Biotech meeting, an event with over 40 researchers from the programme and invited speakers participating (internal meeting).

15/10 P. Sandin was invited to talk on "The adverbial analysis of precaution" at the Helmholtz Research School on Energy Scenarios, Karlsruhe Institute of Technology Autumn School, Karlsruhe, Germany.

4/11 A. Lehrman gave a presentation on "GMO – forskning, framtid och farhågor" at Rotay Glunten, Uppsala.

4/11 A. Lehrman held a lecture on "Science and society – why researchers are not always viewed as the good guys", with emphasis on the GMO issue, as part of the course "Research Ethics for PhD Students".

12/11 C.J. Lagerkvist gave a presentation on consumer attitudes regarding the use of biotechnology in the agriculture and food sector at the Gene Technology Advisory Board, Stockholm.

17/11 J. Sundström and L. Rydhmer were invited to Kungliga Vetenskapssamhället i Uppsala to initiate a discussion on "Bioteknologi i framtidens växtodling – tro och vetenskap".

27/11 Mistra Biotech lunch seminar GM-food – arguments on naturalness and authenticity with philosopher Helena Siipi (University of Turku, Finland), SLU, Uppsala.

28-31/11 L.H. Zhu gave a talk "Genetic improvement of a new oilseed crop *Lepidium campestre*" at the 10th International Symposium on Biocatalysis and Agricultural Biotechnology, I-SHOU University, Taiwan.

10/12 L.H. Zhu gave a presentation about her research, foremost about new breeding technologies, at the Gene Technology Advisory Board, Stockholm.

2015

28/1 A. Lehrman was invited to give a talk on future agriculture and how research can contribute at the Royal Swedish Academy of Agriculture and Forestry Commemorative meeting.

15/2 E. Andreasson gave a talk on "Stress signalling in *Arabidopsis* and *Potato-Phytophthora* interactions" at the Max Plank Institute for Plant Breeding, Köln, Germany.

21-22/2 E. Jonas presented a poster "Can livestock methods and models be used as a basis to develop genomic selection breeding programs in crops?" at the Gordon Research Seminar on Quantitative Genetics & Genomics, Lucca (Barga), Italy.

17-18/3 S.O. Hansson, L. Rydhmer, A. Lehrman, E. Jonas, S. Chatzopoulou, P. Sandin, P. Moula, E. Andreasson, A. Chawade, and C. Dixelius visited the James Hutton institute, of which several contributed with presentations.



8-11/3 J. Lund Orquin gave a talk on “Areas of interest as a signal detection problem for behavioral eye tracking research’s research”, also “Transparency standards in eye tracking research” was presented at the 57th Conference of Experimental psychologists, TeAP, University of Hildesheim.

18/3 J. Lund Orquin gave a talk on “Transparency standards in eye tracking research” at the workshop on Methodological issues in mobile eye tracking, Aarhus University, Denmark.

21/3 A. Lehrman was invited to give a presentation “GMO – vad är grejen” at SciFest Uppsala at Fyrishov.

16/4 E. Jonas gave a talk “Genomic selection - Published research outcomes and scientific questions” at the PlantLink workshop Genomic selection in plant breeding – From theory to practice, Alnarp.

16-17/4 L.H. Zhu gave a talk on “Domestication of a new oilseed crop *Lepidium campestre*” at the Genetics Society spring meeting – Breeding for bacon, beer and biofuels, The Roslin Institute, Edinburgh, UK.

29/4 A. Lehrman was invited to give a presentation on public opinion, media, and GMOs in the working group on biotechnology in crop production at the Royal Swedish Academy of Agriculture and Forestry.

4/5 A. Lehrman gave a lecture on GM crops at the SLU course Växtskadegörare i jordbruket.

13/5 A. Lehrman was invited to a science cafe “Genmodifierad mat – vill du smaka?” organised by Föreningen Medveten Konsumtion, at Kulturhuset, Stockholm.

13/5 K. Edvardsson Björnberg gave her Docent lecture “Grön bioteknologi och den hållbara utvecklingens normativa grundvalar” at KTH, Stockholm.

25/5 P. Sandin and A. Lehrman gave lectures on sustainability (ethics and GMOs respectively) at the “sustainable development day” within the course “Självständigt arbete” for the engineers in molecular biotechnology at Uppsala Universitet.

27-29/5 P. Sandin gave a talk on “Simple plain fare or exquisite eating – is simplicity really a consumer virtue?” At the 12th Congress of the European society for agricultural and food ethics, Cluj-Napoca, Romania.

10/6 S.O. Hansson presented Mistra Biotech at the Genetechnology Advisory Board.

16/6 K. Karantininis was a discussant at the ICABR preconference: The Contribution of the Emerging Bioeconomy to Sustainable Development, in Ravello, Italy 8/8 Rodomiro Ortiz gave a talk on “Plant genetic engineering as a means to improve food security: potential and issues surrounding it” at the ICAE preconference “Global Food Security Challenges”, in Milan, Italy.

9/8 K. Karantininis gave a talk on “Extracting the Kyoto rents: nitrogen efficient gmo rice in China” at the 29th International Conference of Agricultural Economics, in Milan, Italy 19/8 Mulatu Geleta gave a talk on “Domestication of a perennial oil crop and identification of genes governing perenniality” at the SSF meeting with Oil Crops for the Future, in Alnarp.

27/8 E. Andreasson gave a talk on “Forskning på SLU Alnarp för ökad resistens” at Potatisdag i Kristianstad arranged by Lyckeby Starch and Hushållningssällskapet Skåne.

29/8 H. Röcklinsberg and P. Sandin participated at the event “Matologi - ett evenemang om framtidens mat” in Stockholm, organised by SLU.

1/9 D. Eriksson moved to Brussels to spend nine months working at the European Plant Science Organisation (EPSO), with funding from the Mistra Fellow Programme.

17/9 D. Collentine gave a talk on “Assessing the effect on nitrogen leaching of production systems with new and improved crops” at the 17th IWA International Conference on Diffuse Pollution and Eutrophication, in Berlin.

26/9 Mistra Biotech at Öppet Campus in Ultuna. “Tämja en vild växt - går det? Fältkrossing förädlas för sin olja.” Demonstration at the Ecology Centre at SLU by L. Rydhmer and L. Beste.

4/11 S.O. Hansson was a moderator at the conference “Banbrytande forskning med etiska dilemman - genredigeringstekniken (CRISPR/Cas9)” arranged by RIFO, Gentekniknämnden and SMER, Riksdagshuset, Stockholm.

10/11 I. Åhman gave a talk on “Site-directed mutagenesis as a resistance breeding method; for aphid and net blotch resistance” at Nationell växtskyddskonferens 2015, Uppsala.



Activities

24/11 L.H. Zhu gave a talk on “Genmodifierade växter framtidens oljeråvaror” at the conference Underhållsdagen 2015, Göteborg.

27/11 H. Röcklinsberg participated in a panel discussion on how to integrate the accelerating scientific progress with basic principles of our civilisation, at a ScienceEthics-Politics Day in Berlin.

1/12 D. Eriksson, Mistra Fellow at EPSO, organized a workshop on plant breeding in the European Parliament.

9/12 S.O. Hansson and L. Beste participated in a meeting with representatives from Coop, Naturskyddsföreningen and Gentekniknämnden, with the theme “GMO och växtförädlingstekniker - hot eller möjlighet?”

2016

9-13/1 D.J. de Koning gave a talk and presented a poster on “RAD sequencing of diverse accessions of *Lepidium campestre*, a target species for domestication as a novel oil crop” at the Plant & Animal Genome Conference XXIV in San Diego.

5/2 P. Sandin gave a talk “Are we done with debunking? Using the category of nature in technology and environmental philosophy” at the First Annual Bovay Workshop on Engineering and Applied Ethics, Texas A&M University in Texas.

21/3 P. Sandin participated at the workshop “Vad är ett hållbart jordbruk i Norrbotten?”, Länsstyrelsen i Norrbotten, Luleå.



Mistra Biotech at the annual programme meeting in 2016.



Discussions on how we will continue the research in the programme.



Mistra Biotech-selfie at the annual programme meeting in 2014.



Mistra Biotech in the media

NEWSPAPERS/WEB

2012

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

Kristianstadsbladet (31/5) "Genmodifierad potatis orsakar biflytt"

DN Debatt (2/6) "Populistisk miljörelse demoniserar gentekniken" (Stymne and Sundström)

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

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

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

Kristianstadsbladet (29/8) "Försök med grön olja kan tvingas flytta"

Kristianstadsbladet (29/8) "Gränsvärdet för GMO-grödor i mat ingen hälsofråga"

Norra Skåne (29/8) "Delade meningar om genteknik"

ATL (31/8) "Gmo även för ekodlare?"

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

Lantmannen (nr 10) "Europa lever i en bubbla"

Miljöforskning (Sept.) "Eko-bönder öppnar för GMO"

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

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

2013

New Insights (22/4) "Oil plant and catch crop in one"

New Insights (22/4) "Challenges in a Dutch professor's life"

Lantmannen (nr 3) "Hon öppnar dörren mot framtidens odling"

Land Lantbruk (10/5) "Hennes arbete hindras av EU-reglerna"

Landet runt (5/6) "Företagen flyr Sverige men GMO-forskningen fortsätter"

Epoch Times (19/6) "EU at a GMO Crossroads"

Epoch Times (22/6) "Européer inte mer negativa till GMO än andra"

Kristianstadsbladet (24/6) "Inga bin får komma åt GMO-kålen"

Land Lantbruk (27/6) "Skilda världar i synen på framtidens växtskydd"

ATL (11/9) "Negativ attityd till gmo en myt"

Miljöaktuellt (12/9) "Ny studie: EU-medborgarnas skepsis till GMO är en myt"

Livsmedel i fokus (12/9) "GMO-motståndet i EU mindre än man trott"

Jordbruksaktuellt "Frågan avgör uppfattning om GMO"

FreshPlaza (17/9) "EU consumers less negative about GMOs than previously believed"

Science 2.0 (19/9) "Europeans are less negative about GMOs than portrayed"

FoodCulture.dk (24/9) "Europæere er ikke mere kritiske over for GMO"



Mistra Biotech in the media

MarkLynas.org (22/10) "Scientists challenge Swedish government over funding of Golden Rice trial vandalism"

UNT Debatt (22/10) "Ska Sida sabotera matforskning?"

Riksdag&Departement (5/11) "Svenskt bistånd stöttar risbråk"

2014

UNT (7/1) "Sida sprider skrönor"

Land Lantbruk & Skogsland (8/1) "Skattepengar till fältförsöksvandaler"

UNT (12/1) "Omvärlden styrs inte av Sida"

UNT (13/1) "Genteknik måste ifrågasättas"

Svea Jord & Skog (27/2) "Legitimt att bortse från fakta i GMO-debatten"

ATL (17/3) "GMO-forskning i fara"

SVT Nyheter (17/3) "Svensk GMO-forskning läggs ner"

SVT Nyheter (17/3) "Så här tycker forskarna om GMO"

Fjäderfä (24/3) "GMO – en vision om framtiden"

SVT Nyheter (25/4) "Forskare vill lätta på GMO-regler"

KSLA Nytt & Noterat (19/6) "Vad betyder klimatförändringarna för grön ekonomisk tillväxt?"

SvD (23/6) "LRF efter super-broccolin: 'Behövs ny lagstiftning'"

SvD (16/8) "Minskat motstånd mot GMO"

ATL (16/8) "GMO-motstånd luckras upp"

Curie (2/9) "Parallell vetenskap och grön ideologi – ett hot mot demokratin"

Journalisten (9/9) "Granska makt och pengar inom forskningen"

Science Newsline (18/9) "Want to link genes to complex traits? Start with more diversity"

Science 2.0 (18/9) "There is no magic genetic bullet for complex traits, but here are 18 approaches"

Bright Surf (19/9) "Want to link genes to complex traits? Start with more diversity"

MNT (22/9) "Mapping complex trait genes in multi-parental populations"

The Wall Street Journal (28/10) "The warped world of parallel science"

Jordbruksaktuellt (29/10) "DEBATT – Aktivister skadar demokratin"

ATL (29/10) "SLU-forskare ser aktivister som hot mot demokratin"

C – en idétidsskrift om cerealier (nr 4 2014) "Låt egenskaperna och inte tekniken styra"

NewsVoice (9/12) "Det handlar om hur man använder tekniken inte om tekniken i sig"

2015

SVT Opinion (19/1) "Miljöpartiet måste sluta hyckla i GMO-frågan"

SVT Opinion (20/1) "Vi är mer innovativa än andra partier"

Jordbruksaktuellt (20/1) "Sluta hyckla i frågan om GMO"

SVT Opinion (22/1) "Dags att byta politik gällande GMO"

SVT Opinion (23/1) "GMO får allvarliga konsekvenser för både människor och miljö"

Göteborgsposten (1/3) "Omdebatterad ost vanlig i butik"

Greppa Näringen (6/3) "Fältkrassing som fånggröda"

ATL (22/5) "Angelägen forskning med dubbla syften"

Svenska Livsmedel (3/2015) "Låt egenskaperna styra - satsa på hälsa och miljö"

RadioScience (7/7) "Forskaren Anna Johansson kartlägger genetiken hos höns och får"



TV4 (24/7) "Nytt genmodifierat ris - konsumenter är osäkra på GMO-mat"

RadioScience (26/8) "Moralfilosofi om framtida jordbruk"

Lantmannen (8/2015) "Genombrott för ny oljeväxt"

Lantmannen (9/2015) "Genernas kamp om svampen"

Djurskyddet (18/9) "Vanorna styr valet"

Forskning.se (6/10) "GMO påverkar jordbruksekosystem indirekt"

Naturvetare (6/2015) "GMO påverkar indirekt"

KIT (1/12) "Kan kloning vara en lösning på matfrågan?"

SVT Nyheter (1/12) "Måste julnöten vara så tuff att knäcka?"

Forskning.se (10/12) "Att odla genmodifierat en moralisk skyldighet"

SLU, Blogg (2/12) "FDA ber om hjälp att definiera "naturlighet"

Veckans Affärer (14/12) "Hundratals miljoner är undernärda - därför är genmodifierad mat en moralisk skyldighet"

UNT (15/12) "Kan tvingas uppmana: köp utländsk mat"

2016

Helsingborgs Dagblad (31/1) "Veterinärer kräver krafttag mot hundavel"

Dagens Nyheter (2/3) "Hans Ruins bild stämmer inte med verkligheten"

RADIO/TV

2012

Radio Sweden (20/3) "Swedish scepticism blocks GMO crop expansion."

SR, Ekot (18/4) Sten Stymne about "oljekål" *Crambe abyssinica*.

SR, Ekot (4/5) About the need for nets preventing insects from spreading GM-pollen.

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

TV4, News (19/9) Mariette Andersson talks about her work with the starch potato.

SR, OBS (5/12) Per Sandin and Tina d'Hertefeldt gave their view on "Genmodifierade grödor - hot eller möjlighet?"

2013

SR, Klotet (22/5) "Ogräsresistens: Är det gengrödan eller felaktig användning av bekämpningsmedel som är boven i dramat?"

SR, Vetenskapsradion (27/5) "Svensk vildpotatis kan stoppa besprutning"

Hallandsekot (27/5) "Diskussionen: För eller emot GMO-grödor"

SR, Vetenskapsradion (28/5) "Genmodifierade djur på väg ut från labbet"

SR, Morgonpasset (30/5) "Kan zombies bli förkylda?"

SR, Vetenskapsradion (5/6) "Eko-lantbrukare håller dörren stängd för GMO"

SR, Vetenskapsradion (22/10) "Biståndspengar går till vandalisering av forskning"

SR, Vetenskapsradion (25/10) "Svenskt bistånd betalar för både forskning för och motstånd mot GMO"

2014

SVT, Vetenskapens värld (17/3) "Striden om genmodifierade grödor"

SR, Vetenskapsradion (18/3) "Resistent skalbagge i genmodifierad majs"

SR, Vetandets värld (28/4) "Mendel och molekylärgenetik"

SVT (29/4) "Kodjos kval"



Mistra Biotech in the media

SR, Vetandets värld (20/5) "Genförändrad mat – hot eller möjlighet?"

2015

SR, Vetenskapsradion (5/2) "Växter kan bli mer torktåliga"

SR, Vetenskapsradion (6/3) "Revolutionerande genteknik ännu oreglerad"

SR, P1-morgon (8/8) "Vilken väg ska Sverige ta i GMO-frågan?"

SR, Vetenskapsradion (21/8) "Fältkrassing förädlas för olja"

SR, Vetenskapsradion (1/9) "Stressade växter använder samma signalmolekyl som djur"

SR, Vetenskapsradion (17/11) "Genmodifiering med ny teknik kan ske utan tillstånd"

SR, Vetenskapsradion (1/12) "Till våren spirar de första CRISPR-blommorna i Sverige"

SR, Vetenskapsradion (4/12) "Professor: Köttfabrik för kloning en återvändsgränd"

2016

SR Vetenskapsradion (25/3) "Specialdesignade barn och mammutar i blåbärsskogen"





Publications

SCIENTIFIC

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| Lars Sandman | School of Health Science, University of Borås |
| Johan Schnürer | Department of Microbiology, SLU |
| Harald Svensson | Swedish Board of Agriculture |

Researchers

EMPLOYED AND ASSOCIATED RESEARCHERS

| Name | Position | Department |
|---------------------------------------------------------|-----------------------|-------------------------------------------|
| CP1: Plant biotechnology for innovative products | | |
| Alessandro Nicolìa | Researcher | Plant Breeding, SLU |
| Anna Källman | PhD student | Food Science, SLU |
| Camila Cambui | Post-Doc | Forest Genetics and Plant Physiology, SLU |
| Carolin Menzel | PhD student | Food Science, 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 |
| Lena Dimberg | Researcher | Food Science, SLU |
| Li Hua Zhu | Project leader | Plant Breeding, SLU |
| Mariette Andersson | Researcher | Plant Breeding, SLU |
| Marit Lenman | Researcher | Plant Protection Biology, SLU |
| Mattias Holmlund | Research engineer | Forest Genetics and Plant Physiology, SLU |
| Mulatu Dida Geleta | Researcher | Plant Breeding, SLU |
| Nawaporn Onkokesung | Post-Doc | Plant Breeding, SLU |
| Pareesh Dutta | Researcher | Food Science, SLU |
| Per Åman | Researcher | Food Science, SLU |
| Roger Andersson | 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 |
| Anna Johansson | Researcher | Animal Breeding and Genetics, SLU |



Researchers

Christina Dixelius
Dirk-Jan de Koning
Elisabeth Jonas
Erik Bongcam-Rudloff
Fernando Lopes Pinto
Fredrik Levander
Jane Morrell
Lars Rönnegård
Monika Brandt
Mulatu Dida
Patrice Humblot
Rodomiro Ortiz
Zeratsion Abera
Örjan Carlborg

Researcher
Project leader
Post-Doc
Researcher
Post-Doc
Researcher
Researcher
Deputy project leader
Researcher
Geleta Researcher
Researcher
Researcher
Researcher
Researcher

Plant Biology, SLU
Animal Breeding and Genetics, SLU
Animal Breeding and Genetics, SLU
Animal Breeding and Genetics, SLU
Animal Breeding and Genetics, SLU
Immunotechnology, Lund University
Clinical Sciences, SLU
Animal Breeding and Genetics, SLU
Animal Breeding and Genetics, SLU
Plant Breeding, SLU
Clinical Sciences, SLU
Plant Breeding, SLU
Plant Breeding, SLU
Clinical Sciences, SLU

CP3: Ethics

Helena Röcklinsberg
Karin Edvardsson Björnberg
Payam Moula
Per Sandin

Researcher
Project leader
PhD student
Deputy project leader

Animal Environment and Health, SLU
Philosophy and History of Technology, KTH*
Philosophy and History of Technology, KTH*
Crop Production Ecology, SLU

CP4: Consumer attitudes towards biotechnology

Andreea Bolos
Ashkan Pakseresht
Carl Johan Lagerkvist
Jacob Lund Orquin
Joachim Scholderer
Klaus G Grunert
Sebastian Hess

PhD student
PhD student
Project leader
Post-Doc
Researcher
Researcher
Researcher

Economics, SLU
Economics, SLU
Economics, SLU
Business Administration, Aarhus University, DK
Department of Economics, Aarhus University, DK
Business Administration, Aarhus University, DK
Economics, SLU

CP5: Swedish competitiveness

Jun Zhou
Christopher Kevin Ansell
Konstantinos Karantininis
Li Feng
Luca Di Corato
Natalia Montinari
Ranjan Ghosh
Sevasti Chatzopoulou
Torbjörn Jansson

Post-Doc
Researcher
Project leader
Post-Doc
Researcher
Researcher
Post-Doc
Researcher
Researcher

Economics, SLU
Political Science, University of California, USA
Economics, SLU
Economics, SLU
Economics, SLU
Economics, Lund University
Economics, SLU
Society and Globalisation, Roskilde University, DK
Economics, SLU

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

Alessandro Nicolai
Anna Lehrman
Anna Wallenbeck
Anna-Karin Kolseth
Barbro Ulén
Carl Johan Lagerkvist
Charlotta Zetterberg

Researcher CP1
Communications officer
Researcher
Researcher Crop
Researcher
Project leader CP4
Researcher

Plant Breeding, SLU
Crop Production Ecology, SLU
Animal Breeding and Genetics, SLU
Production Ecology, SLU
Soil and Environment, SLU
Economics, SLU
Law Department, UU



Researchers

Christina Dixelius
Dennis Collentine
Dennis Eriksson
DJ de Koning
Elisabeth Ekener Petersen

Elisabeth Jonas
Emma Ivarsson
Erik Andreasson
Flavio Forabosco
Helena Röcklinsberg
Henrik Eckersten
Holger Johnsson
Håkan Marstorp
Ingrid Öborn
Jan Bengtsson
Jens Sundström
Karin Edvardsson Björnberg
Klara Fischer
Konstantinos Karantininis
Kristina Mårtensson
Li Feng
Li Hua Zhu
Linnea Asplund
Lotta Rydhmer
Maren Emmerich
Mariette Andersson
Martin Weih
Mulatu Dida Geleta
Nils-Ove Bertholdsson
Payam Moula
Pernilla Tidåker
Per Sandin
Per Åman
Roger Andersson
Sara Hallin
Sevasti Chatzopoulou
Stefan Marklund
Sten Stymne
Susanne Eriksson
Sven Ove Hansson
Tina D'Hertefeldt
Tanya Cheeke
Thomas Kätterer
Torgny Näsholm

Researcher
Researcher
Researcher
Project leader CP2
Researcher

Researcher CP2
Researcher
Researcher CP1
Researcher
Researcher CP3
Researcher
Researcher
Researcher
Researcher
Researcher
Researcher
Project leader CP3
Researcher
Project leader CP5
Researcher
Researcher
Project leader CP1
PhD student
Project leader
Post-Doc
Researcher CP1
Researcher
Researcher CP1/CP2
Researcher
PhD student CP3
Researcher
Researcher CP3
Researcher
Researcher CP1
Researcher
Researcher CP5
Researcher
Researcher CP1
Researcher
Programme director
Researcher
Researcher
Researcher
Researcher CP1

Plant Biology, SLU
Business and Economics Studies, Högskolan i Gävle
Plant Protection Biology, SLU
Animal breeding and genetics, SLU
Sustainable Development, Environmental Science and Engineering, KTH*
Animal Breeding and Genetics, SLU
Animal Nutrition and Management, SLU
Plant Protection Biology, SLU
Animal Breeding and Genetics, SLU
Animal Environment and Health, SLU
Crop Production Ecology, SLU
Soil and Environment, SLU
Soil and Environment, SLU
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Plant Breeding, SLU
Crop Production Ecology, SLU
Plant Breeding, SLU
Plant Breeding, SLU
Philosophy and History of Technology, KTH*
Crop Production Ecology, SLU
Crop Production Ecology, SLU
Food science, SLU
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Society and Globalisation, Roskilde University, DK
Clinical Sciences, SLU
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Animal Breeding and Genetics, SLU
Crop Production Ecology, SLU & KTH*
Biology, Lund University
Forest Mycology and Plant Pathology, SLU
Ecology, SLU
Forest Ecology and Management, SLU

* Royal Institute of Technology (KTH)





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