Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Mistra Biotech
Annual Report 2017

MISTRA Biotech

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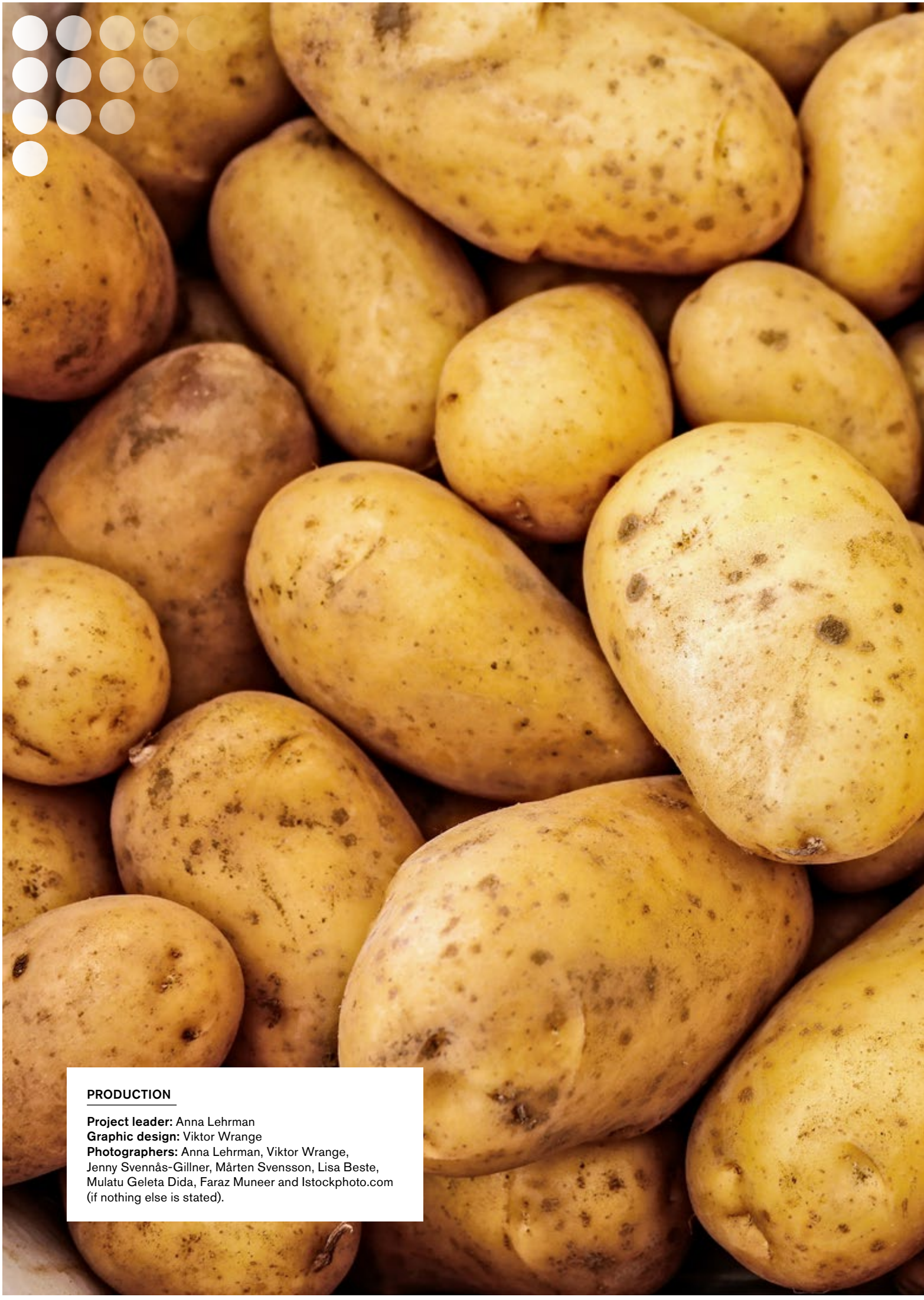

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Project leader: Anna Lehrman
Graphic design: Viktor Wrange
Photographers: Anna Lehrman, Viktor Wrange, Jenny Svennås-Gillner, Mårten Svensson, Lisa Beste, Mulatu Geleta Dida, Faraz Muneer and Istockphoto.com (if nothing else is stated).

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MAIN FUNDERS

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Stiftelsen för miljöstrategisk forskning

SLU

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

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

“Breeding projects take a long time, sometimes decades. You need dedication and endurance to engage in such long-term research.”

– Inger Andersson

Chair's preface

On the board meetings of Mistra Biotech we have the privilege of meeting with both plant breeders and animal breeders. I am often impressed by their patience and endurance. Breeding projects take a long time, sometimes decades. You need dedication and endurance to engage in such long-term research.

The domestication of field cress (*Lepidium campestre*) as a new oilseed and catch crop for Nordic conditions is a case in point. The project was initiated by Arnulf Merker (1945-2010), professor in plant breeding at SLU. In 1995 he published a first article, identifying the need for a new oilcrop and discussing several wild species that could possibly be domesticated. Field cress turned out to be the most promising of these. With the start of Mistra Biotech in 2012, work on its domestication has been speeded up considerably. In 2017 the researchers reported that they have been so successful in obtaining lines with various desirable traits that they are now starting to work on combining ("stacking") these lines into lines that will hopefully have all these traits. This is an important step forward. When the programme ends in 2020 we expect to be fairly close to a variety of field cress that is ready for farmers to use. This will be a quarter of a century after the domestication process started. Without the use of modern genetic knowledge, this would have taken even longer time.

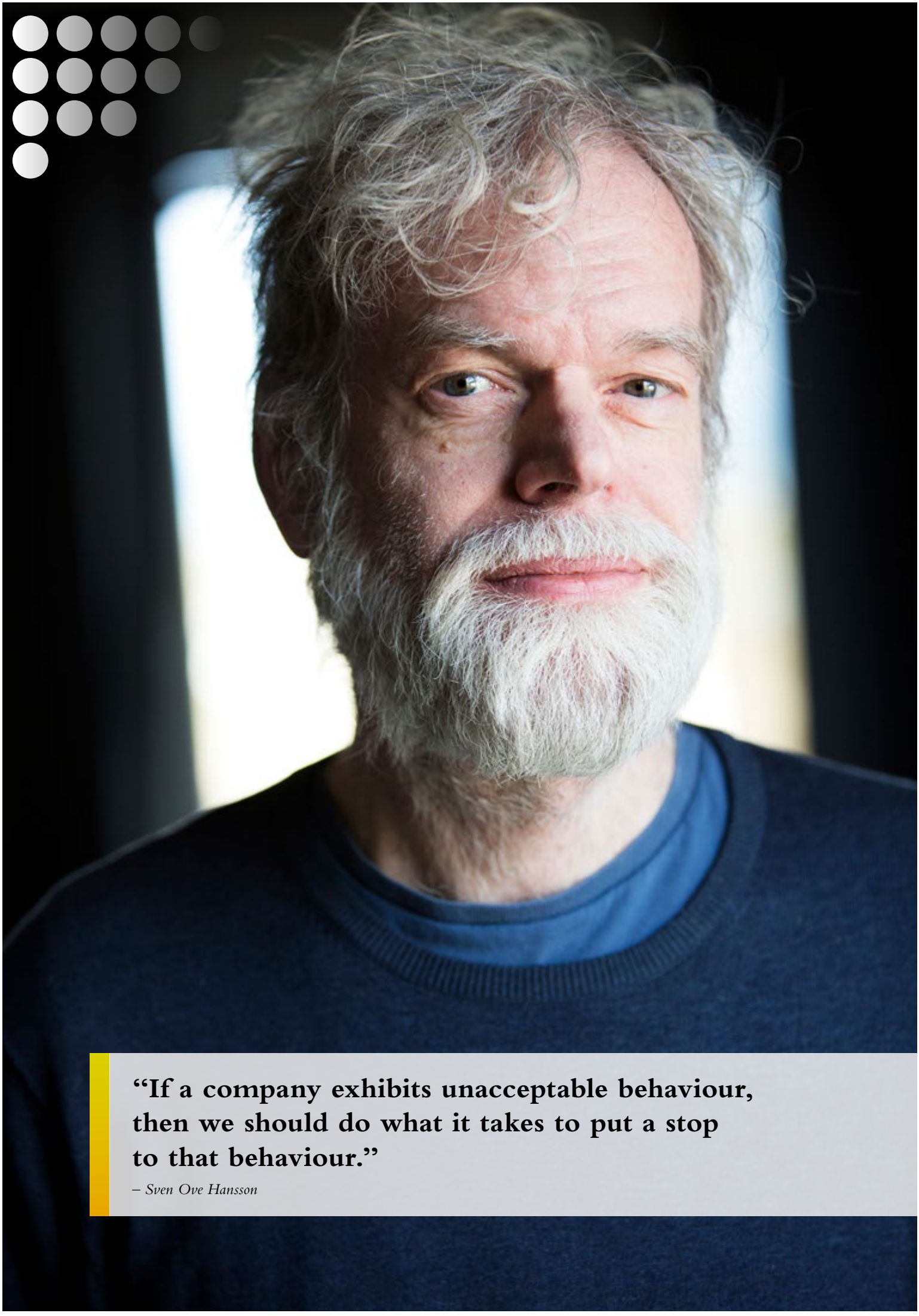
Plant and animal breeding are important for society. We need plants that provide us with healthy food while making less damage to the environment. Plants with inbuilt resistance to pests can reduce the need for pesticides. Animals that are less susceptible to disease can lead a better life. But all of this takes time to achieve, and long-term research projects require long-term funding. Unfortunately, in most countries there is a shortage of funders with a sufficiently long time perspective for innovative breeding projects. Projects that bring no income in the first decade or two are usually not among the first choices of private companies. Public research funders typically apportion money to three- or four-year projects, a much too short period for most breeding projects. However, recently the Swedish government has provided special funding for private-public partnerships in plant breeding. This is part of a Nordic co-operation, and aims at sustainable and competitive agriculture and food production in the Nordic countries.

In Mistra Biotech we have the privileged position of working in an eight-year perspective. We can clearly see the advantage of having more time than what most research projects allow. For instance, the stacking of traits in field cress would hardly have been possible in a project with the usual three-year term.

As I said, plant and animal breeders are a patient lot. They are patient with natural processes that cannot easily be speeded up. But they are also admirably patient with legislators. For decades, European plant breeders have worked in their labs with precise genetic tools that much facilitate their work, waiting for the end of a regulative deadlock that prevents the introduction of the varieties obtained with these tools. But let's hope that we will soon see an end to this long wait.

In its National Food Strategy, the Swedish government emphasized that we need plant breeding in order to develop and improve a sustainable agriculture. Let's hope that the recently allocated funding is the beginning of a new trend.

Inger Andersson
Chair of the Board, Former Director General of the Swedish National Food Agency



“If a company exhibits unacceptable behaviour, then we should do what it takes to put a stop to that behaviour.”

– Sven Ove Hansson

The fallacy of the Big Ag Argument

A few days ago I had a look at anti-vaccination sites on the web. Needless to say, this was a rather depressive reading. People with virtually no knowledge of immunology or infectious diseases claim that they have a better understanding of these topics than the world community of experts. Vaccination against deadly diseases saves lives, and the activities of anti-vax campaigners have a death toll.

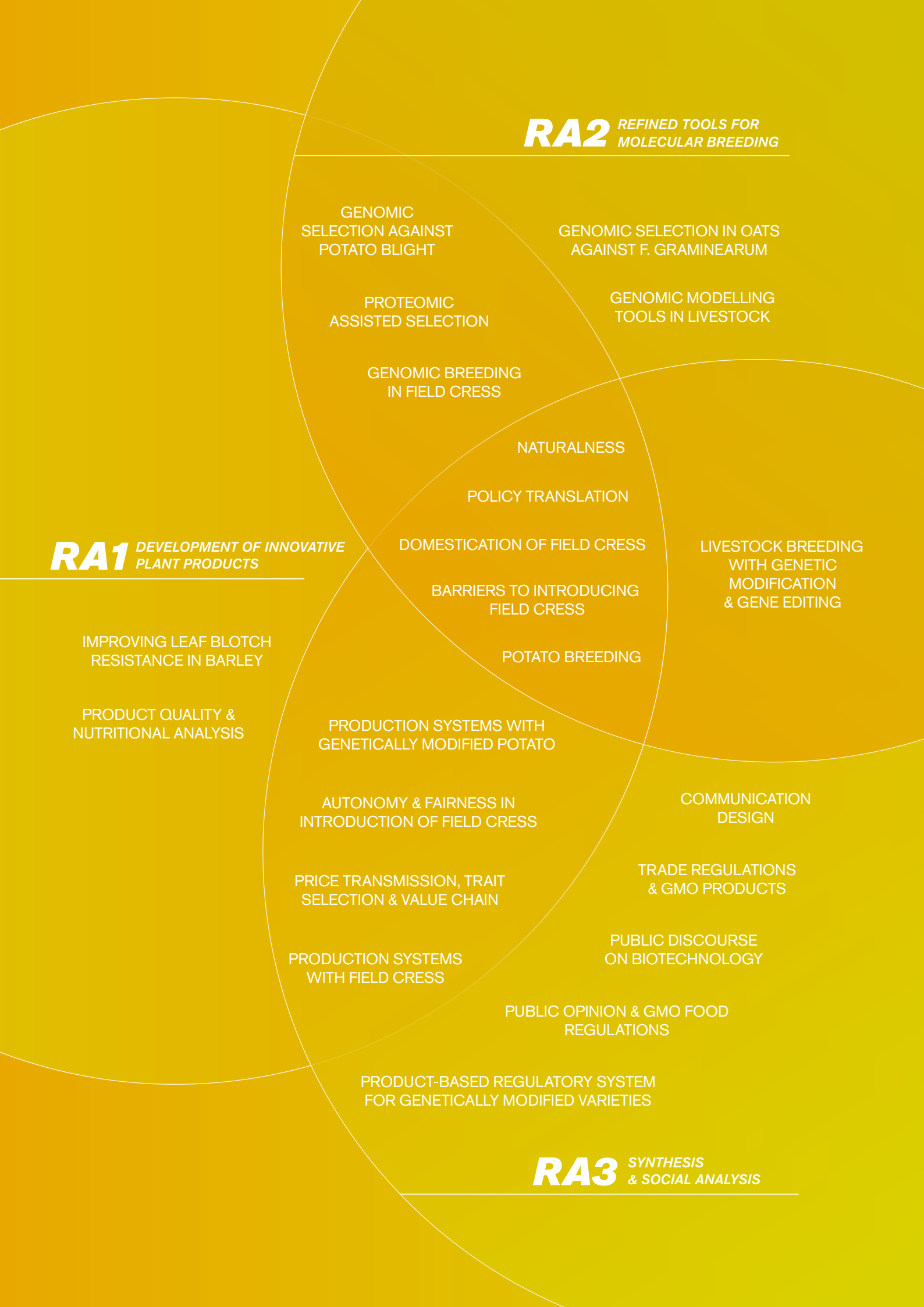
One thing that strikes me on these pages is the prominence of the Big Pharma Argument. It goes like this: The big pharmaceutical companies are irresponsible if not outright evil. They earn money by selling vaccines. Therefore, anyone advocating vaccination is furthering the interests of Big Pharma, and consequently such persons cannot be trusted. And the use of vaccines is in the interest of Big Pharma, which is contrary to the interests of common people, so surely the vaccines are bad for us.

This is a garbled argument that goes wrong in a very obvious way. Whether the pharmaceutical industry behaves irresponsibly is one issue, and the quality of their products is another, quite separate issue. Irresponsible business can be conducted either with good or bad products. It may in fact be easier to earn an unreasonable amount of money by selling a product that works than one that doesn't. Even if you have reasons to be highly critical of a company's business practices, it does not follow that their products are of inferior quality.

This type of argument is almost equally common in debates on biotechnology. Currently, the seed industry is dominated by a small number of multinational companies. It is far from unreasonable to be worried about the weak position of farmers on an increasingly oligopolistic market. In addition, some of these companies have a deeply problematic history of peddling poisonous pesticides. But nevertheless, the quality or the usefulness of their products is a separate issue. It will have to be determined on a case-by-case basis, for each individual product.

Plants with Bt (*Bacillus thuringiensis*) genes are an example of this. There is ample evidence that the introduction of these genes significantly reduces the use of toxic insecticides. Farmers in many countries have adopted Bt varieties to a very large extent (and more likely than not, you are wearing at least one piece of clothing containing Bt cotton when reading this). Anti-GMO campaigns have been directed against the use of Bt genes for plant protection. But when reading the arguments used in these campaigns, I have found very little discussion of the actual agricultural properties of these plant varieties. Instead, I find abundant use of a variant of the Big Pharma Argument: The agribusiness companies are unscrupulous, and therefore their products are bad. We can call this the Big Ag Argument. And it just does not hold. If a company exhibits unacceptable behaviour, then we should do what it takes to put a stop to that behaviour. But the products they sell will nevertheless have to be judged by their actual properties.

Sven Ove Hansson
Programme Director, Professor in Philosophy at the Royal Institute of Technology (KTH)


RA2 REFINED TOOLS FOR MOLECULAR BREEDING
GENOMIC SELECTION AGAINST POTATO BLIGHT
GENOMIC SELECTION IN OATS AGAINST F. GRAMINEARUM
PROTEOMIC ASSISTED SELECTION
GENOMIC MODELLING TOOLS IN LIVESTOCK
GENOMIC BREEDING IN FIELD CRESS
NATURALNESS
POLICY TRANSLATION
RA1 DEVELOPMENT OF INNOVATIVE PLANT PRODUCTS
DOMESTICATION OF FIELD CRESS
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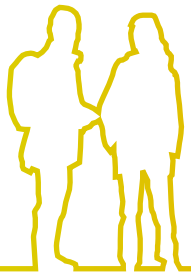
BARRIERS TO INTRODUCING FIELD CRESS
IMPROVING LEAF BLOTCH RESISTANCE IN BARLEY
POTATO BREEDING
PRODUCT QUALITY & NUTRITIONAL ANALYSIS
PRODUCTION SYSTEMS WITH GENETICALLY MODIFIED POTATO
COMMUNICATION DESIGN
AUTONOMY & FAIRNESS IN INTRODUCTION OF FIELD CRESS
TRADE REGULATIONS & GMO PRODUCTS
PRICE TRANSMISSION, TRAIT SELECTION & VALUE CHAIN
PUBLIC DISCOURSE ON BIOTECHNOLOGY
PRODUCTION SYSTEMS WITH FIELD CRESS
PUBLIC OPINION & GMO FOOD REGULATIONS
PRODUCT-BASED REGULATORY SYSTEM FOR GENETICALLY MODIFIED VARIETIES
RA3 SYNTHESIS & SOCIAL ANALYSIS

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 involves social, economic, and ethical aspects of the use of biotechnology in agricultural production, with a strong focus on sustainability issues and on the perspectives of stakeholders in the food production systems. The first phase of the programme started in 2012. During 2016 the programme entered its second phase (2016-2020) and reorganized its research in order to put more emphasis on programme synthesis and policy issues. Mistra Biotech now consists of three research areas (RA): RA1 Development of innovative plant products using modern breeding tools, RA2 Refined tools for molecular breeding, and RA3 Synthesis and social analysis.



Mistra Biotech involves about 60 researchers. Most are at SLU, but some work at KTH, Lund University, Roskilde University and Uppsala University. The programme also includes collaborations with University of Copenhagen, the University of Edinburgh, and other institutions. Phase 1 (2012 to 2016) was funded by Mistra with 10 million SEK per year and co-funded by SLU with the same amount. Lantmännen also contributed financially with a sum of 50,000 SEK per year during the first phase. In phase 2 (2016-2020) Mistra and SLU continue their support, with additional funding from Lantmännen (800, 000 SEK), Graminor (770,000 SEK), and Lyckeby Starch AB (200,000 SEK) for the remaining four years. Many companies, agencies, and organisations also support the programme with their knowledge and advice.

We use the term "biotechnology" in a broad sense that includes (but is not limited to) the use of genomic tools, molecular markers, genetic modification, and gene editing as well as technologies for cell and tissue culture and for animal cloning.

RA1

DEVELOPMENT OF INNOVATIVE PLANT PRODUCTS USING MODERN BREEDING TOOLS

The major focus in this research area is the breeding for late blight resistance and altered starch composition in potato, and the development of field cress (*Lepidium campestre*) into a new oil and cover crop with several improved agronomic traits. The genetic improvement of target traits is carried out by using conventional breeding, genetic modification (GM), site-directed mutation including the new CRISPR/Cas9 technology and other non-GM approaches. We analyse the characteristics and health aspects of the potato starch and the field cress seed oil of improved lines. Apart from the assumed reduced nutrient leaching through the domestication of the biennial, and potentially perennial, catch crop field cress, we address this issue through increasing plant nitrogen use efficiency in potato. We also work with improving leaf blotch resistance in barley.

RA2

REFINED TOOLS FOR MOLECULAR BREEDING

In this research area the central focus is the improved use of molecular information in crops and livestock breeding by refining the tools for genomic and proteomic selection. Based on prior information on genetic variation and mathematical models of resource allocation we can differentiate among genomic regions in the selection process to improve feed efficiency in livestock. We will evaluate scenarios for genomic selection in cross-breeding in the context of current and potential future scenarios in livestock. We develop new diploid potato clones, implement genomic selection in existing potato breeding material, and investigate new ways to select for improved resistance against *F. graminearum* in oats. In our work on proteomics we search for peptides to be used as markers in potato breeding together with genomic information. The same approach is used in the work on bull fertility where we use our previously gathered information on a larger cohort of bulls.

RA3

SYNTHESIS AND SOCIAL ANALYSIS

It is not sufficient to produce new crop and livestock varieties and breeds, with all the desirable properties. The new products also have to be introduced to, and accepted by the farmers, the food industry and consumers. This raises a wide range of issues: environmental effects, economic viability, legislation, attitudes and preferences among consumers and other stakeholders, as well as ethical considerations. This research area is devoted to analyses of these factors.

We perform field trials with the plants developed in RA1 in order to provide knowledge about agricultural properties and ecological consequences. The field trials also provide seeds and tubers for analyses of oil and starch quality (RA1), phenotypes for genomic analyses (RA2), and opportunities to communication activities that we use in studies of consumer attitudes.

Several studies focus on the GMO regulatory system in the EU and its effects on the use of biotechnology to make agriculture and food production more sustainable from an environmental, economic, and social point of view. We highlight ethical argumentation for and against different designs of the legislation. We use a hypothetical market introduction of genetically modified field cress as a case study, investigating scientific, regulatory, economic, and ethical barriers to its introduction, and arguments concerning naturalness, precaution, fairness, labelling, and consumer autonomy. We also perform a case study of the use of GM feed for animals in Swedish meat and dairy production, including a value chain analysis estimating the costs of segregation.

In a simulation study that includes genetic and economic investigations, as well as an ethical analysis, we analyse breeding programmes for GM livestock for food production.

We investigate how consumer attitudes to breeding biotechnologies are influenced by different types of information, and analyse farmers' perspectives on the use of such technologies.

Photo: Andreas Lilja

“To distinguish between crops based on how they were developed, instead of looking at their traits, appears outdated.”

– Minna Hellman

Swedish consumers – not as sceptical as before

The Stockholm Consumer Cooperative Society made its first survey on attitudes towards GMOs and gene technology in 1998. Since then the public opinion has mainly been negative, but the proportion of people who are very or somewhat negative has fallen steadily (from 74 percent in 1998 to 38 percent in 2017). At the same time the group describing themselves as positive has increased noticeably from 6 to 30 percent, and today four out of ten Swedes could consider buying such food products. Men as a group, younger people, and those with higher education, are generally more positive towards gene technology than the average.

Swedes consider themselves to have little knowledge about gene technology and GMO – less than a third think that they have knowledge of the subject. Although it is highly unusual to find GMO products in our larger chains of food stores, seven out of ten Swedes believe that they can be found there.

Concerns have been raised, although less frequently in later years, over unknown potentially negative consequences of gene technology on humans and the environment. This is maybe not surprising as it is in human nature to be afraid of things you do not know anything about.

Acceptance is high when gene technology is used to reduce the level of toxic chemicals in agriculture and to develop tolerant and resilient crops. 75 percent of the Swedes are positive towards such applications.

If the choice is between a GM potato that does not have to be sprayed with pesticides, and a conventionally breed potato that needs spraying ten times per season, a third choose the GM potato, and a tenth the conventional one. The largest change from the similar survey in 2012 is that the indecisive group has decreased with 16 percentage points (in favour of the GM potato).

The increased acceptance of gene technology is probably due to the fact that many people, like myself, believe that the use of such a technology in plant breeding is very different today from thirty years ago. We know more about both risks and benefits of the technology as such. To distinguish between crops based on how they were developed, instead of looking at their traits, appears outdated.

Two of the benefits of gene technology are that it saves time during the breeding of new crop varieties, and that you can edit specific traits, which can be crucial when a new pest appears or when the climate changes. The shortened breeding time increases the chances to make use of wild species or landraces, which could increase the genetic variation.

Comparisons have been made with the digital development in recent years, and gene technology has been described as agriculture's counterpart to digitalization. It took quite a while for some of us to accept the new digital era, but nowadays there are few people who don't use the technology in our part of the world. There are risks with both digitalization and gene technology, but the benefits outweigh potential disadvantages.

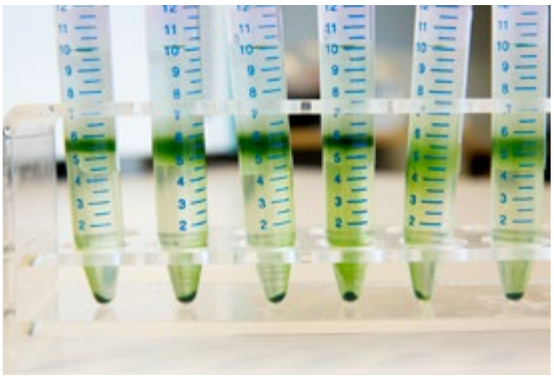
With the challenges we face today such as climate change, reduced biodiversity and a global population increase, gene technology is not our only hope, but it is part of the solution for a more sustainable crop production.

I would like to refer to Mark Lynas, a former anti-GMO activist who had a change of heart. He recently gave a speech at the Oxford Farming Conference, in which he framed the GMO situation in a pragmatic way. He does not see gene technology as a silver bullet that will solve all the issues related to today's large-scale agriculture, but he sees it as part of the solution for a more sustainable cropping system.

For a long time, debaters have been divided into two sides, for and against GMO, in a similar way that the supporters of organic and conventional farming are divided. Lynas thinks that with today's climate challenges, we must become more solution-oriented and crawl out of the trenches that the advocates and activists sit in. The situation is not black or white, and there is not one cropping system that can solve all today's problem with deforestation, climate change and reduced biodiversity.

It is concluded that genetic modification in itself does not involve any increased risks for human health or the environment. It is the application of the technology that matters. To develop crop varieties that can be sprayed with harmful herbicides does not benefit the environment or us. But if the technique is used to breed crops that are tolerant to drought or flooding, contain more nutrients, are resistant against insect pests and pathogens, require less pesticides, or maybe no pesticides at all – then we would be well on the way towards a more sustainable agriculture. And I think that the more such products we get, the more positive the consumers will become.

Minna Hellman
Manager, consumer health and well-being, Stockholm Consumer Cooperative Society



Mistra Biotech selections from 2017

In the following section we present research highlights during 2017.

Should GM crops be grown in the EU? Let the countries decide for themselves

The cultivation of genetically modified (GM) crops has long been a contentious issue in the European Union. In the authorization of commercial cultivation of GM crops, several countries regularly demonstrate a voting behaviour that seems to be politically rather than scientifically motivated.

In 2015, a new directive gave individual EU countries the right to restrict or prohibit the cultivation of GM crops despite EU-level authorization. This effectively moved away from the harmonization objective of the GMO legislation in the direction of giving preference to national interests, but the voting behaviour is yet the same as before.

To take the political edge out of the authorization process, Dennis Eriksson and Sevasti Chatzopoulou, together with other biotech specialists and legal experts, propose that the European Commission should develop a legislation that will allow EU countries to individually authorize the cultivation of GM crop varieties that have passed the EU risk assessment in the European Food Safety Authority. This would allow countries to adopt specific crop traits according to their needs. It would also take the pressure off the Commission, which would no longer be forced to take (or not take) decisions against the will of several EU countries.

The proposal provides a more predictable situation for both farmers and the market, enabling countries to allow the cultivation of crops with traits that will for example reduce pesticide use, provide gluten-free cereals, and improve the nutritional and health-promoting qualities of our food.

The proposal was published in the journal *Nature Biotechnology* with the title "Why the European Union needs a national GMO opt-in mechanism".

Contact: *Dennis Eriksson, dennis.eriksson@slu.se*
Dept. of Plant Breeding, SLU

The cultivation of genetically modified crops has long been a contentious issue in the European Union. The biotech specialists and legal experts propose a mechanism to take the political edge out of the authorization process.

The decision-making on GMOs in the European Union has become highly politicized. Attempts at including public opinions and stakeholder voices have opened up for strong lobbying, and the authors provide examples showing that science has fallen short in the process.

Responsible decision-making in the EU

Technological and scientific progress provide great potential for policy innovation and sustainable solutions for food insecurity, malnutrition, environmental impact and climate change. The technical advances can contribute to economic growth and social prosperity. In order to make this possible, it is necessary for the EU to establish a regulatory framework that enables and encourages research, using for example new plant breeding techniques, and to ensure high standards and safety of these techniques.

In a recent research paper Sevasti Chatzopoulou and Dennis Eriksson propose a policy agenda that is compatible with the concept "Responsible Research and Innovation" which has been introduced by the European Commission. According to this concept, societal actors should be involved during the research and innovation process, in a balanced and inclusive way. Such a process has to encourage collaboration among the involved actors (researchers, citizens, policy makers, business, organisations etcetera) so that the existing evidence and knowledge is taken into account by the policy and decision making institutions. Moreover, it will ensure that decisions are made effectively, objectively and based on a transparent and inclusive dialogue, and not based on vested political interests.

In their paper, the researchers use three examples to show that politicization hinders or delays an efficient decision-making process, despite the fact that the EU regulatory framework concerning plant breeding is based on scientific evidence:

1. Regulatory delays for GM maize.
2. The GMO national opt-out Directive.
3. The lack of regulatory status for new plant breeding technologies.

The researchers also point out that all three examples indicate a high degree of politicization that nurtures fears and concerns in the public. Most worrying, the examples impede the introduction of clear and effective rules that could enhance innovation and economic growth. The proposed policy agenda has a technological baseline as a starting point and aims at a forward-looking discourse for an appropriate handling of technological progress.

The study was published in the journal *GM Crops & Food* with the title "Responsible decision-making for plant research and breeding innovations in the European Union".

Contact: *Sevasti Chatzopoulo, seva@ruc.dk*
Dept. of Social Sciences and Business, Roskilde University

Plant biotech from a Scandinavian perspective

Scandinavia is unique not only when it comes to climate, temperature and day length, but also with respect to its specific regulations on the use of fertilizers and pesticides. The global trend, with just a few large multinational companies dominating the seed market, results in a concentration of plant breeding to few crop varieties developed for large markets. The small markets in Scandinavia limit private investments in regionally adapted plant breeding. This poses a challenge for the development of crops well adapted to the northern climate.

Together with plant researchers from other Scandinavian universities, Dennis Eriksson argues that public investments in crop breeding for this region is of outmost importance in order to achieve a sustainable agriculture with reduced negative environmental impact and adapt to the effects of climate change.

In addition to long-term government investment, it is also important to discuss the role of innovative solutions in plant breeding and research, and how these should be regulated, the researchers point out. Plant breeding is a slow process where gene technologies can help us to meet challenges more quickly.

Europe is often seen as uniformly politically restrictive towards gene technology. In reality, owever, there is considerable variation between the countries. Between 2004 and 2014, Finland and Sweden voted almost always according to the scientific recommendations when the EU decides whether or not new GM plants would be approved, while Denmark voted against in 40 percent of the cases.

In Scandinavia, Denmark is the only EU member state implementing Directive (EU) 2015/412, which allows a national ban on the cultivation of genetically modified (GM) crops approved in the EU. The fact that other countries in Scandinavia do not invoke this is not surprising, as the only GM crop approved for cultivation in the EU is a maize that is not suitable to grow in northern Europe.

The Scandinavian countries, primarily Finland and Sweden, represent an innovation-friendly and scientifically motivated attitude towards plant gene technology, compared to some other European countries, and the public in Scandinavia, with the exception of Norway, is slightly less negative towards GMO compared to the rest of Europe.

Although it is difficult to determine whether it is the national policy that reflects on the opinion, or the other way around, there seems to be no conflict between the two, the researchers say. All of the Scandinavian countries are well positioned within the overall strategy to develop sustainable bioeconomies in Europe, and plant biotechnology can be an important tool in the implementation of sustainability strategies.

The study is published in the journal *Physiologia Plantarum* with the title "Scandinavian perspectives on plant gene technology: applications, policies and progress".

Contact: *Dennis Eriksson, dennis.eriksson@slu.se*
Dept. of Plant Breeding, SLU

Scandinavia is unique when it comes to climate, temperature and day length and development of crop varieties (and livestock) adapted to those conditions are crucial.

Shifting from import of non-genetically modified soy to genetically modified (GM) soy in Sweden would imply an increased negative environmental impact since the cheaper imported GM soybean would replace our domestic production of protein.

Environmental consequences of soy feed regardless of breeding technique used

Which is best for the environment, animal feed based on genetically modified (GM) soy or GM-free soy? It depends on how you look at the matter. Mattias Eriksson and colleagues analysed how it would affect the environment if Swedish farmers began to give their animals feed based on imported GM soy, which is common in many other European countries, instead of using 100 percent GM-free soy as Sweden does today.

The study showed that there are no significant environmental gains from importing non-GM soy, instead of GM soy, when comparing the two parallel supply lines. But when the researchers used a more holistic approach, including the market effects of a shift from the more expensive GM free feed to the cheaper GM feed in the analysis, they predicted a different scenario. The cheaper GM based feed would lead to an increased demand for soy which could lead to deforestation to release new farmland in South America. At the same time, the demand for Swedish protein crops would decrease.

It is logical that the production moves to where it is cheapest, but lower prices can also make us start consuming more, requiring increased production. In that way, starting to import GM soy to Sweden could bring more negative consequences for the environment, despite the fact that the global warming potential and the freshwater ecotoxicity are higher from non-GM import than import of GM soy, per imported amount of soy.

Transportation and waste has increased as a result of keeping the two supply chains separated. Controls and certifications also need to be segregated to ensure that the different types of soy are not mixed. This makes the GM-free soy more expensive, but smaller volumes also contribute to higher prices. The most environmentally friendly option would be to develop protein-rich plants that can grow in the Nordic climate to replace soy that is now being imported.

The study was published in the *Journal of Cleaner Production* with the title "Environmental consequences of introducing genetically modified soy feed in Sweden".

Contact: *Mattias Eriksson, mattias.eriksson@slu.se*
Dept. of Energy and Technology, SLU

Consumers attitudes towards products developed with gene technology is affected by the GM policy and the stance taken by actors in the food chain.

Perceptions among food chain actors influence consumers

The restrictive legislation on GM crops in EU is often claimed to be a result of a skeptical opinion. Likewise, in Sweden the organizations and retailers in the food supply chain have chosen as a policy not to use or market products containing GM ingredients due to low consumer acceptance. But what if the consumer acceptance is influenced by the perceptions, policies and actions upstream in the food chain? In a so-called artefactual experimental study, Ashkan Parkseresht and colleagues examined consumer decision-making where the participants were given different policy scenarios including descriptions of actions taken by actors in the food chain.

The results suggest that the current policy in itself induces resistance to GM food and opposition to the application of biotechnology in food production, among consumers, as typically reported in consumer studies. More importantly, however, this study suggests that the nature of consumer acceptance is also accommodated to the policy context and to stances taken by the food chain actors. Regulations embedded in food policies defined the context that affects the actors' behaviour. Issues such as labelling, origin of the product and product accessibility were the main components in possible alternative policies towards biotechnology in food production. The consumers had a greater tolerance for domestically grown GM products compared to imported ones. Increased availability of GM foods resulted in more positive consumer attitudes to such products. The consumers are affected by information about actions taken by food chain actors, and adapt their choices to these actions, but the effect is context-dependent and differs between actors and consumer segments. The experiment showed that consumers are more inclined to reject GM product if the other actors in the food chain do not support it. In contexts implying a more restricted GMO legislation, the actions taken by retailers were the most decisive.

The study is published in the journal *European Review of Agricultural Economics* with the title "Consumer acceptance of food biotechnology based on policy context and upstream acceptance: evidence from an artefactual field experiment".

Contact: *Ashkan Pakseresht, ashkan.pakseresht@slu.se*
Dept. of Economics, SLU

Stakeholder reservations against genetic modification do not apply to genome editing

Genetic modification has been highly debated since the first commercialized crop was introduced. Those who develop genetically modified crops face consumer concerns, strict regulations and rigorous testing. All this might be circumvented with the new biotechnological advancements such as the genome editing technique CRISPR/Cas9.

In her Master Thesis, Sanaz Habibi found that the most prevalent reservations against GMOs, from different stakeholders and anti-GM NGOs in Sweden, do not apply to the new technique. But whether genome editing will be available or not, and accepted among Swedish stakeholders, depends on its legal classification, which the EU Commission has yet to determine.

Arguments that have been raised against GMO's (ranked by no. of stakeholders listing)

1. Risks of endangering the biodiversity, ecosystem and environment
2. Unethical applications
3. Risks of endangering human and animal health
4. Corporate control and farmer dependence
5. Uncertainty of long-term effects
6. Unnaturalness

Sanaz Habibi also found that the stakeholder reservations against GMOs are often based on generalizations and misconceptions. Most of the concerns are based on the technology that is involved rather than the GMOs that are produced, reflecting conformity with the current GMO regulations. Many of the reservations against GMOs seem to lack relevance for the alternative methods of breeding, such as mutagenesis.

To put the issue of GMOs and genome editing techniques in a broader perspective, Sanaz compared how the reservations apply to GMOs and conventional breeding. The comparison shows that the general reservations against GMOs also can be applied on conventional breeding.

The study is a Master Thesis in Sustainable Development at Uppsala University and is published at www.diva-portal.org with the title "GMO perceptions among Swedish stakeholders and their implication on the acceptance of a new biotechnological advancement". Anna Lehrman was the supervisor.

Contact: *Anna Lehrman, anna.lehrman@slu.se*
Dept. Crop Production Ecology, SLU

The most common concern about GMOs raised by different stakeholdes in Sweden were; risks of endangering biodiversity, ecosystem and environment.

Breeding for public health: A strategy

Significant improvements in public health can be achieved if we manage to enhance the nutritional quality of our diets. This is true for populations in all parts of the world, although the needs for dietary change are partly different. Plant and animal breeding can contribute to promote human health by providing new and healthier food products that farmers can produce in an economically viable way and consumers can choose to buy and eat. However, this will only be achieved if breeding makes full use of knowledge about nutrition, consumer behaviour, farming and agricultural economics. A strategy is needed for breeding for public health. A multidisciplinary group of researchers, food scientists, nutritionists, animal and plant scientists and social scientists led by Sven Ove Hansson has developed a strategy for plant and animal breeding for public health. The strategy includes the following:

- Breeding for health-promoting traits should target both micronutrient deficiency (primarily low-income countries) and diseases such as overweight and coronary disease (primarily high-income countries).
- The highest priority should be given to healthy variants of traditional food items that can be introduced universally *i. e.* completely replace older, less healthy variants, followed by products that may not be suitable for universal introduction but have a large market potential in major consumer segments.
- Efficient incentives to produce healthier foodstuffs are currently lacking and need to be created. The crops and products must be attractive for farmers to produce and for consumers to eat.
- Social influence through general endorsement is key to obtaining a general adoption of more healthy food habits among consumers.
- The best available technologies should be used. For certain crops and traits, modern technologies such as genetic modification and genome editing will be needed.
- Breeding has to be combined with economic development treatment of diseases that aggravate malnutrition, and adequate dietary information.

The current market structure for farm products does not give farmers sufficient incentives to produce more healthy plant and animal products. Farmers are often paid for quantity, without any reward for health-related quality. The food production chain needs to be reformed so that consumer demands for healthier products have a stronger impact.

Contact: *Sven Ove Hansson, soh@kth.se*
Dept. of Philosophy and History, KTH

Photo: Neil Palmer (CIAT)

Breeding of crops and livestock can provide us with healthier food. One example is the biofortified rice with higher zink levels.

After cooking, the modified potato with high amylose content gets a healthier so called resistant starch.

A new potato with more slow carbohydrates

When studying a potato that is high in amylose content (developed previously in the programme), Xue Zhao and Roger Andersson found that a high content of amylose gives a high content of resistant starch in the cooked potato.

Resistant starch is a dietary fiber with benefits for our bodies. As such, it lowers the glucose levels and the insulin responses, increases faecal output and reduces the faecal transit time. It decreases the calorie content in foods, which has positive effects on body weight, and it promotes the growth of beneficial gut bacteria.

Potato starch usually consists of 25 percent amylose (linear molecules) and 75 percent amylopectin (highly branched molecules). The high amylose potato has been developed by down-regulating two starch branching enzymes which, apart from increasing the level of amylose, also affected the amylopectin structure. In the modified potato the outer chain-length of the amylopectin was much longer than in the unmodified potato cultivar.

This unique amylopectin has properties that are similar to amylose. After cooking, the modified amylopectin recrystallizes, and after that it does not split as easily as the ordinary potato starch, which means that it is more resistant and takes longer time to digest. An additional analysis revealed that one extra day of cold storage gives a further increase of resistant starch content, since amylopectin needs some time to get recrystallized.

The down regulation of the two enzymes was made through genetic modification. At the moment Mariette Andersson and her team are working on a new similar "high amylose" potato using the genome editing technique CRISPR/Cas9. This genome editing technique is comparable to traditional mutagenesis breeding, but more specific and can target predefined genetic regions or genes. In the new "high amylose" potatoes, the same enzymes are targeted, both individually and in combination. Potato is tetraploid, i.e. it has four copies of each chromosome, and therefore also four copies of each gene. Most likely, three to four of the gene copies need to be mutated to get a high amylose potato.

The study on the starch molecules was published in the journal *Food Chemistry* with the title "Resistant starch and other dietary fiber components in tubers from a high-amylose potato" and in *Carbohydrate Polymers* with the title "Improved material properties of solution-cast starch films: Effect of varying amylopectin structure and amylose content of starch from genetically modified potatoes".

Contact:
Roger Andersson, roger.andersson@slu.se
Xue Zhao, xue.zhao@slu.se
Dept. of Molecular Sciences, SLU

Mariette Andersson, mariette.andersson@slu.se
Dept. of Plant Breeding, SLU

Breeding for blight resistant potato

Phytophthora infestans, an oomycete, is the most harmful pathogen of potato. It causes the disease late blight, which generates increased yearly costs of up to one billion euro in the EU alone, and it is tough to control. In the potato project focusing on resistance against late blight, Erik Andreasson, Svante Resjö and colleagues are testing different ways to understand and prevent infection by this pathogen.

ALTERNATIVE HOSTS OF LATE BLIGHT

During 2017, the researchers have studied the pattern of late blight resistance and susceptibility found among three wild relatives to our cultivated potato. These putative late blight hosts; *Solanum physalifolium*, *S. nigrum,* and *S. dulcamara*, might possess traits that can be used in the breeding for blight resistance. The pathogen *P. infestans* has an unusually high local diversity in Sweden, and the researchers also want to know more about how the wild *Solanum* species contribute to the epidemiology of potato late blight.

In field and laboratory experiment, the pathogen sporulated in all investigated *S. physalifolium* plants, suggesting that this species is susceptible. Field-grown *S. physalifolium* was naturally infected but could regrow, though highly infected plants became smaller at the end of the season. In the *S. nigrum* plants, there were no symptoms, or just a lesion restricted to the point of inoculation, indicating that this species is resistant to the pathogen. Among the *S. dulcamara* plants, a resistance variability was found. Some plants of this species were susceptible, some had no symptoms or restricted lesions, while others were identified with lesions larger than the point of inoculation, but without visible sporulation of the pathogen. Molecular analyses confirmed that *P. infestans* differed in growth on plants with different types of resistance or susceptibility. Thus, in Sweden *S. physalifolium* is susceptible and could contribute to the spread of the disease. A limited role of *S. dulcamara* leaves in spreading of late blight was suggested, since no major symptoms were found in the field trial, but due to the variation found in resistance, *S. dulcamara* is a potential source of resistance genes.

PROTEINS CAN TELL THE STORY ON THE COURSE OF THE DISEASE

In order to find out more about how the late blight pathogen *P. infestans* acts during the disease infection, the researchers have identified proteins that seem to be of high importance for the pathogen at different life stages. Among 10 000 peptides, from over 2000 proteins, they found 59 interesting ones that were highly abundant in the pathogen at pre-infectious life stages, *i. e.* in its germinated cysts and the cells that penetrate into the potato plant. A large majority of these proteins have not been recognized as being part of this infection process before, but based on their similarity to other proteins, with known function, the researchers could predict that they play roles in transport, amino acid metabolism, pathogenicity and cell wall structure modification.

The researchers also analyzed the expression of the genes encoding nine of these proteins and found an increased level during disease progression, in agreement with the hypothesis that these proteins are important for the infection to happen. Among the nine proteins was a group involved in the pathogen's struggle to modify and hold on to the cell wall structure. Silencing of these genes resulted in reduced severity of the infection, additionally indicating that these proteins are important for pathogenicity.

The results are published in the journal *Molecular and Cellular Proteomics* with the title "Proteomic analysis of *Phytophthora infestans* reveals the importance of cell wall proteins in pathogenicity".

Contact: *Erik Andreasson, erik.andreasson@slu.se*
Dept. Plant Protection Biology, SLU

The researchers use gene technology both to understand how the pathogen causes late-blight works and to breed for resistance against it. In the back, a plant genetically modified to resist the pathogen. In the front, the susceptible control plant.

Breeding of field cress

The development of field cress (*Lepidium campestre*) into a new oil and catch crop has now come to the stage where the researchers have started to combine some of the specific traits they have worked on. This is carried out though crossings and hybridizations. In parallel, the researchers are developing an inter-cropping system where the biennial field cress is grown together with annual cereal crops. The use of the genome editing technique CRISPR/Cas9 in the breeding of field cress is also in progress.

FIELD TRIALS

Out of 176 previously evaluated hybrid lines from crossings between field cress accessions and other *Lepidium* species, the researchers have selected 44 lines to test if they work well for undersowing in spring barley. The selection was based on germination, growth vigour, weed competiveness and flowering time. In this trial, it was discovered that the flowering and seed set of the field cress plants were adversely affected by a herbicide usually used in rapeseed. Lesson learned, the trial will be repeated with another type of weed control.

From the same 176 field cress lines, the researchers also selected eight early maturing lines and 16 late maturing lines, for multi-environment field trials located in different locations in Sweden with various climate and soil conditions. The collected data indicate a higher yield in the early maturing lines (2.5 to 3.6 tons per hectare) compared to the late maturing lines (1.7 to 2.6 tons per hectare). The seed oil content was the same in all lines (31 percent). The trials need to be repeated after optimizing the planting approach for field cress to avoid uneven seed germination.

MOLECULAR MARKERS FOR LEPIDIUM

As a contribution to the development of genomic tools and resources for field cress breeding, Mulatu Geleta and his colleagues have identified a large number of variable sites in the genome, so-called microsatellite markers that can be used to link traits with the genetics of this plant species, without the need for phenotyping. Microsatellites are repetitive stretches of DNA that are very diverse due to the higher mutation rate in those areas compared to other parts of the DNA. 120 of these markers were used for preliminary assessments of genetic diversity and relationship among field cress populations, and the results have shown that several of the markers can be used to identify interspecific *Lepidium* hybrids as well.

By comparing sequences found in the genomes of field cress and related plant species, the researchers have also identified 30 genes coding for traits that are important in the *Lepidium* domestication. DNA samples from different field cress breeding lines were sequenced and the variation in the coding regions of these genes was analyzed to verify the genes mentioned above. These genetic variations can be used as molecular markers to identify plants that have desirable traits.

GENOME EDITING IN FIELD CRESS

The genome editing method CRISPR/Cas9 is the most recent and well applied new breeding technique, which has taken the world of plant breeding and research by storm. This technique offers a possibility to induce genetic mutations in crops in a way that could happen naturally. However, its successful application is not straightforward and some hurdles may have to be overcome when trying to apply the technique in a new crop. Li-Hua Zhu and her colleagues are now developing an efficient CRISPR/Cas9 protocol for field cress.

The best way to introduce the CRISPR/Cas9 vector into the plant and achieve the desired genetic change is to use protoplasts, *i. e.* cells that had their cell walls removed. This allows a transient gene expression without integrating the vector DNA into the plant genome and therefore generates non-GM lines. There are several crucial steps in this protocol: protoplast isolation, protoplast regeneration and protoplast transfection. The first two steps, especially protoplast regeneration, are the keys for a successful application of the CRISPR technique. It's important to get a high number of protoplasts that are viable enough to grow into plants. Once the researchers had made the molecular part of the genome editing work, the plant regeneration growth medium was adjusted for field cress for shoot and root induction and growth. While there is still fine tuning to be done for getting a well working protocol, there are good hopes for CRISPR/Cas9 to work in field cress during 2018.

STACKING OF IMPROVED TRAITS

Genetic transformation is one plant breeding techniques that could be used for speeding up the breeding process for crops. Li-Hua Zhu and colleagues have previously improved some important traits of field cress through genetic transformation. They are now stacking these improved traits into single breeding lines, including oil content, oil composition and pod shatter. By now some

A new breeding line of field cress has grown into rosettes during the first year at Lönnstorp. The picture was taken in September 2017.

Greenhouse trials of field cress breeding lines with long inflorescence and dense pods.

hybrid seeds have been obtained and the more detailed analysis of the improved traits in the stacked lines will be carried out in the segregated lines. These lines could be used in the further breeding through either traditional breeding or genome editing for further genetic improvement of the species.

Contact: *Li-Hua Zhu, li-hua.zhu@slu.se*
Mulatu Geleta Dida, mulatu.geleta.dida@slu.se
Dept. of Plant Breeding, SLU

GENETIC LINKAGE MAP OF FIELD CRESS

The selection process in breeding can be speeded up by using genetic information. In contrast to our domesticated crops, the knowledge on the genetics of field cress is fairly limited. Previously, several thousand so-called single-nucleotide polymorphisms (SNPs), *i. e.* variations in single nucleotides, have been detected. Now, Zeratsion Abera Desta and Rodomiro Ortiz used these SNPs to compare the genetic makeup of different field cress individuals (genotyping) and to construct a genetic linkage map which gives an overview of how the DNA is organized on the chromosomes. The researchers used 7624 of the SNPs to genotype offspring of selfed second generation plants (i.e. F2 derived offspring) from crossing *Lepidium campestre* (field cress) and *L. heterophyllum*. The polymorphic markers were then used to construct a map describing where the different SNPs are located on the 8 linkage groups (chromosomes of the haploid genome) of the plant. This linkage map is the first step to developing genomic tools to accelerate the domestication and further breeding of field cress.

EFFICIENT ANALYSIS FOR PROTEIN, MOISTURE AND OIL CONTENT

The common laboratory wet-based chemistry technique to measure the oil content in seeds is in need of improvement. It can take up to four days per sample, and it lacks accuracy. Furthermore, the measurement of other seed components such as protein and moisture is difficult and costly. Through a research partnership with a seed laboratory company, the researchers have developed a protocol that meets the ISO seed analysis standard for analyzing oil, water and crude protein content in the seeds of Lepidium species, using a high-throughput near infrared (NIR) instrument. They used representative seed samples to build a reference model which was calibrated using specific models for oil, moisture, and protein. This protocol will be a very helpful tool for the researchers to find plants with desired seed traits during the domestication of field cress.

Contact: *Zeratsion Abera Desta, zeratsion.abera@slu.se*
Dept. of Plant Breeding, SLU

Better prediction of desired traits by improved genomic selection model

In both animal and plant breeding, the main goal is to select individuals that will improve future generations with respect to desired traits. For that purpose, statistical methods are applied to predict the genetic values of the individuals, and to rank the candidate progenitors of the future generation. In the last decade genomic selection, which is a selection method based on the availability of hundreds of thousands of DNA markers, has been used more and more. Today this method is applied routinely for selection in several livestock species like dairy cattle, pig, chicken and beef cattle. Nonetheless, the applications of strategies based on genomic selection are not always straightforward for all species and populations, and studies are needed to determine the specific requirements for each case.

The most common statistical method used to predict the genomic breeding values (GBLUP) assumes that the markers are independent and all have some effect on the analysed trait. However, this is rarely the case. As an example, there are studies indicating that markers located within or near regions rich in genes on a chromosome can explain more variance than markers located in intergenic regions. Presently, knowledge of the genetic architecture of complex traits is available, and the amount of information on the DNA markers is continuously increasing in the form of accurately annotated genomes, Quantitative Trait Loci (QTLs) databases, gene expression and gene pathway studies. More recently, an attempt has been made to include these types of information in the prediction models in order to improve the accuracy of the genomic breeding values.

Elena Flavia Mouresan, Maria Selle and colleagues have looked into the possibilities to include explanatory variables for marker-specific variances in a general BLUP analysis method. Starting with simulated data they created different scenarios of the genetic architecture of a trait which were then analysed using the traditional GBLUP model and the alternative model that includes the extra information on the markers. The models were evaluated in terms of their predictive accuracy.

Their results indicate that the alternative model tends to perform better compared to the traditional GBLUP, and yield higher accuracies in most of the scenarios tested. Moreover, the researchers identified two factors that influence how well the alternative model will work: *1. The genetic architecture of the trait*. The alternative model performed better than GBLUP when the number of genes controlling the trait was low, but its predictive ability decreased with an increasing number of genes involved. *2. The external information*. In the study the researchers assumed that the location of the genes was known, and they defined windows of markers around the genes to have higher weights than the rest of the markers. The results show that larger windows tend to decrease the accuracy because the information provided to the model was vaguer in this case.

Including biological information into the model is beneficial as it can increase the accuracy compared to the standard GBLUP. Nonetheless, this benefit depends upon the underlying genetic architecture of the trait and on the quality of the external information.

Contact:
Elena Flavia Mouresan, elena.flavia.mouresan@slu.se
Dept. of Animal Breeding and Genetics, SLU

Maria Selle, maria.selle@ntnu.no
Dept. of Mathematical Sciences, Norwegian University of Science and Technology

The method genomic selection can be used to choose specific individuals as parents in the breeding programmes.

“They recommended me to apply for the Master programme in Sweden because it’s a high-quality education.”

– Xue Zhao

Wishing to make both the environment and your gut happy

Xue Zhao grew up in the northeast of China in a village named Quanyan, which means the mouth of a spring. She had close contact with agriculture already as a little girl.

– Feeding animals and harvesting vegetables together with my mother was the most fun activity in my childhood. I never realized it may become my career until I started my Bachelor in animal science at Northwest Agricultural and Forestry University in China, says Xue.

After graduating from the university she started an internship as a laboratory technician in an agricultural enterprise, which gave her valuable hands-on experience of techniques for analyzing feed and some food ingredients. Xue came to Sweden 2012 after recommendations from friends.

– They recommended me to apply for the Master programme in Sweden because it's a high-quality education, and they also told me SLU has a very flexible study environment.

After her MSc in animal science Xue took a summer course in food analysis, followed by an individual research project in food science entitled "Yellow mealworm protein for food purposes – Extraction and functional properties" which inspired her interest in food research. In the project, they established a protocol for the extraction of proteins from yellow mealworm larvae and analyzed the functional properties of the protein.

During 2017 Xue came back from parental leave after having her first child, and now she is in the second year of her PhD studies. She is working on characterizing the properties of starch from a high-amylose potato developed by another research group in Mistra Biotech (you can read more about this on page 23).

– In a recent study we show that the high content of amylose gives a high content of resistant starch in this cooked potato and one extra day of cold storage after cooking gives a further increase of resistant starch content due to the interesting structure of the amylopectin.

Xue thinks that it's extra relevant to work with potato because it is such a popular food, and she finds it satisfying that her work can have an impact on people's health and wellbeing.

– If we can understand the details in the biosynthesis of starch and the relationships between structure and properties we may tailor starch at the genetic level for various food. We could also customize starch with desired functional properties for non-food applications, without need for further physical or chemical modification of the starch. This would be a sustainable, economic friendly and green alternative approach, since physical and chemical modification of starch is time, money, and energy consuming as well as chemical and labor intensive.

Being a PhD student Xue feels that she has embarked on a journey of constant challenges, but she feels lucky to work with highly qualified people from whom she learns a lot.

– I am happy with what I am doing and it feels meaningful.

Xue thinks that working in Mistra Biotech gives her a chance to work with many researchers in different disciplines.

– I am glad that I can share my experience and the results of my work with others within the programme and to make joint contributions to sustainable food safety and security.

Contact: *xue.zhao@slu.se*
Dept. of Food Science/Molecular Science, SLU

“The environmental consequences are often more complex than what they seem at a first glance.”

– Mattias Eriksson

From alligator pheromones to old food

The researchers in Mistra Biotech are involved in the programme on both longer and shorter terms, for example as PhD students, or, as in the case with postdoctor Mattias Eriksson, when special competence is needed.

Most of his work is done in front of the computer in Ultuna, not many kilometers from Knivsta where he grew up. After military service he moved to Uppsala to study chemistry.

– Simply because I found chemistry and history to be the most interesting topics in the gymnasium, he says.

From the beginning he focused on biochemistry, genes and proteins, but after a while he became more interested in organic chemistry. In his Master thesis at TU Braunschweig in Germany Mattias tried to synthesize alligator pheromones. But his years as an undergraduate student did not end there.

– Chemistry positions were scarce at the time, so I continued as a student and found an interest in food science, which took me to SLU where I studied to become a food inspector, says Mattias.

This became his occupation for two years until he noticed an advert for a position as a PhD student at SLU. The doctoral studies focused on food waste in supermarkets, analysing the carbon footprint of different ways to either prevent the generation of waste, or to reuse or recycle it.

– After the dissertation I stayed in the same field and I am still very fascinated with old food. Well, not exactly the food in itself since rotting food is quite disgusting, but rather the complexity of the problem that perfectly edible food is wasted for so many reasons even though no one really wants this to happen, he says.

At the moment Mattias evaluates what kinds of measurements are the most efficient to reduce waste and increase sustainability in the food supply chain. This time, it's about food waste quantification in professional kitchens like hotels or canteens. He uses life cycle assessment to evaluate the environmental consequences of waste reduction, which include the benefit that less food are produced in vain, but also the negative impact of introducing measures like reduced storage temperature or increased transport.

– I mainly analyze the management of wasted food. But since food and feed are obviously related to each other, the step to also do analyses of the environmental impact from feed production, wasn't that far, says Mattias.

It was in the feed production context that Mattias became involved in Mistra Biotech. In the programme, Mattias analyzed what the environmental consequences could be if Sweden would start using GM feed in the future, and especially soy feed where the GM version is the dominant (you can read about this study on page 19).

– The environmental consequences are often more complex than what they seem at a first glance. Everything we do has consequences, even unintentional ones, and therefore it's important to analyse what the potential consequences would be if GM-crops were to be used in animal feed in Sweden. Even though a low price of feed can increase the competitiveness of Swedish farmers, which is something we probably want, lower prices can also lead to rebound effects with more consumption which gives higher environmental impact. We try to highlight this goal conflict so that society can have a more balanced discussion of what we want to achieve and what price we are prepared to pay for these achievements, he says.

Mattias' involvement in Mistra Biotech gave him the opportunity to work with colleagues from another research field, at another department at SLU.

– Even though it's a big research programme, involving many people, I have been working in a small group with nice and engaged people. The tight collaboration with the closest colleagues have really been the highlight of the work, he says.

Contact: *mattias.eriksson@slu.se*
Dept. of Energy and Technology, SLU

“We want to link science to the everyday life recognized by the general public.”

– Lisa Beste

A podcast about plant and animal breeding

In the podcast *Shaping our food*, the Mistra Biotech communications officers Anna Lehrman and Lisa Beste meet researchers and other experts working on topics related to plant and animal breeding. How can a nasty fungus be prevented from attacking a plant? Is it possible to breed sows not to lie on their piglets? How do researchers change the genes of plants and animals? And how can we reason on what is ethically right and wrong? These are some of the questions discussed.

– Shaping our food is a new channel for our researchers to reach out and explain their work, and for listeners to receive knowledge in an effortless way – education straight in your ears, says Lisa Beste.

Plant and animal breeding have a substantial impact on how our future food is shaped. Issues on food safety and environmental risks that might come along with new crops and livestock varieties do not only concern the researchers themselves. The debate on gene technology in general, and GMOs in particular, is a complex one, including political, ideological and ethical, as well as scientific concerns. *Shaping our food* is presented to provide the public with science-based information about how biotechnology and plant and animal breeding work.

– A podcast is a brilliant format for sharing knowledge, and gives the researchers a forum where they get to elaborate. News media seldom allow for more than a few sentences, and there is no time to explain basic facts, says Anna Lehrman.

Anna Lehrman and Lisa Beste also take the opportunity to give their personal reflections on the subject for the day, connecting the sometimes complicated research to things familiar to people – potato crisps, oat porridge or the family dog.

– We want to link science to the everyday life recognized by the general public, says Lisa Beste.

The first five episodes were released during the autumn 2017, of which numbers one and two were devoted to explaining why we need plant breeding and animal breeding in the first place. In the third and fourth episodes researchers in the programme explain how they have changed the oil composition of field cress, and how they have made a potato variety resistant to late blight. In the episode released in December, breeding of oats and the use of genomic selection and other techniques were in focus. In total, the podcast had 555 downloads of the five episodes published during 2017, and there are more in the pipeline.

Shaping our food is produced and funded by Mistra Biotech, but researchers and experts, plant and animal breeders, from both within and outside the research programme, are invited to give their perspectives on the issues discussed. The music is written and produced by Jonas Josefsson.

Information channels for Mistra Biotech

Website
www.slu.se/mistrabiotech
- follow the news updates through the RSS

Twitter
@mistrabiotech

Digital newsletter
Sign up at www.slu.se/mistrabiotech/nyhetsbrev

Podcast
http://shapingourfood.libsyn.com/

Contact
mistrabiotech@slu.se

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Management

Name	Department	Assignment
Sven Ove Hansson	Philosophy and History of Technology, KTH*	Programme Director, Project Leader RA3
Li-Hua Zhu	Plant Breeding, SLU	Project Leader RA1
Dirk Jan de Koning	Animal Breeding and Genetics, SLU	Project Leader RA2
Lisa Beste	Crop Production Ecology, SLU	Communications Officer
Per-Erik Holmlund	Crop Production Ecology, SLU	Financial Administration
Anna Lehrman	Crop Production Ecology, SLU	Deputy Programme Director, Communications Officer

Researchers

EMPLOYED AND ASSOCIATED RESEARCHERS

Name	Department/Company
Aakash Chawade	Plant Breeding, SLU
Ashkan Pakseresht	Economics, SLU
Carl Johan Lagerkvist	Economics, SLU
Catja Selga	Plant Breeding, SLU
Cecilia Gustafsson	Plant Breeding, SLU
Charlotta Zetterberg	Department of Law, Uppsala University
Dennis Eriksson	Plant Breeding, SLU
Dirk-Jan de Koning	Animal Breeding and Genetics, SLU
Elena Flavia Mouresan	Animal Breeding and Genetics, SLU
Elisabeth Jonas	Animal Breeding and Genetics, SLU
Emelie Ivarson	Plant Breeding, SLU
Emma Hansson	Economics, SLU
Erik Alexandersson	Plant Protection Biology, SLU
Erik Andreasson	Plant Protection Biology, SLU
Fernando Lopes Pinto	Animal Breeding and Genetics, SLU
Fredrik Levander	Immunotechnology, Lund University
Fredrik Reslow	Plant Breeding, SLU
Freddy Fikse	Animal Breeding and Genetics, SLU
Helena Röcklinsberg	Animal Environment and Health, SLU

Name	Department/Company
Henrik Svennerstam	Forest Genetics and Plant Physiology, SLU
Inger Åhman	Plant Breeding, SLU
Jakob Willforss	Immunotechnology, Lund University
Jane Morrell	Clinical Sciences, SLU
Julie Clasen	Animal Breeding and Genetics, SLU
Karin Edvardsson Björnberg	Philosophy and History of Technology, KTH*
Klara Fischer	Urban and rural development, SLU
Lars Rönnegård	Animal Breeding and Genetics, SLU
Lena Dimberg	Food Science/Molecular Science, SLU
Li-Hua Zhu	Plant Breeding, SLU
Lotta Rydhmer	Animal Breeding and Genetics, SLU
Maria Selle	Mathematical Sciences, Norwegian University of Science and Technology
Mariette Andersson	Plant Breeding, SLU
Marit Lenman	Plant Protection Biology, SLU
Mattias Eriksson	Energy and Technology, SLU
Mattias Holmlund	Forest Genetics and Plant Physiology, SLU
Micaela Maria Kulesz	Economics, SLU
Mickey Gjerris	Food and Resource, University of Copenhagen
Muhammad Awais Zahid	Plant Protection Biology, SLU
Mulatu Geleta Dida	Plant Breeding, SLU
Nils-Ove Bertholdsson	Plant Breeding, SLU
Patrice Humblot	Clinical Sciences, SLU
Per Sandin Crop	Production Ecology, SLU
Pernilla Vallenback	Lantmännen Lantbruk
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Rodomiro Ortiz	Plant Breeding, SLU
Roger Andersson	Food Science/Molecular Science, SLU
Sebastian Hess	Dairy and Food Industry Economics , Kiel University
Selvaraju Kanagarajan	Plant Breeding, SLU
Sevasti Chatzopoulou	Society and Globalisation, Roskilde University
Shyam Kumar	Basnet Economics, SLU
Sung-Yong Kim	Plant Breeding, SLU
Susanne Eriksson	Animal Breeding and Genetics, SLU
Svante Resjö	Department of Plant Protection Biology, SLU
Sven Ove Hansson	Philosophy and History of Technology, KTH*
Torgny Näsholm	Forest Ecology and Management, SLU
Ulrika Ganeteg	Forest Genetics and Plant Physiology, SLU
Xue Zhao	Food Science/Molecular Science, SLU
Zeratsion Abera Desta	Plant Breeding, SLU

** Royal Institute of Technology (KTH)*

Anna Lehrman interviewed researchers and technicians for the podcast during a visit to CIMMYT outside Mexico City.

Mistra Biotech arranged an excursion to the potato field trials in connection with the agricultural fair Borgeby Fältdagar.

Activities

19/1 Anna Lehrman visited CIMMYT (International Maize and Wheat Improvement Center) in Mexico. She interviewed researchers for the Mistra Biotech podcast “Shaping our Food”.

19/1 Sven Ove Hansson was in the evaluation committee at the doctoral defense of the dissertation Seeding moral responsibility on ownership: How to deal with uncertain risks of GMOs by Zoe Robaey, University of Delft, Netherlands.

9/3 Elisabeth Jonas and Dirk-Jan de Koning participated in a meeting at the Swedish National Food Agency about labeling of products from animals fed on GM feed.

16-17/3 Erik Andreasson gave a talk about “Disease resistance and stress physiology in potato” at the 5th Plant Genomics and Gene Editing Congress, Amsterdam.

22-27/3 Ulrika Ganeteg was invited to South China Agricultural University, Guangzhou, China. She held a seminar “Plant organic nitrogen nutrition”.

26-28/3 Rodomiro Ortiz attended, as co-chair of the organizing committee, the Current Opinion 2nd Conference on Agriculture and Climate Change, Sitges, Spain.

30-31/3 Sevasti Chatzopoulou participated at the stakeholder meeting on circular economy and bio-economy at the European Environmental Agency in Copenhagen.

2/3 Dennis Eriksson gave a presentation about scientific perspectives on stakeholder engagement in regulatory development for genetic engineering, at the PAGIT workshop in London.

4-8/4 Inger Åhman presented a poster on “Streamlining greenhouse and field testing for selection for resistance to net blotch in barley breeding materials” at the 2nd International workshop on barley leaf diseases at ICARDA in Rabat, Morocco.

10/5 Zeratsion Abera Desta gave a presentation “Accelerating domestication with genomic prediction” at the National Center of Plant Gene Research, Huazhong Agricultural University in Wuhan, China as part of the "SLU Study tour in China".

18-20/5 Sevasti Chatzopoulou gave a talk, “From citizens’ mobilization to policy representation? The pilot ECI on GMOs”, at the 12th Organisation studies workshop “Food Organizing Matters: Paradoxes, Problems and Potentialities”, Chania, Greece.

29/5-1/6 Torgny Näsholm gave a talk, “The root perspective of soils; microdialysis mimics mass flow and diffusion”, at the 8th International Symposium on Root Development, Umeå.

1/6 Anna Lehrman, Klara Fisher, DJ de Koning, and Elisabeth Jonas attended the National Food Agency’s second meeting about the investigation on potential labeling of products from animals fed GM feed.

31/5-2/6 Emma Hansson gave a talk “Consequences on carbon footprint of introducing GM soy-feed in Sweden: Results from a LCA study” at the International Consortium on Applied Bio-economy Research Conference, UC Berkeley.

31/5-2/6 Shyam Basnet gave a talk “How does feed price in EU respond to upstream GM innovations? A scenario analysis based on price transmission elasticities of soy-feed” at the International Consortium on Applied Bio-economy Research Conference, UC Berkeley, USA.

5-8/6 Dennis Eriksson arranged a satellite network meeting at the International Symposium on the Biosafety of GMO in Guadalajara, Mexico.

25-28/6 Dirk Jan de Koning gave an invited talk on “Inbreeding in the genomics era the flip side: Cross-breeding” at the American Dairy Science Association (ADSA) Annual meeting in Pittsburgh, USA.

28-29/6 Mistra Biotech organized a guided field tour in the potato trials (blight resistance) during the agricultural fair in Borgeby.

2-5/7 Poster presentation by Emelie Ivarson et al., ”Reduction of pod shatter in *Lepidium campestre* through biotechnical approaches” at the 8th European Symposium on Plant Lipids, Malmö.

A buffet of products partly made with GMOs was served at the Mistra Biotech seminar "Teknikneutralitet i praktiken - hur ska moderna växtförädlingstekniker få en chans i Sverige och EU?" in Almedalen.

4/7 Mistra Biotech Seminar "Teknikneutralitet i praktiken - hur ska moderna växtförädlingstekniker få en chans i Sverige och EU?" at the Almedalen week in Visby (Watch it on YouTube).

3-6/7 Poster presentation by Catja Selga et al. "Phenotyping and genotyping to enable genomic breeding values in potato" at the Society for Experimental Biology annual meeting "Scientific smorgasbord" in Gothenburg.

7-8/7 Mariette Andersson gave a talk "Efficient targeted multiallelic mutagenesis in tetraploid potato" at the Society for Experimental Biology (SEB) meeting "Sowing the Seed" in Gothenburg.

7-8/7 Dennis Eriksson participated in the SEB/Global Plant Council workshop "New breeding technologies in plant sciences" in Gothenburg, as well as arranged a satellite network meeting following up on the network meeting in Guadalajara. (See prev.)

9-14/7 Oral presentation by Svante Resjö et al. "Proteomics and phosphoproteomics of *Phytophthora infestans*", and poster presentations by Marit Lenman et al. "Suseptibitly genes in potato" and Catja Selga, et al. "Genomic estimated breeding value approach for selection in potato", at the European Association of Potato Research 2017 20th Triennial Conference. Versailles, France.

27-28/6 Sevasti Chatzopoulou et al. gave at presentation "The agencies' role of the externalization of standards beyond the EU borders- EEA, EFSA, EMA" at The Academic Research Network on Agencification of EU Executive Governance (TARN) Conference in Luxembourg.

18/8 Release event for Mistra Biotech's podcast Shaping our Food.

28/-1/9 Poster presentation by Maria Selle, Elena F. Mouresan and Lars Rönnegård "Genomic prediction including external information on markers" at the 68th Annual Meeting of the European Federation of Animal Science, EAAP, in Tallin.

4-7/9 Dennis Eriksson gave a presentation "Scandinavian perspectives on plant gene technologies" at the GPGR4 Genomics of Plant Genetic Resources conference, Giessen, Germany.

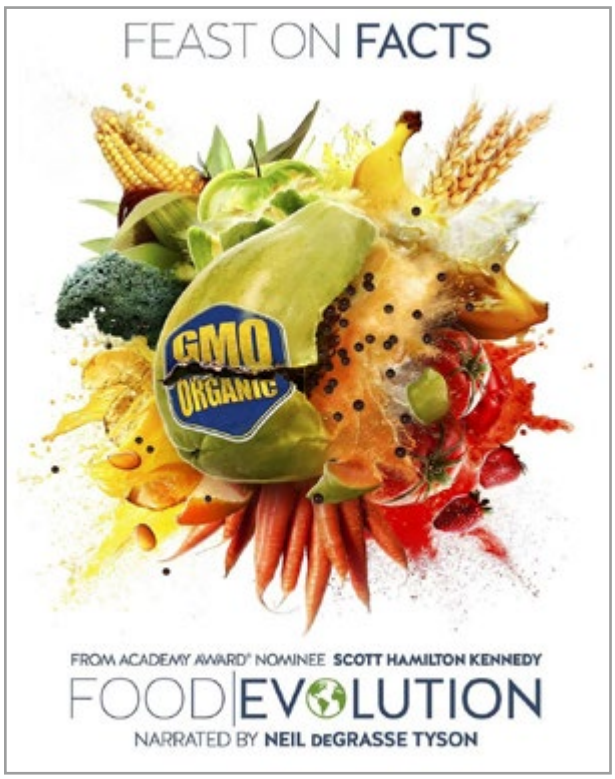
21/9 Sweden Food Tech visited SLU and Anna Lehrman was invited to present Mistra Biotech.

21/9 Per Sandin et al. gave a presentation on "The ethical matrix", at Klimatrådets klimatvecka, Jönköping.

24/9 Participation in the SLU Open Campus Alnarp.

The plastics made from potato was shown at an exhibition in the Botanical Garden of Uppsala.

Researchers, board members and invited speakers share their views at the Mistra Biotech annual meeting



The screening of and discussion about the film Food Evolution was a highlight activity 2017.

25-26/9 Mariette Andersson was invited speaker at “CRISPR and Precision Genome Editing AgBio conference, giving a talk on “Efficient targeted multi-allelic mutagenesis in tetraploid potato”, London.

26/9 Mistra Biotech organized a screening of the documentary "Food Evolution" followed by a discussion in Ultuna.

28/9 Dennis Eriksson participated in bilateral meetings with Swedish policy makers at the European Commission conference “Modern biotechnologies in agriculture” in Brussels, Belgium.

30/9 Participation in the SLU Open Campus Ultuna.

19/10 Mistra Biotech hosted the GMO-network meeting at SLU Ultuna.

26-27/10 Dennis Eriksson was invited on behalf of the Swedish Ministry of Enterprise to present “Scandinavian perspectives on plant gene technologies” at the Vitenskapskomiteen för Mat og Miljö/European Food Safety Authority symposium on Environmental Risk Assessment, Oslo Norway.

30/10 Carl-Johan Lagerkvist and Lotta Rydhmer participated in an on-line chat following the episode “Mat och genteknik” in the science programme Vetenskapens Värld (SVT).

6-9/11 Inger Åhman gave a talk on ”Breeding for resistance to aphids in wheat and barley” at 4th Conference of Cereal Biotechnology and Breeding, EUCARPIA, Budapest, Hungary.

9/11 Micaela M. Kulesz gave a presentation “The market of meaning: the case for GMO – Evidence from an evolutionary game experiment.”, at the seminar “Frontiers in food consumer research”, SLU, Ultuna.

6/12 Rodomiro Ortiz was Chair of panel after screening of the film “Food Evolution” at Universiad Nacional Agraria La Molina(UNALM), Lima, Perú.

7/12 Sven Ove Hansson participated in a debate "DNA analys och genteknik i människans tjänst” at Uppsala Folkuniversitet.

13/12 Dennis Eriksson was invited to give a presentation “Forskning i gränslandet - Vetenskapsbaserad policyutveckling av växtbioteknik” at the Swedish Gene Technology Advisory Board, Stockholm.

Mistra Biotech in the media

Click the titles to access

1/2017 Forskare kan ändra anlag i embryon, Nötkött.

2/2017 Video interview with Rodomiro Ortiz at the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria.

17/2 Komposterbar bioplast av GMO-potatis *Plastforum.*

3/3 "Om grisar som genmodifieras för att inte bli sjuka" at 24:25 min, Vetenskapsradions veckomagasin.

22/3 Genmodifierad växt tar upp mer kväve ur jorden *Lantbruksnytt.*

22/3 GMO-växt tar upp mer organiskt kväve *ATL.*

23/3 GMO kan vara lösningen på kväveupptaget *Jordbruksaktuellt.*

9/4 Kritisk forskare med rättvisepatos, about Klara Fischer in Upsala Nya Tidning.

18/4 Nu finns det genmodifierad potatis som står emot bladmögel, in Lantbruksnytt's web TV.

20/4 At være eller ikke være GMO, Mickey Gjerris writes in Landbrugsavisen.

18/5 Skånska "päror" klarar mögel med ny gen, in Lokalnyheterna Skåne, SVT.

28/5 Framtidens mat påverkas med bioteknik, in DN.

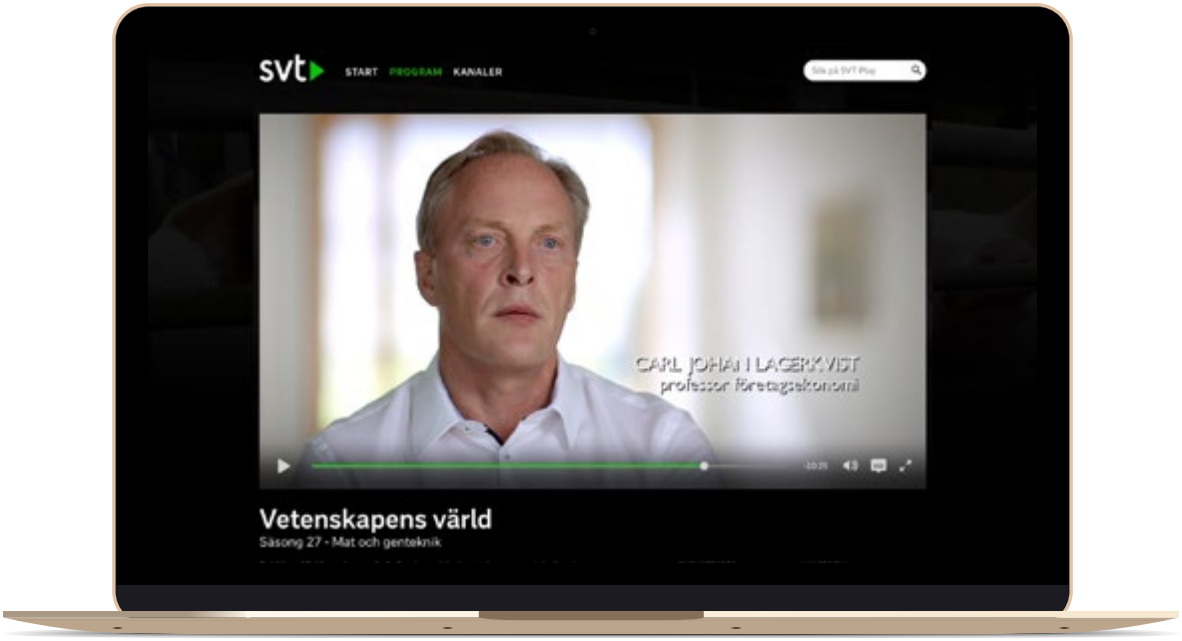
5/6 GMO och andra typer av växtförädling, Anna Lehrman in the podcast Tyngre Träningssnack.

6/6 Vetenskapsseminarium om djur – förståelse, empati och djuridik, Helena Röcklinsberg in Djurens Rätt's Youtube channel (starts at 31:25).

13/7 Hur går det med fältförsöken av genmodifierad potatis som ska stå emot bladmögel? Lantbruksnytt.

25/8 Solyntas nya potatis testas i Umeå, ATL.

Erik Andreasson demonstrated the late blight resistant potato in a feature on the local news Skåne in Swedish Television.



Carl Johan Lagerkvist about consumer acceptance of gene technology in the Swedish television science programme Vetenskapens Värld.

28/8 Lyssna på experter om bioteknik, Land Lantbruk.

21/9 EU and GMOs: The case for a knowledge-based society, Euractiv.

5/10 Ordet naturligt borde förbjudas, SvD.

13/10 Kritikstorm mot Jordbruksverkets djurskydds-förslag, Land Lantbruk.

30/10 Mat och genteknik, Vetenskapens Värld, SVT.

1/11 ”Vi behöver spana in framtiden”, ETC Uppsala.

3/11 Miljön är den stora förloraren när gentekniken ratas, Mistra.

9/11 "Ovärdigt och odemokratiskt", Land Lantbruk.

13/11 Svenska forskare sågar EU:s MO-lagstiftning, Aktuell Hållbarhet.

27/11 Heat tolerant durum wheat discovery to aid farmers in West Africa, Biosciences for Africa, and others.

29/11 SLU-forskare prisas för ”galen idé” kring vete, SvD, Genteknik i avel väcker frågor, Land Lantbruk, and others.

11/12 5 vetenskapliga skäl att sluta vara rädd för GMO, KIT.

21/12 Genetic technologies rely on active roles for researchers, industry, Feedstuffs, and Cowsmopolitan.

5/12 Äkta potatisfrön, Viola potatis.

Susanne Eriksson was interviewed on GM- and genome edited animals in Cowsmopolitan.

"Konventionella metoder kan vara minst lika riskfyllda. För konsumenter blir det en osäkerhet" said Charlotta Zetterberg in the online newspaper KIT.

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