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Old genes or new genes – possibilities and limitations

Eigtveds Pakhus, Copenhagen, 13 December 2005

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ANP 2006:717

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ISBN 92-893-1306-4

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Content

Preface

The conference ”Old Genes or new genes – Possibilities and limitations” was held on 13 December 2005 at Eigtveds Pakhus in Copenhagen. The event was arranged by the Danish Plant Directorate (Ministry of Food, Agriculture and Fisheries) and was financed by the Nordic Council of Ministers. The conference is one of the activities arranged during Denmark’s presidency of the Nordic Council of Ministers in 2005.

This brochure has been produced by science journalist Bodil Pedersen. It is not intended to give a complete account of the conference, but to convey the main views and impressions from the event to the public at large.

See slides from the conference on http://www.pdir.dk/oldgenesnewgenes

Conference attracts many participants

Over 100 people have gathered for the conference taking place at the beautifully restored old Eigtveds warehouse near the centre of Copenhagen. The proximity of the conference to Christmas has not deterred people from Denmark, Norway, Sweden Finland, Iceland, Lithuania, Latvia, the Netherlands and the Japanese Embassy from attending this public meeting in Copenhagen today.

The theme of the conference is genetically modified (GM) crops, but in contrast to many other conferences, this is not a 'for and against gene technology' conference.

- There has been a fairly heated debate on the use of GM crops in Europe during the last decade, which has focused mainly on the potential risks associated with gene technology. The debate has revealed that many Europeans are very sceptical towards the technology. Traditional breeding methods have, on the other hand, not received much attention. We therefore thought it would be interesting to compare the two technologies side by side in terms of their possibilities and limitations, explains Svend Pedersen from the Danish Plant Directorate. He and Lars Landbo from the directorate have been in charge of the organisation of the conference.

He continues:

- The objective of the conference is thus to widen the discussion. The discussion will not just be limited to the needs of the Europeans, but it will also address how other countries, in particular developing countries, are making use of gene technology.

The meeting is targeted at the general public, but the people who have turned up are primarily those already involved with plant breeding and gene technology. Many of the participants are researchers from universities and research institutes, but commercial plant breeders, the agrochemical industry, organic farming, the retail trade, environmental organisations and students are also represented.

Focus on possibilities, not on differences

There have been numerous conferences on the issue of genetically modified organisms in recent years, and at many of these there has been a strong clash of opinions between opponents and supporters.

The organisers, however, decided on a different approach for this conference:

What is the potential for future crop development with or without gene technology?

The aim is therefore to shed some light on the scope and limitations both with traditional breeding methods and with genetic engineering.

All speakers expressed their satisfaction with the focus of the conference having been shifted away from the usual ’for and against’ genetic modification to a more open format, where the focus rests on the possibilities in both technologies.

An introduction to traditional breeding and gene technology

Preben Bach Holm, Research professor at the Department of Genetics and Biotechnology at the Danish Institute of Agricultural Sciences, kicks off the meeting by outlining the traditional and genetic breeding methods. Towards the end of his talk he introduces some questions:

How do the methods used in traditional breeding and gene technology differ?

With traditional breeding we can only recombine genes within the same or related species, so what takes place is the sexual crossing of related species.

This restriction does not apply in gene technology, also called genetic modification (GM), where one gene from one organism in principle can be moved to any other organism, such as from bacteria to plants, plants to animals or animals to plants.

Do the methods used in traditional breeding and genetic modifications always differ?

Particularly the transfer of genes between species has generated much debate. Are we trying to play God and do we interfere too much with natural processes when we decide which genes go where?

As scientists we take these views very seriously and this means that we now work less with transgenes – i.e. the transfer of genes between different species. Much of our work now focuses on finding genes within the same species, also called cis genes, which is frequently possible.

This work can involve the transfer of genes from, for example a wild variety to its related cultivated species. The interesting question here is then whether you can distinguish between traditional breeding and gene technology.

The aim should determine the means

As a scientist I would finally wish to be allowed to choose the method most suitable for the purpose in hand. This is achieved by firstly deciding which plant traits we would like to promote and then which method would help us achieve the best result.

Legislation on genetically modified plants in Europe

Svend Pedersen gave a brief overview of both the Danish and the EU legislation that applies when new plant varieties require marketing approval. All new varieties produced have to comply with specific requirements irrespective of breeding method, with additional restrictions applying to GM varieties. Denmark and a few other EU countries also have legislation on the coexistence of GM crops with conventional crops in place.

It is therefore the choice of breeding method (traditional or gene technology) that determines how the plant is subsequently dealt with in EU legislation.

The EU has ratified the legislation on genetically modified organisms (GMOs) and, in principle, EU farmers are now able to grow GM crops.

Svend Pedersen provides examples of herbicide-resistant varieties of maize, wheat and oilseed rape. Some of these have been produced using gene technology and some using a traditional breeding method (chemical mutagenesis), where genes are mutated by treating them with chemicals. Herbicide-resistant plants can therefore be produced both with and without the use of gene technology, but the varieties produced using gene technology are far more difficult to bring to market than plants produced using chemical mutagenesis.

Part conference – part judicial hearing

After the preliminary presentations have given the participants an update of the current status of breeding technology and the most recent legislation on genetic engineering, the scene is changed. We are now in a courtroom. Two lawyers have been hired to explain and clarify the applicability of the methods. A judge – or, more accurately, chairman – will be guiding the process and will be drawing the final conclusions.

The lawyers have been chosen not because of their support or opposition to gene technology, but because of their knowledge in the area. Bert Visser is therefore not as such against gene technology and Per Pinstrup-Andersen is naturally not opposed to the use of traditional breeding.

Per Pinstrup-Andersen elaborates on the possibilities and limitations of gene technology

Per Pinstrup-Andersen is a Professor at Cornell University and at The Royal Veterinary and Agricultural University (Denmark). He is a World Food Prize laureate and much involved in the international debate on global food security.

Bert Visser elaborates on the possibilities and limitations of traditional breeding

Bert Visser is Director of the Centre for Genetic Resources, the Netherlands, and has extensive knowledge on both the practical and policy-related aspects of plant genetic resources.

Johan Bodegård is the judge, who chairs the discussion and acts as moderator

Johan Bodegård is Deputy Director, National Resources Department (Swedish Environmental Protection Agency), and is an experienced negotiator in international fora such as in the negotiations on the International Treaty on Plant Genetic Resources.

The jury

The jury – comprising the participants to the conference – is put to work three times during the proceedings. The jury members have to give their verdict by answering questions in a questionnaire following each of the three sessions (see the result of the votes on pages 18-20).

Theme 1: Gene technology versus traditional breeding – an artificial distinction?

Per Pinstrup-Andersen: Does traditional breeding have the potential to make dramatic changes?

My answer to this is yes. I base this on the considerable historical development that has taken place in agricultural crop production.

Research is crucial for developing countries

- Why is research so important for agriculture? It is important because of the growing world population. By 2025 a predicted additional 50% will need to be fed, which is why we need to increase productivity, control plant pests and diseases effectively and breed plants that, for example, are able to tolerate salt-rich soils. Research is crucial for this challenge to be met successfully.

- Agriculture has seen an annual productivity increase of 1-1½% over the years and this is due to research. The green revolution has doubled productivity and has had a positive effect on the development in third world countries. The money we invest in agricultural research in developing countries is returned manyfold and has a considerable positive impact on the economy and development in these countries.

Artificial distinction

- I believe a distinction between traditional breeding and gene technology is an artificial one. There is a considerable difference, for example, between the traditional breeding methods used just ten years ago and the very advanced methods we use today.

- In China, a disease-resistant variety of rice has been developed by moving a specific gene from a wild rice variety to a cultivated variety. The same could have been achieved using traditional breeding methods, but it would have taken far longer. The question is whether this new variety of rice should then really be classified as genetically modified when the gene is from the same species? Is it the process or the product that should be classified?

The area planted to GM crops is growing

There are people in the EU who believe that gene technology is dead and that GM crops will never be widely used. They are completely wrong. Gene technology is thriving and if EU countries continue to be so restrictive, the European research and breeding programme will end up lagging far behind its competitors.

If we continue to be so dismissive of the technology and then realise in 15 years' time that we were wrong, we will have to go to China to learn how to do it.

Bert Visser: Are there risks associated with traditional breeding?

- It is important to emphasize that current traditional breeding methods bear very little resemblance to the breeding methods used in days of yore. Current breeding techniques are effective and advanced and use state-of-the-art technology and tools.

Examples of adverse effects

Bert Visser provides several examples of traditionally bred crops that have turned out to contain toxic compounds, provoke allergic reactions or have had undesirable agronomic traits. Potatoes and tomatoes, for example, contain glycoalkaloids that are toxic at high concentrations.

- Toxicity is usually discovered during the breeding process, but there have been reports of subsequent poisonings. Glucosinolates, for example – the compounds that give oilseed rape a bitter flavour and make it unsuitable as an animal feed – have successfully been removed from this crop with traditional breeding methods. But this then made it attractive to wild animals, who then foraged the crop in the field, with subsequent negative effects on their health.

Bert Visser also recounts cases of allergy among field technicians responsible for the harvesting of a particular variety of celery. The variety did not cause allergic reactions in the people eating the vegetable. He finally gives an example of a new variety of oil palm that was produced, but turned out not to be able to flower and hence bore no fruits and produced no oil, resulting in significant economic losses for the producers.

According to Bert Visser there are also other risks associated with the current methods of breeding. We risk, for example, reducing the gene pool by focusing too narrowly on specific traits.

Are we able to handle the risks?

Bert Visser concludes:

- There have always been risks associated with the development of new varieties with traditional breeding methods, but we have been able to deal with those along the way. The question is if the risks are larger with genetic modification or if it means new forms of risk are introduced that we have not met before.

Extracts of the debate

- Do we need gene technology? We already produce more food that we can eat and there are food mountains in many places of the world?

Per Pinstrup-Andersen replies:

There is enough food in the world, but the problem is that there are 800 million people who do not have enough to eat. That is why we have to use all the tools available to help these people. The woman in West Africa who does not have enough food to feed her six children does not worry about whether what she grows is genetically modified or not. She will grow the crops that are resistant to the pests and diseases that would otherwise destroy the crop.

And as far as I can see, the crops are safe. In the United States we have been eating these crops for the last 6-7 years without any adverse effects on the American population.

Is public funding necessary?

Bert Visser replies:

Public funding is crucial if we are to solve the problems in the developing countries. Private companies are not interested in developing new plant varieties for developing countries if there is no economic gain for them.

It is, for example, nearly impossible to develop resistance to a serious fungal disease in bananas using traditional breeding methods. It may be possible using gene technology, but this is not attractive enough to private companies. The only possible way is by public investment in the development work.

Theme 2: Gene technology and traditional breeding – possibilities

Bert Visser: What has been accomplished by traditional breeding?

It is important to remember the developments that have taken place in breeding technology. Until the 19th century the farmers themselves chose the varieties that they wanted to use for breeding. This subsequently became the job of actual specialists, i.e. farmers turned specialist breeders, and thus breeding became a core business. Today most small-scale breeders have disappeared and have been replaced by large-scale private breeding companies who are at the forefront of developments within breeding and biotechnology.

Plant breeding and other measures have resulted in a large increase in the amount of food being produced. A significant contributor to the increase in food production has been the green revolution.

Reduced growth period

Not only has it been possible to significantly increase the yield of a number of crops, it has also been possible to reduce the growth period for some important crops from 150-180 days to only 110 days. This means that the crops are less exposed to drought and in some parts of the world it is now possible to have three croppings per year.

Healthier plants

Improved resistance is another important effect of breeding and some diseases have been completely eradicated. Another important initiative has been the establishment of gene banks, from which genes are taken to develop healthier and improved varieties.

Per Pinstrup-Andersen: What has been accomplished by using gene technology on plants?

Research into gene technology is currently being undertaken by 63 countries including China, Indonesia, Malaysia, Bangladesh, Pakistan, India,

the United States and several European countries. Many of these are noticeably middle-income countries, while very few low-income countries are involved. Many semi-developed countries are about to join the gene technology train. It is, however, very important that the remaining very underdeveloped countries receive help so that they are not left behind.

New variety of Golden Rice

- Golden Rice is a genetically engineered variety of rice with a high level of beta-carotene, which the body converts to vitamin A. The variety contains genes from the daffodil. Critics contend that Golden Rice is of little value because a child has to eat several kilos per day in order to meet their daily vitamin-A requirements. Scientists subsequently discovered that if they transferred a gene from either maize or another rice variety to Golden Rice, the vitamin-A level could be increased 23-fold. This is approximately half the daily dietary requirement of a child. Then we are really in a position to be able to help the poor.

- We could not have achieved the same result with traditional breeding, as these genes are not present in rice. But because scientists already were well-acquainted with the genetic composition of rice and maize, gene technology was the best tool for the job.

You will always find people who treat new results with scepticism, but we must remember that if we always criticise scientific results, we will stunt the initiative. It is important that we have a responsible debate.

Biosafety is important

It is also important that we ensure that new varieties are soundly tested. It is crucial to have a high level of biosafety by, for example, carrying out field trials and by prioritizing food security.

Genetically engineered cotton that is resistant to the worst pest to afflict cotton plants – the larva of a butterfly– now makes up two thirds of the area planted to cotton in China. This has led to an 80% reduction in the use of pesticides and farmers have a better economy. There has been much talk about the risk of the butterflies developing resistance, but quite a different problem has emerged instead. Now that the worst pest has been removed, other pests have taken over, and farmers risk having to spray the crops as much as they used to before.

Bert Visser: The future – Potential of traditional breeding

There is a potential for improvement in many areas. I believe we ought to shorten the growth period for many crops, change plant architecture and

yield potential, increase plant water use efficiency and reduce the need for fertilization.

The main breeding programmes today focus on only a few species. We have to widen the scope to include other underutilized or neglected crops such as fruits and vegetables, which are particularly important to human health in developing countries.

Modern traditional plant breeding programmes use many different techniques. We are able to do things today that were not possible only a few years ago. There is the potential for progress – also without the use of gene technology.

Per Pinstrup-Andersen: The future– Potential of gene technology

As long as we achieve our objectives, it is really quite irrelevant which technique we use to improve plant traits. This means we have to choose the method most suitable for each task.

It would appear that we can make much more progress than previously thought just by using intra-species genetic modifications. Perhaps in 20-30 years' time there will be no need whatsoever to include genes from unrelated species in gene technology. The question is whether the opposition to gene technology in Europe will persist if genes from within the same species are used. I certainly think that this will eliminate a risk factor.

People in Europe and in developing countries have different attitudes to benefits and risks. In Europe we are happy to maintain status quo, which is why we are more focused on the risk aspects. The West African woman, however, who needs to provide food for six children will be more focused on the advantages that GM crops can give her.

During a drought in southern Africa, the United States offered to send some maize to the starving population of Zambia. But as it was GM maize, Zambia refused to accept it. Zambia wanted to be able to continue selling its own maize to Europe and if they accepted the GM maize, their own maize may have been contaminated and they would have lost their export to Europe. The problem can be solved by sending maize flour instead as food aid.

Extracts from the debate:

How do you choose between traditional breeding and gene technology?

Bert Visser replies: Are we allowed to choose the best technical solution to the problem, or do other factors decide which method breeders choose?

It is the responsibility of society itself to construct the right framework. Politicians should reconsider the whole legal aspect of breeding rights. At the moment we have two competing systems. We have the plant variety rights for the traditionally bred varieties, while GM varieties can be patented. Patenting is a much more restrictive and limiting system for the users.

Do we need gene technology? Why not just use traditional breeding?

Per Pinstrup-Andersen responds: It is difficult to say if we can dispense with gene technology. If that were so, we would need more land to grow crops and this would be detrimental to our natural resources.

What will be the effect of not using gene technology?

- asks a member of the audience and provides the following answer:

- It will take much longer for agricultural problems to be solved. With gene technology we can reduce the time taken for new varieties to be produced.

Per Pinstrup-Andersen' statements are somewhat provoking

- is the opinion of another participant. You make it sound as if we do not support GMO and that we do not wish to help feed the poor, but it is not as simple as that. Environmental organisations in many African countries do not want GMOs into their countries.

Theme 3: Gene technology and traditional breeding – limitations

Per Pinstrup-Andersen: Gene technology – limitations

It is extremely important to have a high level of biosafety.

Health benefits to both people and animals

There have been reports of adverse health effects on experimental animals fed GM crops. In several cases there has, however, been some uncertainty about the results.

New GM crops must be safe for both humans and animals. I think it is very wrong that some GM crops can be approved for animal feed, but not as human food crops. We cannot be certain that animal feed and human food products can be kept separate, which is why only products that are safe both for humans and animals should be approved.

Crosspollination

Biosafety also includes the crosspollination aspect. There has always been crosspollination between plants, but the question is whether GM crops carry a larger risk. We must remember that we can never be certain that something will be 100% safe. Every time we eat there is a risk that something will go wrong.

It is the evidence that counts

Whether we eat GM crops in Denmark or not is not such an important issue. But our attitude to other people and their problems and needs for different solutions is very important.

We all have to behave responsibly. Both the large commercial enterprises who insist that gene technology will solve all our problems and those who oppose gene technology. We have to base our debate on the available evidence. China has now produced several GM plants but cannot market them because of the strong European opposition.

I believe in Farmers' Rights in developing countries. The farmer should be allowed to sow the seeds he produces himself, including the genetically modified ones. This is why it should not be possible to patent GM plants. They should be treated just like any of the plants produced by traditional breeding methods.

Bert Visser: Traditional breeding – limitations

In traditional breeding, genetic crossings take place between related species. Nevertheless, it is now possible to perform very advanced crossings using modern technology. There are also many very valuable genes in the related wild species – many more than can be found in unrelated species.

The traditional breeding process is time-consuming, but new techniques have also shortened the breeding time here. With gene technology you achieve a breeding result much faster, but the subsequent approval process is much longer.

Areas where gene technology can be advantageous

It is difficult to clone plants such as bananas, potatoes, cassava and fruit trees using traditional methods, and this is an area where gene technology is useful. Gene technology has also been more successful in the breeding for plant resistance to viruses and insects than traditional breeding methods have. But in other aspects I think traditional breeding still outcompetes gene technology.

Centralisation in the breeding sector

There are restrictions in the use of genetic material within traditional breeding, but with GM crops these restrictions are even tighter. It can also be termed restrictive that the considerable amount of expensive modern technology needed means that plant breeding can only be afforded by a few large private enterprises.

Although traditional breeding has its limitations, it is also a fact that gene technology cannot survive without traditional breeding, but traditional breeding will survive without gene technology.

There appear to be four main reasons why people are sceptical towards gene technology. Firstly, it is believed that we interfere with Nature and that it is against God’s will. Secondly, that gene technology creates food security problems, but as I have previously mentioned, I think we are capable of handling this. Thirdly, that genetically modified plants can be invasive. Neither do I think that this is a problem. That is something we can handle.

The fourth reason, however, I believe is a major problem. This is the concentration of power that it leads to. The production of GM plants requires large investments, which means that only large companies have the financial strength to do this. This gives them much power and influence on which foods we will be eating in the future.

Extracts from the debate:

Johan Bodegård: I understand that you agree that gene technology as such is not a problem. How do we ensure that we have good biosafety regulations?

Per Pinstrup-Andersen: Biosafety regulations have to be sensible. We cannot test for everything and on the other hand the breeders should not market products with adverse effects.

Bert Visser: I completely agree with Per. We must decide on how to test and formulate the regulations from case to case.

What are the advantages of gene technology in Europe?

Bert Visser: If gene technology can produce a potato that is resistant to late blight, this would be a great advantage to Europe. But other forms of resistance to pests and diseases would be interesting too. But for other tasks there is still a great potential in using traditional breeding methods. And, if relevant, we can combine it with gene technology.

A breeder's experience

We developed a Roundup-resistant forage beet using gene technology. It was tested in field trials and on animals. But the authorities were unable to give the final approval and the EU demanded yet more expensive tests. So now we have given up the project and outsourced the breeding work to China.

The jury’s views

Theme 1 – The jury’s view on the distinction between methods

1. Do you believe crop plants should be evaluated and regulated according to:

a) the properties of the plants	30
b) the breeding method (i.e. traditional breeding or gene technology)	2
c) both a) and b)	41

2. Do you think unexpected, harmful effects could result from a plant made by traditional breeding?

a) yes	65
b) no	5
c) don’t know	3

3. Do you think unexpected, harmful effects could result from a plant made by gene technology?

a) yes	67
b) no	5
c) don’t know	1

4. Should some plants made by traditional breeding also undergo risk assessment?

a) yes	54
b) no	10
c) don’t know	9

Theme 2 – the jury's view on the possibilities in the technologies

5. Do you believe developing countries can obtain food security and reduce poverty if they use only traditional breeding methods in the development of their crop plants?

a) yes	32
b) no	18
c) don't know	18

6. Do you think gene technology can contribute to the improvement of food security and reduction of poverty in developing countries?

a) yes	54
b) no	4
c) don't know	11

7. How promising is the future of European agriculture if it relies only on traditional breeding?

a) not very promising	15
b) somewhat promising	42
c) very promising	12

8. How promising is the future of European agriculture if it also includes gene technology?

a) not very promising	8
b) somewhat promising	30
c) very promising	30

Theme 3 – the jury's view on the limitations of the technologies

9. Do political factors (lack of public research, administrative burdens, intellectual property rights etc.) currently limit the benefits we get from the use of traditional breeding?

a) no	23
b) yes, to some extent	36
c) yes, to a large extent	7

10. Do political factors (lack of public research, administrative burdens, intellectual property rights etc.) currently limit the benefits we get from the use of gene technology?

a) no	4
b) yes, to some extent	17
c) yes, to a large extent	46

11. Do you think public participation in development of crop plants by the use of traditional breeding should be:

a) low	11
b) intermediate	28
c) high	26

12. Do you think public participation in development of crop plants by the use of gene technology should be:

a) low	9
b) intermediate	23
c) high	34

The verdict – what we have learned!

Johan Bodegård is not a high-court judge who has to deliver a verdict on the basis of the discussions and views expressed at the meeting, but as a conclusion to the meeting he presents some final observations:

- Middle-income countries have started investing in and using biotechnology to develop GM plants.
- For most crops GM technology has so far only had limited effect on the breeding of new plant varieties, but it has had a large impact on some of the major crops.
- The world is for different reasons divided in the use of gene technology – who will win and who will lose?
- Does Europe have any real issues that warrant the use of gene technology? Do we need gene technology to solve future problems? Is it a future option for European agriculture?
- The experts present here today have agreed that gene technology as such does not pose a risk, but this view is generally not accepted by ordinary people. For me this is the crucial issue for the future use of gene technology – at least in Europe.