Who is joining at table?

Will genetic engineering end hunger?

An information brochure of the rural movement from Belgium and catholic rural people movement from Germany edition 2005

Three questions:
What is white, red and green biotechnology?
What is the role of gene banks for agricultural crops?
Why is patenting of plants so controversial?

Internationaler Landvolkdienst (ILD) is the development organisation of KLB, the catholic rural people movement from Germany. ILD supports projects of poverty reduction and rural development of partner organisations in less developed areas in Africa, Latin America, Asia and Central and Eastern Europe. ILD is also informing KLB members about development subjects

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Preface

A tangle of emotions and economic interests

Genetic modification in agricultural crops is a controversial topic, both in Europe as well as in many developing countries. Some people are uncritical proponents, others are absolute opponents, still others are somewhere in between. The majority however does not even know what the fighting cocks are talking about.

In this tangle of emotions and major economic interests, the concerns of farmers in developing countries are often overlooked. This brochure wants to situate genetically modified crops (GM crops) in the context of family farming in developing countries. Particularly for those countries it is important not only to look at the impact of GM crops on food safety and the environment, but also to consider first and foremost the impact on food security. We will explain the differing opinions that exist in this context.

Since this is an information brochure on GM crops in developing countries, we try to pay special attention to the concerns and opinions of farmers and their organizations in the countries of the South.

This brochure is the result of a joint European initiative between member organizations of rural movements in Germany (Katholische Landvolkbewegung - KLB Deutschlands) and Belgium (Landelijke Beweging in Flanders and Ländliche Bewegung in the German-speaking eastern part of Belgium).

We hope that this text may contribute to a better understanding and to an open dialogue about GM crops, a topic that is actually both important for the North and for the South.

Noël Devisch
Chairman Boerenbond

Hermann Kroll-Schlüter
Chairman KLB

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Reading aid:
While reading this brochure you may encounter some rather difficult words or concepts. The terms that are underlined, are explained in the glossary.

Introduction

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Genetically modified crops are controversial. Quotations from the GM crops discussion, divided in voices from here and voices from there, illustrate a wide variety of arguments and contradictory opinions.

Step 2. *The causes of hunger and the persistency of food insecurity*.
Hunger and food insecurity are obstinate problems with very complex underlying causes. The (agricultural) policy affects the availability of food and therefore also food security. The impact of genetic engineering on food security as such is not clear. In theory genetic engineering may tap new reserves for food production. In practice however there are still too many barriers for developing countries and for small farmers.

Step 3. *Technologies that tinker at the code of life*. We present an introduction
to the scientific basis of those technologies. The difference is made clear between publicly accepted technologies of biotechnology in agriculture and the more controversial genetic engineering.

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Plant breeding is a central topic in this brochure, since selective breeding of plants constitutes the foundation of any agricultural system. The development of an agricultural system leads on the one hand to an increased distance between plant breeders and farmers and on the other hand to a decrease of biodiversity. Still biodiversity is the source as well as the cornerstone of plant improvement.
Western, sophisticated agricultural systems increasingly appeal to the genetic diversity of more primitive agricultural systems in order to find solutions for plant diseases and pests. The concentration and privatisation of breeding stations reduce the agricultural biodiversity and hence affect the foundations of various agricultural systems.

Step 5. *Farmers and intellectual property rights on plant varieties.*
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At international level the introduction of genetic engineering has lead to agreements that are based upon the precautionary principle, which is also endorsed in Europe.

Step 6. *Government funding for research remains more than necessary*.
The international community has consigned the care for the gene banks of agricultural crops to the CGIAR. This institution will keep playing an important role for agricultural crops in developing countries and for crops that do not have a commercial interest. The decreasing role of governments, the growing importance of multinational corporations in 'life sciences' and the urge to patent require special attention of the CGIAR centres.

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What's the news of GM crops in the world? On the one hand there are a limited number of applications, on the other their share is growing strongly and GM crops have a real impact. The current use of GM crops at a large scale is limited to six countries, four crops and two traits. Today there are only two crops (maize and cotton) and one trait (Bt trait) that are relevant for developing countries, if a number of prior conditions are fulfilled.
It is not possible today to predict whether it will be feasible to commercialise other GM crops and properties that may be of potential importance for developing countries. China does promise a breakthrough for GM rice in 2005.

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The advantages of the existing GM crops are concrete and mainly concern agricultural technical aspects. At the same time GM crops can also have a favourable impact on health and environment. Advantages must be assessed for every crop and for every trait. Differing degrees of precaution are applied with regard to a risk that cannot be excluded and that is not quantified. Therefore there may be wide differences between the assessments of different experts.

Step 9. *Some main lines of the ethical debate on GM crops.*
Ethicists interpret the debate starting from opposing basic attitudes: what attitude does each of us adopt towards nature? Most people who are active in agriculture think that animals and plants have no intrinsic value and are utility goods for the benefit of men. Some remarks and principles may provide some background for an open dialogue between people with differing basic attitudes.

Step 10. *Experiences with bananas and genetic engineering.*
A practical example is bananas, an important food crop for subsistence farming in developing countries. Networking between government research centres stimulates the exchange of diseases free plant material.
For the time being traditional plant improvement still overshadows the possible introduction of the already existing GM banana.

In conclusion: *what are the points of interest of the rural movements?*
The rural movements in Belgium and Germany consider it as their task to interest many stakeholders in the theme of GM crops and food security. They want to point to the plight of the most vulnerable people in the developing countries.

Step 1. An anthology of the many differing opinions in the GMO discussion.

GM crops are controversial. Quotations from the GM crop discussion, divided into voices from here and voices from there, illustrate a wide variety of arguments and contradictory opinions.

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Voices from here …

A specialized website

"There is a big propaganda war going on about GM crops. As in any war, truth is the first victim."
Claire Robinson, GMWatch, England, December 2004

Greenpeace

"Mother Nature is overtaken by the inventions of modern man. But if researchers manipulate the living matter, aren't they sorcerer's apprentices then? Who is benefiting most from this alarming lottery in which the future of our agriculture, our food, our health and our environment are hazarded for millions of dollars?"

Friends of the Earth – Les Amis de la Terre, Brussels

"George Bush makes use of the WTO to oblige you to eat genetically modified food.
To introduce GM crops on the world market president Bush has lodged a complaint with the WTO against the EU, because the EU would hinder world trade by restricting GM crops. GM crops annul consumers' freedom of choice, make farmers dependent on large multinational corporations and undermine the food security of developing countries."
Bite Back campaign, January 2005

Some demands of the GMO Platform, Flanders

"Producers of non GM crops must not in any way be damaged by producers of GM crops: the polluter pays. No threshold of tolerance should be allowed for the presence of GM crops in conventional seed. It cannot be accepted that it is possible to take out patents on living matter. Developing countries are entitled to GM-free food aid."
Signed by Bond Beter Leefmilieu, Greenpeace, Natuurpunt, Oxfam Wereldwinkels, VELT, VODO, Vredeseilanden and Wervel, June 2002.

Farmers, Flanders

"Only GM crops that are safe for public health and for the environment can be considered for growing in Flanders. Rules with regard to coexistence should have the objective to allow the growing of safe GM crops. Plant breeders' rights should be maintained. Flemish farmers do not want to suffer as a result of competition with regard to other member states and regions in Europe that do allow GM crops."
(Biotechnology in agriculture, position of the Boerenbond, October 2004)

Alternative farmers, Europe

"Contamination by GM crops is irreversible. Consumers and farmers do not need GM crops and the large majority does not want GM crops. Propaganda by the industry wants us to believe that GM crops will free poor countries from hunger. Producers and traders of GM crops should be held legally responsible for the possible economic, environmental of health damage caused by GM crops. We are against GM crops on test plots." Coordination Paysanne Européenne, Brussels, April 2002

World Food and Agriculture Organization (FAO)

"Biotechnology holds a major promise for agriculture in developing countries. But until now only farmers in some developed countries have been reaping the fruits. Biotechnology is complementary to traditional plant breeding. Poor farmers can only benefit from biotechnology if they have access to it and if it is beneficial to them."
FAO, May 2004

World Health Organization

"We do not have information that it is dangerous to eat food that contains GMOs. But at the same time we do not sufficiently know the negative effects of GMOs. So we do not know the health risks of GMOs."
Kerstin Leitner, assistant general director WHO, October 2004

Ministry of Development Cooperation, Germany

"Genetic engineering is not accessible for developing countries, is does not offer any hope for fighting famine but it is neither an illusion. It is up to the farmers to choose the seed that they want to sow. If there is a technical problem, then the cheapest, the most ecological and the best socially adapted technology must be used. For the time being genetic engineering is only very seldom the most appropriate technology."
Hans-Jochen de Haas, director Department agricultural development and hunger in the world, October 2001

Ministry of Development Cooperation, United States of America

"The large majority of African heads of state, prime ministers and ministers of Agriculture whom I have met want to introduce this GM crop technology in their agricultural systems. Europeans have distributed wrong information and this has caused a lot of damage to poor people in Africa."
Andrew Natsios, director USAID, April 2003

Scientists, Belgium

"The global agricultural production must double in the 21st century. The biggest growth in food production should be the result of more intensive agriculture in the South. There is a need for a double Green Revolution: higher productivity and at the same time less pressure on the environment. Biotechnology may contribute to this, although there are also risks and dangers. Multinational corporations are not so much interested in small developing countries because they only have a small market and patents are not sufficiently protected there. Moreover these countries suffer most from food insecurity. It is a priority to train local scientists and to develop the necessary legislation with regard to biosafety and patents."
(Eric Tollens and Rony Swennen, KULeuven, 2004)

…and voices from there

Farmers from South Africa

"My experience with Bt maize is fantastic. I dare say that I believe in this technology and its impact on small farmers. The demonstration plots in our experimental farm have proven that Bt maize offers the following advantages: higher yields, better use of land, a higher income and better control of insect plagues."
Mrs. Sabina Khoza, general secretary of National African Farmers' Union (NAFU) and director of Fairdeal Training Centre, South Africa, 2004.

Farmers' organization from the Philippines

"We demand the immediate suspension of planting Bt maize in the Philippines, because there are several cases of people who have become inexplicably ill after breathing in pollen of Bt maize."
Francis Morales, Magsasaka at Siyentipiko Para sa Pag-unlad ng Agricultura (Masipag), Philippines, October 2004

Multinational Biotechnological Company

"Plant biotechnology is a continuation of traditional plant breeding allowing to transfer a bigger variety of genetic information in a more controlled way. This precise science allows plant breeders to develop plants with specific favourable properties and without the unfavourable ones.
These improvements help to create an abundant and healthy food supply and to protect the environment for the future generations."
Monsanto, Africa, 2004

NGO from Mexico (area of origin of maize)

"For 10 000 years our maize seeds have proven not to do harm to anybody. Today they tell us that genetically modified seeds are not harmful. What proof do they have for that? It is not because you have been planting these seeds for six years that they are not harmful for mankind. We have many reasons to doubt about their seeds."
Aldo Gonzales, Union de Organisaciones de la Sierra Juárez de Oaxaca (UNOSJO), Mexico

Farmers' Platform from Kenya

"Farming is our livelihood and not just a trade. Our lives are threatened by GMOs. GMOs are a danger to food security and our indigenous gene pool. Patented GM crops threaten farmers' ability to save and share their indigenous seeds which have stood the test of time. GMOs will hand control of our food systems to the multinational companies, who have created these seeds for financial gain, and not for our need. These new seeds may create conflict between farmers due to the risks of cross pollination from GM to non GM crops. GMOs will increase costs for farmers because they have to buy a package of seeds and pesticides. GMOs threaten Kenya's environment. Our government is arm-twisted to accept GMOs by multinational corporations without considering the effects on small scale farmers. Government should invest in irrigation, improvement of infrastructure, appropriate technologies, marketing, subsidies, credit and not in GMOs. We believe that God created life and that no one can own it, not even Monsanto, Syngenta or other multinational corporations. We demand a moratorium of 20 years on GMOs in Kenya."
Kenya Small Scale Farmers Forum, August 2004

Step 2. The causes of hunger and the persistency of food insecurity

Hunger and food insecurity are obstinate problems with very complex underlying causes. Agricultural and other policies affect the availability of food and therefore also food security. The impact of genetic engineering on food security as such is not clear. In theory genetic engineering may tap new reserves for food production. In practice however there are still too many barriers for developing countries and for small farmers.
(adapted from N. Koning, P. Bindraban & A. Essers, Wageningse visies op voedselzekerheid, WUR, 2001)

Hunger is obstinate

Since 1970 the percentage of undernourished people all over the world has decreased considerably. But in absolute numbers malnutrition remains a big problem: 820 million people do not have enough to eat. Even much more people do not have access to sufficient quantities of clean water.
Absolutely speaking the problems are the most serious in South and East Asia. In that region more than 520 million people are undernourished. Sub-Saharan Africa (SSA) is second with 180 million. Nutrition problems mainly occur in certain city districts and in vulnerable rural areas. The problems are also concentrated among vulnerable groups such as refugees and homeless people, ethnical minorities, young children, pregnant women and elderly people.
Hunger and malnutrition therefore have not disappeared, in spite of the Green Revolution, in spite of the sharp increase in food aid and in spite of measures to improve access to food. International political initiatives neither have succeeded to put an end to the problem. At the World Food Summit in 1996 186 countries decided that the number of undernourished people should be reduced by half by 2015. By then the overall number should have been reduced to 400 million. This is one of the so-called Millennium Development Goals. Nine years later it does not seem that this goal will be achieved. Hunger and malnutrition are more stubborn than one would think.

Causes at different levels

There are all kinds of causes why people who have to cope with hunger and malnutrition do not manage to face the problems. Causes may be: natural disasters, lack of work and hence insufficient income, health problems and discrimination. But malnutrition may partly be attributed to certain strategies of people themselves: farmers may economize on fertilizers in order to lose less if their crop fails in case of drought. But as a consequence the fertility of the soil may deteriorate. Farmers may also be obliged to eat their sowing seed to escape death by starvation in case of crop failure. But this means that the next season there will be no crop either.

Local conditions: hunger as a whirlpool

A lot of people who suffer from hunger and malnutrition are like struggling in a vortex, from which only the strong swimmers can escape. Local circumstances may make it difficult to escape or draw even more people into the vortex. Thus lack of land, water, money and education may attract more people to the whirlpool. Due to discrimination of women households spend less resources on food. Improper governance leads to discrimination and exploitation of people, so that they are drawn back into the vortex every time again instead of receiving help to escape. Misfortune like illness, decease of relatives, natural disasters and armed conflicts may push people into the vortex forever. In particular poor people, who have few properties and only little opportunities, are hit by disasters, the result being that they remain poor. Poverty may also incite people to try and improve their own situation at the expense of others instead of working together in a productive way. This may lead to vicious circles of conflicts, group selfishness and suspicion that frustrate development.

Factors at macro level

In addition to local events and local relations there are also national factors that play a part: the natural resources of a country, population growth, the social structure, economic development and national politics. Policies may make it easier or more difficult for people to escape from the vortex of hunger and malnutrition. The same is true for other international factors, like the world economy, world market prices, multinational corporations, foreign governments, international institutions like the World Bank and the IMF and agreements like those of the WTO.

Agricultural prices play their part

In developed countries food insecurity has decreased considerably nowadays. But countries that are not yet industrialized are in a more complex situation. On the one hand the low international agricultural prices provide more and cheaper food in the growing cities. But on the other hand farmers are not stimulated to invest in a sustainable agricultural production because of the low agricultural prices. Therefore it is more difficult to absorb an increasing population pressure than it was in Europe before industrialization. When the population pressure increased in Europe in those days food prices increased as well and farmers were able to invest. In developing countries that relation between population growth and agricultural prices has been disturbed. Therefore an increasing population pressure can lead more easily to vicious spirals of poverty and deterioration of the soil.

The problem of hunger is simplified

Looking at the international discussion on food security and development, we can see a continuous shift in the dominant concepts: land reform in the fifties, Green Revolution in the sixties, strengthening of rights and participation in the seventies, structural adjustment in the eighties, public investments and good governance in the nineties, poverty reduction, empowerment and institutional ownership today. Nowadays poverty reduction is playing a central role within development cooperation and there is no attention for the relation between agriculture and hunger.

The Green Revolution

In the fifties and sixties hunger and malnutrition often were considered as a consequence of a lack of food: people go hungry because there is not enough food available. The solution was sought in an increase of food production in developing countries. An important breakthrough was the Green Revolution, based upon highly productive new varieties of rice and wheat in Asia. This caused a sharp increase of the food supply. Without Green Revolution the population growth and the increase in income of the middle classes would have lead to a growing scarcity of food, higher prices and hence more hunger and malnutrition among lower income groups.

But the Green Revolution did not put an end to hunger and malnutrition. Even in many countries with enough food, like India, a lot of people are not able yet to buy food or get it in another way. We think of poor people in the cities, people in less favoured rural areas that were not included in the Green Revolution and poor farmers and landless workers in the areas of the Green Revolution. Just like a paradox, the food problem sometimes was even aggravated by the Green Revolution. To introduce the highly productive new varieties a whole package of inputs was needed – agrochemical products, artificial fertilizers, irrigation and new management skills. For small farmers this package was inaccessible. They could not cope with the competition, their income deteriorated and some even completely lost their earnings.

Access to food

The persistence of hunger and malnutrition in spite of the Green Revolution has lead to new reflections with regard to the world food problem. Hunger and malnutrition are not principally problems of availability, but problems of lacking food entitlements: people cannot attain food. And it does not matter whether they have no access to food due to lack of money, lack of relations or lack of land to grow food themselves. To put it briefly, in many cases enough food is produced, but people who are hungry cannot attain that available food. A new agricultural technology, like GMOs, will not be able to improve this situation immediately.

The future is uncertain

It is not clear how the food situation in the world will develop in the coming decades. The global demand for food will grow strongly due to the increasing world population. The increase in income in successful developing countries will strongly boost the demand for meat and the derived demand for cattle feed. At the same time the traditional resources of agricultural growth are getting depleted. Classical plant improvement can no longer produce the same increase in productivity, the quantity of fertile farmland is shrinking in many areas due to salinization, soil exhaustion and building, and more regions will probably have to cope with water shortages. In theory genetic engineering may tap new reserves for food production, but it is not certain how easy that will be. In practice there are still too many barriers for developing countries and for small farmers.
Therefore it is not correct to suppose that genetic engineering will be able to abolish hunger. Consequently, it is hardy possible to predict what the world food situation will be in 25 years.

Women play an essential role.

In many countries women produce 80 to 90 % of food in subsistence farming. In countries with a high food insecurity women also keep the seeds. They control the treasure of biodiversity. The mutual exchange, the patient selection of proper plant material, the fostering of vegetable and fruit varieties and the care for food crops are traditionally part of the women’s tasks. The more an agricultural system develops, the smaller the role of women

Step 3. Technologies that tinker at the code of life

This chapter presents an introduction to the scientific basis of those technologies. The difference is made clear between publicly accepted technologies of biotechnology in agriculture and the more controversial genetic engineering.

Cells, genes and proteins

All living organisms, plants as well as animals and human beings are composed of cells. The cell is the smallest living unit that can grow independently and that is able to multiply.
Bacteria or yeasts are composed of one cell. Many multi-cellular organisms, like humans, have originated from only one cell at fertilization. An adult person is composed of 10.000 billion cells. In nearly all multi-cellular organisms groups of cells get specific functions and they are organized in tissues and organs. Within the organs, tissues and cells proteins guarantee that the different biological processes run properly.
Every cell contains a nucleus with a number of chromosomes inside. These microscopic short sticks contain a very compactly rolled DNA. DNA (Deoxyribonucleic Acid) is the data carrier of the cell and controls which proteins are produced at what point in time.
Hence DNA determines to a large degree how a plant, animal or human being will look like and it also has an important impact on other properties such as resistance to diseases. This information is passed on from the parent generation to the next generation: DNA is the carrier of hereditable information.
This hereditable information is stored within the DNA in the form of a code. This code is composed of only four building stones or bases (A for Adenine, C for Cytosine, G for Guanine and T for Thymine). These bases follow each other in a certain order, for example '…AGTCGTAATTGGCCCCAATTGCAAAAA…'. Such an order or sequence that takes care of the production of one protein is called a gene. Thus any property of a living being is described in one or more DNA-fragments or genes.

Every form of life is like a symphony

People sometimes compare life with music. Every form of life from bacteria to gorilla is a symphony. Music disposes of seven notes and five minims. The score of life has to make it with only four notes (A, C, G and T). Every cell contains the complete score of the life form and is able to transpose that score into music. All cells of a living being together form the orchestra. Every gene within the cell produces a separate melody based upon a different combination of the four notes. The combination and order of melodies make the difference between the forms of life on earth.

Biotechnology versus genetic engineering

The word biotechnology is composed of the words biology and technology. Biology is the science of living beings. Technology refers to a human intervention. Sometimes biotechnology is defined as the use of (parts of) organisms for the production of useful (nutritious) substances.
Genetic engineering forms a part of biotechnology. Both terms are often used without any distinction. In the text below we will try to explain the difference by giving some examples.

Red …

Biotechnology is already used frequently in medical and veterinarian research, in diagnostics, the production of vaccines and medicines (antibiotics, insulin). This aspect of biotechnology, called red biotechnology, is restricted to research labs and the pharmaceutical industry and is largely accepted in society.

Grey or white…

Biotechnology applied on micro organisms is often used in fermentation industries (breweries, production of chymosine for cheese making, enzymes for detergents and in food industries like for the production of yoghurt, glucose syrup and salami), in environmental technology (waste water purification, decontamination of soils, etc.) and other industrial processes that usually take place within the walls of a plant. These aspects of white (or grey) biotechnology are often not known by the public at large and therefore the problem of social acceptance does not matter here.

… and green biotechnology

Not so much biotechnology in plant breeding but especially genetic engineering is lacking broad public support in Europe. The application in the open field and the direct link with human food foster fears and make emotions run high. Therefore the public debate is very polarized.

Green biotechnology is specific plant breeding

Since the origin of agriculture 10.000 years ago during the Neolithic, people have grown plants and have started to select crops, at first unintentional and later more and more on purpose.
Classical plant selection becomes part of biotechnology as soon as the knowledge of the inheritance of certain properties is pursued on purpose. In the case of plant selection more and more sophisticated technologies of biotechnology are used for this, but in general this does not provoke a public debate. (see box)

Green biotechnology technologies

Cloning of vegetal material by use of in vitro cultures is used for example to achieve plant material that is free of diseases, to multiply plants in large quantities and to store them in gene banks. In vitro means literally “ in glass” and refers to growing organisms or cells in test tubes and other glassware in a sterile way.
Very low temperatures are used to store plant material: this is called cryopreservation.
Immunological tests are used among other things for detecting plant diseases (viruses, bacteria, fungi and nematodes).
DNA sequencing is the determination of the order of bases within a DNA strand. Such a determination for all DNA strands of a living organism is called a genome project. For plants the genome of wall cress or Arabidopsis thaliana (116 million base pairs) and rice are already completely known. Plants like wheat (16 billion base pairs) often have much more pairs of bases than human beings (6 billion base pairs).
In case of the genetic fingerprint the DNA is searched for variable DNA-pieces that are different for every person just like real fingerprints and that occur in every cell. This can be done by using the PCR technology (Polymerase Chain Reaction), allowing to multiply DNA fragments so that they can be studied more easily.
Molecular markers make it possible to trace the presence of certain DNA sequences more quickly. This may amongst other things save time in plant breeding, especially for slow growing plants, but also in typification of plant diseases and pests.
A mutation or change in DNA, which happens spontaneously in nature, may be brought about by irrad irradiation or by chemical substances.

Genetic engineering is at the heart of the controversy

Genetic engineering or recombinant DNA technology, also called transgenesis, implies technologies to isolate, to identify, to characterize, to clone and to use genes for genetic modification. Genetically modified organisms (GMOs) are the products of genetic engineering. This technology does not only break through the borders between plant varieties, but also between bacterium, virus, plant and animal.
In the seventies the Belgian researchers Schell and Van Montagu, working at the State University of Ghent, discovered that nature itself is applying this technology. They found out that the soil bacterium Agrobacterium tumefaciens penetrated through a little wound in a tomato plant and introduced a small piece of its own DNA into a tomato cell. As a consequence of this inserted hereditary material these tomato cells received a new assignment, in particular to produce a tumour in which the intruder could lodge. This technology is still used today to insert foreign DNA into a plant cell.
A more radical method is to use a gene gun in which microscopic balls of gold or tungsten clad with DNA are shot under a high pressure into a cell.

A fast method?

Genetic engineering may be a faster method than patiently crossing in new properties or traits by way of classical breeding of improved varieties. Above all it is a technology in which properties are exchanged across varieties, which offers unknown possibilities. The insect resistance of Bt maize is achieved by inserting a gene of the bacterium Bacillus thuringensis (hence the abbreviation Bt) into an existing variety of maize. The much talked-of golden rice is able to produce provitamin A thanks to the insertion of two genes of an Erwinia bacterium and of a gene from a daffodil. That is more easily said than done. After firing with a gene gun only 1 cell out of 10.000 has 'taken in' the intended property. You never know in advance where the new property will be located in the cell. You always have to wait and see whether it will work and how it will work. Afterwards research will have to show what has happened exactly, whether the property is actually useful and whether that property can be inherited in a stable way. Before the developed combination of property-in-the-plant is planted into the open field for trials it has already gone through a long way in the laboratory. The way to commercial introduction often is even much longer. In the end the whole procedure does not go any faster because of the stern demands that are imposed for GMOs. In many cases traditional improvement is preferable. Moreover genetic engineering is always an expensive technology.

Classical plant breeding is increasingly using biotechnology

Not all traits of plants can be changed, modified or added just like that. Traits that are bound to only one gene, such as resistance to diseases, are sometimes easier to insert by means of genetic engineering than traits that are bound to several genes, like yield or resistance to drought.
Classical plant breeding therefore still plays an important role. But classical breeding is increasingly using biotechnological techniques that do not belong to genetic engineering in the narrow sense. An important technology is the use of molecular markers for improvement by cross-fertilization. By means of marker technology genes that are involved in the desired traits receive a molecular label. These "labelled" genes then are molecular technologically followed to monitor their presence in descendants. When breeders are thus able to find out at an early stage of development which of the descendants has the desired genes, they can save a lot of time. For further crossing they do not have to wait until the fully-grown plants display the property in the field or not. In combination with information technologies the marker technology may considerably reduce the average duration of improvement – taking 10 to 15 years. By means of calculating models (genomics) it is possible to calculate in advance what is the chance to obtain descendants with the desired properties, starting from certain parents.

Step 4. The importance of plant improvement and biodiversity for agriculture

Plant breeding is a central topic in this brochure, since selective breeding of plants constitutes the foundation of any agricultural system. The development of an agricultural system leads on the one hand to an increased distance between plant breeders and farmers and on the other hand to a decrease of biodiversity. Still biodiversity is the source as well as the cornerstone of plant improvement.
Western, sophisticated agricultural systems increasingly appeal to the genetic diversity of more primitive agricultural systems in order to find solutions for plant diseases and pests. The concentration and privatisation of breeding stations reduce the agricultural biodiversity and hence affect the foundations of various agricultural systems.
(Adapted from D.Reheul, in A. De Walsche, Noord-Zuid Cahier, 2000)

Age-old plant breeding

Breeding improved plant varieties is an age-old craft. At the same time it is also very modern with regard to safeguarding sufficient safe food. Plant improvement originated in the Neolithic, 10.000 years before Christ, when nomads founded the first villages at places where nutritious plant varieties, like for instance predecessors of wheat and maize, were abundantly available. These areas are the centres of origin of the agricultural crops that we know today. The inhabitants of those settlements collected seeds, bulbs and tubers, and they used them as food. After some time they discovered that it was useful to store part of the collected harvest, and to sow or plant it again in the following year. During this annually recurring process of collecting, storing and sowing, they always chose the plants with the most, largest and strongest seeds, tubers or bulbs that were growing best under the local circumstances.

Variation and selection

The inhabitants of those early villages unwittingly used the fact that for every plant variety there is natural variation or diversity for all kinds of different properties or traits, such as the yield per plant, the size of seeds or fruits, the taste, the presence or absence of thorns or prickles and the susceptibility for diseases and pests. Within varieties of wild plants there is a big diversity for a whole range of properties. These plants are called very heterogeneous (as opposed to homogeneous). Such a population is resistant, also called “buffered”, against all kinds of bad conditions: due to the variability there will always be some specimen that survive and keep up the species. By choosing the most attractive plants the villagers selected those plants they thought most appropriate at that moment. Moreover nature itself also implements a selection. Plants that for example are very sensitive to diseases or pests, or that are eaten easily by insects or other animals, do not get the opportunity to grow into strong plants with a lot of fruits or tubers. Also climatologic conditions and the quantity of water and nutrients have an impact on the growth rate and the yield of every plant variety.

Crossbreeding

The variation that plants possess for all these properties came into being at a certain point in time because plants of the same species pollinate each other and also plants of closely related varieties. During these crossings the hereditary properties of plants are mixed and stored in new combinations into the seed. If the seed then is sown again in the next year, the germinating plants that are best adapted to the growing conditions (such as temperature, availability of water and nutrients) and that are least sensitive to diseases and pests will grow best. These will also certainly be the plants with the highest yield, of which the most seed will be stored for the coming year. For centuries this has been the way in which people, usually unintentionally, have selected plants with the most favourable combination of properties to grow well in the local environment.

Local breeds

Strong variations in soil fertility and weather conditions resulted in countless variants of crops, the so-called landraces. Landraces typically are well adapted to the environment for which they have been selected. Moreover these varieties are and remain genetically heterogeneous, so that they are considerably buffered against bad conditions. Landraces therefore guarantee a fairly stable yield so that a kind of crop security is safeguarded. But this stability also has its price: the level of production often is not very high.
As long as the crops were grown in the neighbourhood of their wild ancestors, spontaneous crossing was possible between the cultivated variant and the wild ancestors. In this way there still was an exchange of genes and genetic diversity remained high.

Seed is made for travelling

With the wandering of nations plants travelled along. These plants then arrived in a different environment and natural selection “obliged” such populations to adapt themselves to the new environment. Our wheat for bread originates from the Middle East, but now it grows all over the world. In Siberia you may find very cold tolerant selections of bread wheat, in India very drought tolerant selections. The schedule below provides a survey of the location and the starting date of the centres of origin of some agricultural and horticultural crops. It is striking that these areas are nowadays often situated in developing countries. These countries therefore have an important potential of agricultural biodiversity.

Centres of origin of agricultural and horticultural crops.

Area of origin	chronology (BC)	agricultural and horticultural crops
Middle East	10.000	wheat, barley, peas, flax, lentils
New Guinea	10.000	taro
Central America	9.000	maize, cotton, paprika, pumpkin, avocado, peas,
China	8.500	rice, millet, cabbage,
South America	6.000	potato, quinoa, lupine
North America	4.000	pumpkin, elder, sunflower,
Secondary areas		
South East Asia		broad beans, taro, yam, kohlrabi, litchi, banana, sugar cane
Africa		sorghum, millet, African rice, African peanut, yam
South America		long-staple cotton, paprika, sweet potato, pineapple, papaya

Plant breeding

By sowing, selecting and sowing again, people are dealing with selective breeding or plant breeding. It costs a lot of time and efforts to change a wild plant into a good agricultural crop, because wild plants often possess unfavourable properties. Sometimes they contain poisonous substances as a protection against insects, or their seed has an inedible husk. Other wild plants are difficult to harvest. Grains of corn for example sometimes may fall very easily off the spike. This is favourable for the distribution of seed of the plant in nature, but very inconvenient for harvesting and collecting.
The selection that the farmers applied themselves, the so-called mass selection, is a traditional form of selection. Today we know that this method is not very efficient and that improvement through mass

selection is very slow. In Flanders mass selection is still practised in farms and market gardens, though it is rather exceptional. Particularly for a number of vegetables such as leek, celery and chicory you still find "grower selections". These are selections that are made and maintained by the growers.

Gregor Mendel

In developed countries plant improvement mainly consisted of mass selection until the beginning of the 20th century. In many developing countries this is still the case today. The application of specific crossbreeding between plants to create new variations and hence to be able to select even better plants, only became popular after the rediscovery of the work of Gregor Mendel, the German monk who grew and crossed peas in the garden of his monastery. His laws of heredity laid the scientific foundations for modern plant improvement. Thus it became possible to combine favourable properties of different parent plants in their ascendants in a faster and more direct way than before. Qualitative properties (such as resistance to diseases, or colour) in general only involve not more than 1 to 2 genes, and the inheritance clearly follows Mendel's laws. Quantitative properties (yield or size) often involve much more genes, which makes improvement much more difficult and especially time-consuming.

Biodiversity

Crossbreeding is always followed by a selection: only the desired specimen are kept. They form the basic material with which the following generation will be made. Plant improvement works like an accordion: a variation is extracted (crossbreeding takes place) and immediately compressed again (a selection is made) into a useful and usable variation. What is not usable, is thrown away. Such a process has to be repeated cyclically, if only because the contents of the notions 'what is usable', 'what is best', evolves together with the needs of societies and agricultural systems. To combine properties these properties of course must be available. Genetic variation is the cornerstone of plant improvement. If there is no genetic variation, there is nothing to combine and no 'improved' plants can be produced. This is the origin of the care for genetic diversity and for the access to that diversity.

Retain the right combination

An equally important stage in plant improvement is the preservation of a good combination of properties. And that is not obvious at all.

For plants that reproduce asexually or vegetatively this is no problem. Through vegetative reproduction it is possible to make clones. A number of crops do this spontaneously, like potatoes, bananas and bulbous plants (daffodils, tulips, etc.). For a number of other crops man has found a solution, like grafting for fruit trees.

But plants that cross-pollinate undergo a rearrangement of their genetic material after every sexual reproduction, because every plant needs another plant to be able to reproduce. It is not possible to keep the genetic combination of the keenly sought-after specimen and the wanted gene combination unrelentingly is lost again. Of course the genes themselves do not disappear, they are hidden in all kinds of combinations within the population. Grasses like wheat, barley and maize are examples of cross-pollinators that are also wind pollinators. Canola is a cross-pollinator and an insect pollinator. The following horticultural crops are cross-pollinators: leek, parsley, courgette, pumpkin, gherkin, cucumber, chicory, onion, asparagus.

Self-pollinating plants do not need congeners to reproduce and evolve towards a situation of genetic stability: after some generations of self-pollination their hereditary material is fixed and is also transmitted unchanged to the following generations through sexual reproduction: the seed of self-pollinating plants remains stable. Soy, lettuce, endive, tomato, paprika, pea, bean and salsify are self-pollinating crops.

Vilmorin and genealogical selection

At the beginning of the 19th century Vilmorin, a French plant breeder, discovered a method to get more grip on the desired genetic combinations for cross-pollinating plants: he invented genealogical selection. This is a more laborious method than mass selection: you have to register, note and measure a lot of things. Everything has to be well organized, you must permanently follow up things and you have to be very alert. Since this work is beyond the capacities of many farms and market gardens, in the second half of the 19th century breeding stations were established in many European countries: France, Denmark, Sweden, Germany and the Netherlands. In Belgium there have never been many private initiatives in the field of plant improvement, except for sugar beets (SES in Tirlemont, today a subsidiary company of Vanderhave).

Breeding industry and state interest

In Europe plant improvement drifted further apart from productive farming. Originally there still were some clear links. In France, Denmark and Germany cooperative societies of farmers established breeding stations, companies that operated for their farmers, and in which the farmers were shareholders. This was the origin of Limagrain in France, DLF in Denmark and IG Pflanzenzucht in Germany.
During the first decades of the twentieth century governments became active in plant breeding too. They considered plant breeding to be an important instrument to improve and safeguard food production. It was thought then that such a strategically important activity was of state interest. Moreover it happened that through the seed trade seeds came to farms that were not always of the best quality. Therefore the government established inspection services to control that only good seeds came onto the market. Meanwhile a number of farmers and market gardeners continued to select on their own account: they maintained good populations, produced sowing seed for private use or sold some of it in the neighbourhood. But as more good varieties became available, more and more farms in our regions gave up selection. In developing countries this dynamics is now taking place or has not yet even started. An important element in this evolution is the protection of plant breeders' rights. We will come back to this topic on page 22.

Governments in Belgium and Germany regulate seed market

In Belgium the government established two important breeding stations, one in every part of the country. The station in Gembloux specialized in grain crops and achieved great success. In Flanders the 'Rijksstation voor Plantenveredeling' (RvP – State Station for Plant Improvement) was created in 1932. This station focused on feed crops. It became world-famous for the improvement of grasses and clovers. Until today the DVP – Department for Plant Genetics and Plant Improvement) in Merelbeke, a subdivision of CLO – Centres for Agricultural Research, is still very active.
In Germany the government has never been active in the field of plant improvement. In both countries the government is active in comparative variety testing and the composition of a catalogue of varieties in accordance with the European regulation. At the beginning of 2005 the German Parliament discussed about the simplification of procedures for the German legislation on seed.

The wonder of hybrids

In the interbellum period hybrids of maize created a furore in the US. At that time maize as an agricultural crop had not yet reached Northern Europe. People discovered that maize, which is a cross-

pollinating crop, can also self-pollinate and that this creates inbreeding lines that lose a lot of vitality. Crossing these strongly weakened inbreeding lines in a number of cases created descendants or hybrids with exceptional performances: this was the so-called heterosis effect. Hybrids have a number of additional properties. They are uniform and in our specialized agriculture (and society) uniformity offers large advantages: mechanization is easier too because the plants all have the same size and shape; ripening takes places in a short period of time. Packaging and trading are easier because the product is uniform. But that uniformity is only present in the first generation (F1 generation). One generation later (F2) the gene combination is split up again and that generation will again be as variable as the original population: gone is the uniformity, gone the heterosis effect. This is a “built-in protection system”, which safeguards the interests of breeders, for it is not longer obvious to use farm saved seed. People who want to fully enjoy the advantages of hybrids must buy seed every year.
By no means every combination of inbreeding lines does provide a good hybrid, only exceptions score well. It is a tough job to find the right combinations. It requires a lot of time, money, land and human organization and is no longer suitable for an average farm.
Meanwhile breeding companies have produced hybrid varieties of many cross-pollinating plants because of the intrinsic agricultural advantages and the built-in protection system. For many crops this has meant the end of mass selection and genealogical selection by farmers.
Hybrids are important for maize, wheat, canola and cotton and in vegetable growing (carrots, leek, onion, radish, asparagus, paprika, tomato, cucumber, gherkin, courgette, sprouts, pumpkin, etc.).

Green Revolution and biodiversity

In a number of cereal crops like wheat and rice people discovered a dwarf gene that makes plants stay short and thus provide less straw. Short plants remain standing more easily in every kind of weather and can cope with more nitrogenous manure. This means higher yields. For tall plants fall down in case of too large doses of nitrogen and this is at the expense of yield.
Researchers at the International Rice Research Institute (IRRI) in the Philippines and at the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) in Mexico built in this dwarf gene in rice and wheat. This entailed large increases in produce in combination with an increased use of fertilizers and agrochemical products or pesticides. Short crops appear to be more sensitive to mycoses in the spikes, so that more fungicides are needed. In a number of developing countries, in particular in Asia – where rice and wheat are important crops in subsistence farming – these varieties were very successful and in many cases they displaced the less productive landraces. Part of these landraces disappeared forever, causing a loss in biodiversity. Another part was saved and stored in gene banks.

Increasing yield

Different studies show that about half of the increase in produce in our crops is caused by plant improvement. The other half is due to better growing methods. It is supposed that crop produce has increased during the last decades by about one percent per year thanks to plant improvement.
This process has drawbacks too, though: choosing always means losing. Modern varieties often have a very uniform genetic structure. Plant improvement companies like varieties with a large area of distribution: it costs too much money to develop and maintain each time a separate variety for a large number of areas. So genetic diversity is shrinking also among varieties provided on the market. Genetic uniformity is increasing.

Genetic uniformity involves risks

If a disease occurs it often strikes a whole area. If a pest becomes resistant to a pesticide, this remedy will soon work no more anywhere. Therefore resistance improvement has become so important. Plant improvement is continuously looking for new genes to make crops resistant to diseases and pests. But diseases and pests also get quickly resistant because the resistance pressure in case of genetic uniformity is so high. As long as we do not give up genetic uniformity in our crops, a lot of efforts of plant improvement will only be challenges addressed to diseases and pests: we are lucky if we can stay one step ahead of them, but our lead is never large and not lasting.

The decreasing role of government …

After 1980 there have been two evolutions in plant breeding worldwide. In a lot of countries government withdrew from plant breeding. Research stations disappeared or became satellites of private companies. Because their continued existence did not necessarily depend on the largest commercial profit, state companies were still dealing with locally important crops that have no commercial interest for private seed companies. The disappearance of breeding activities in charge of governments constitutes a setback for diversity.

… and the arrival of biotechnology and genetic engineering

Straight away expectations ran high. Soon everybody talked about the old, classical or conventional breeding versus biotechnology and genetic engineering. Meanwhile expectations have been tempered. Biotechnology and genetic engineering have become tools in plant breeding: just a tool in a tool-kit. But there is more. Genetic engineering is an expensive technology that requires a high level of knowledge. Small breeders cannot afford it. Therefore there has been a whole wave of take-overs. Companies are getting bigger all the time. They buy a competing company including the corresponding gene bank and the methods to use it in a specific way. Property rights have become very important nowadays. A merger often means that improvement programmes are joined together or cancelled completely. The diversity between and within crops had already shrunk considerably, and now the diversity between plant improvers is shrinking too, which is most regrettable. In the past divergent opinions of different improvers have lead to surprising developments. Now improvers are shrinking in numbers as well, which means that their own diversity is under pressure.

Organic farming

Moreover there are some new developments. Organic farming goes one step further and wants a completely new operational framework. These developments have an impact on plant breeding because breeding of improved plant varieties always happens for the purpose of agricultural and horticultural practices. Changes in those practices create the need for 'other' crops. In organic farming there is a large demand for adapted varieties. There is nearly no supply. Therefore a movement is growing that pays a lot of attention to (partial) decentralization of breeding activities. Organic farms are much more diversified and due to this farmers become more prominent again.
The questions that are asked in organic seed production are often the same questions as for seed production in developing countries: how to coordinate and control a process of decentralization, in combination with participation of farmers? Who should do this? Will this be viable from a commercial point of view? What will happen with property rights? Will non-uniform varieties get a better chance? Will biodiversity really increase?

Step 5. Farmers and intellectual property rights on plant varieties

Patents on plant varieties are very important for companies that practice genetic engineering. Patenting is supported by the WTO. But patents on agricultural crops are at odds with the interest of farmers who use farm saved seeds, of independent breeders of improved varieties, of developing countries and of biodiversity and hence also of food security.
At international level the introduction of genetic engineering has lead to agreements that are based upon the precautionary principle, which is also endorsed in Europe.
(according to M. Blakeney, University of London, from Seminar on intellectual property for Ajman University, May 2004)

The legal framework is very important

In agricultural systems where there is little trade in seeds, because most farmers use farm saved seeds, there is no problem of property rights. But as breeding stations develop and as more specialized and hence more expensive technologies find acceptance, the problem of property rights does arise. Legislation with regard to intellectual property is essential for the development of breeding stations that want to conquer a share of the market to the detriment of farmers using farm saved seeds. Once there is such a legislation, the activity of private breeding stations expands considerably: it is indeed difficult to legally protect the landraces that farmers traditionally use, because they are not specific enough and they belong to the public domain. These native varieties belong to everybody and therefore to nobody. Still it is important that farmers, and particularly farmers in developing countries with a large share of subsistence farming, keep the right to continue to use farm saved seeds also for specific varieties for private use and for exchange with neighbours. This is the so-called “farmers’ privilege”. This privilege is a stabilizing factor for food security. Big seed companies look upon this right with envy because it reduces their sales. They sometimes work hard to cancel or strongly reduce this “right” in national legislation because it is at odds with patent right. A patent protects the inventor with the exclusive right to produce and/or sell a certain product, limited to a period of twenty years and to countries where the patent has been recognized. This protection only allows exceptions for non-commercial research and does not concede the farmers’ privilege or exceptions for breeders.
It is also important that the rights of breeders are safeguarded. This is the “breeders’ right”. It takes at least ten years to develop a new variety and it is also risky because the outcome of all that work cannot be predicted. Breeders want to protect themselves against imitation, against the risk that others will just copy and commercialize the new invention. But breeders also try to find free access to the existing genetic diversity. Patents however hamper that access.

Intellectual property rights or IPRs

In the development of regulations on Intellectual Property Rights (or IPRs) in agriculture industrial associations and breeders’ associations played a major part: the breeders of fruit trees, of vegetable and agricultural seeds wanted to have more protection for their products. The instable character of cross-pollinating seed, the fear for monopolization and the fact that farmers use farm saved seed, do not make it easy to achieve a well-balanced regulation.

Protection of breeders' rights through UPOV

A breeder is a person who has gained or found a new variety, a breeding product. Only in 1961 the UPOV Convention established an international legal form of protection for breeding products. UPOV stands for ‘Union pour la Protection des Obtentions Végétales’ (Union for the Protection of New

Varieties of Plants). UPOV is an intergovernmental organization with headquarters in Geneva. It counts 58 members, amongst which the European countries, the US and Russia.
To protect a variety it must be new, stable and homogeneous and it must have an identity. Without a minimum of uniformity you cannot identify anything. For self-pollinators this is no problem. For cross-pollinators this means that the internal variety must be narrowed, for the purpose of protection. As a consequence of that legal protection private breeding stations developed more activities than before and at a high tempo a lot of new varieties were created with a narrower genetic basis. People who want to sell seed, cuttings or seedlings of a protected variety, should ask the permission of the breeder in advance and must comply with his (commercial and other) conditions. It is allowed to use the breeding material freely (i.e. without paying any licences) as a source of variation (starting base) for creating other varieties (this is the so-called breeders' exemption), for scientific research (the research exemption) or for private and non-commercial use (this is the farmers' privilege). The UPOV Convention was changed in 1972, 1978 and 1991.
The modification of 1991 was fundamental: it was decided that it is possible that one and the same variety falls under UPOV protection of the breeders' right and under a patent. Moreover the farmers' privilege for protected varieties was limited to "the product of one's own harvest for use on their own holdings within reasonable limits and with subject to the safeguarding of the legitimate interests of the breeder". Unlike the Convention of 1978 this does not allow farmers to exchange seeds with other farmers for the purpose of reproduction. Therefore it is not sure whether the informal traditional exchange of seeds between farmers in developing countries falls under the free use. In spite of opposition from developing countries the modified convention was adopted in 1991. Landraces never fall under UPOV, because their variation is too large to describe their identity.

Genetic engineering companies want free trade

In 1994 the agreement on Trade Related Intellectual Property Rights (TRIPS) was adopted by the 148 members within the Uruguay Round of the World Trade Organization (WTO). This agreement obliged all members to develop national legislation to protect plant varieties by means of patent rights and/or another "effective" system. This obligation is criticized for several reasons. First and foremost there is no relation with the topic of development; moreover there are technical discussions with regard to patents on plants and on other "effective" legal systems; there are ethical objections to patents on life forms; there is a problem with the conservation and sustainable use of genetic resources and finally there is a problem concerning the concepts of traditional knowledge and the rights of farmers.

The African countries (and other developing countries) have clear wishes concerning TRIPS:

"The protection of genetic resources and traditional knowledge is an important tool to fight poverty and is a matter of justice and recognition of the keepers of genetic resources and traditional knowledge. Protecting genetic resources and traditional knowledge will only be effective if international mechanisms are fixed within the TRIPS agreement." In general WTO arrangements are considered to be better enforceable through the system of WTO panels.

Free access to genetic resources for breeders at risk

Breeders attach much importance to free access to genetic resources, including material that is protected by IPRs. Therefore UPOV provides for an important "breeders' exemption", including a "research exemption" and a "farmers' privilege". Patent legislation has a much more restricted "research exemption", often limited to non-commercial scientific or experimental research.
Patents are meant to protect "inventions". In general plant improvement is not considered as an invention, but as a unique combination of existing material. What counts in plant improvement is "cumulative" innovation and this highly depends on the availability of genetic resources with the highest possible diversity. Genetically modified plants are often protected by UPOV as well as by patent right.

Patents highly limit free access to those genetic resources. The FAO International Treaty provides an answer for this (see p. 26). Access to the non-commercial genetic resources in developing countries is restricted by the Convention on Biological Diversity (see also p. 25).
The combination of IPRs and the privatization of agricultural research, the shrinking of independent research by governments and the growing concentration of breeders' material, research instruments and technologies within the hands of a small number of multinational companies are increasingly threatening breeders' free access to genetic resources.

Patenting of plants, plant varieties and seeds.

Legal protection of plant varieties by patents was developed together with the advance of genetic engineering companies with the main purpose to protect the expensive genetically engineered innovations. But patent legislation does not recognize the farmers' privilege. Formal consideration of the farmers' privilege is indeed a protective measure on behalf of the government to protect food security and at the same time it is an effective form of monopoly restriction.
The European Patent Convention (EPC) excludes plant varieties and "other essential biological processes" from patenting. The European Guideline on legal protection of biotechnological inventions leaves an opportunity for "biological material that is isolated from its natural environment or is produced by a technical process even if it never did occur in nature before".
Outside Europe, Canada, India and a limited number of other countries there is no prohibition on patents for plant varieties.

Argentina vs. Monsanto

In 2004 Argentina had more than 14 million ha of soybeans. In a short time soy has conquered 44% of the Argentine farmland. The large majority (98%) is genetic engineered RR soy, 95% of which is exported in an effort to pay off the crushing debt burden. Only a small share of the seed trade however produces patent rights because farm saved seed is legal and still important in Argentina (and is for soy also easy). Moreover there is also a flourishing illegal trade in genetically modified agricultural seeds within the country as well as to the neighbouring countries Brazil, Paraguay, Uruguay and Bolivia.
Forced by American soy farmers, who complain about unfair competition, Monsanto, worldwide the largest owner of commercial GMO patents, tries to introduce special contracts in Argentina that prohibit farmers to save seed on their farms, although this is conflicting with the current Argentine seed law.
In January 2004 Monsanto increased the pressure on the Argentine government by declaring that it would close down all its activities in Argentina. Since the government did not react in an adequate way, Monsanto in August threatened to levy a tax of 3% on the value of the transaction in the ports of destination in countries that recognize Monsanto's patents. Argentina reacted by creating an emergency act.
In January 2005 the most important Argentine farmers' union, Federacion Agraria Argentina (FAA), demanded that the emergency act would be withdrawn, it rejected restrictions on farm saved seed for a sown surface of up to 65 ha and required measures to fight the illegal seed trade in certain provinces.
The FAA told the seed companies, multinational corporations and the government: Keep your hands off the farmers' privilege, "one of the last of grandmother's jewels".

Convention on Biological Diversity (CBD)

The Convention on Biological Diversity was proclaimed during the Earth Summit in Rio de Janeiro (1992). The CBD is an effort to launch an international programme for the conservation and use of biological resources in the world, and for the fair distribution of the proceeds of the use of other people's genetic resources. The most difficult issue was the relation between IPRs and the access to genetic resources. The developing countries – which in general are the most important source of genetic diversity and also hold the centres of origin of agricultural crops within their borders – want to “use” the CBD to receive money, technological cooperation and research results. The developed countries, the source of biologically engineered innovation, stressed an IPR approach. The CBD stipulates that states have sovereign rights on their natural resources and that legislation on genetic resources should be the subject of national regulations. If a transfer takes place, this often is done as a “Material Transfer Agreement” on the basis of a mutual agreement, prior informed consent and a distribution of (possible and future) profits. The CBD entered into force at the end of the year 1993 and includes 188 member states.

Biosafety and the precautionary principle regulate the trade in GMO seeds

Within the CBD the Cartagena Protocol for Biosafety was negotiated. This protocol entered into force in September 2003. 111 member states of the 130 that signed the protocol have already actually ratified it. Notorious exceptions are the countries of the so-called Miami group, consisting of the United States, Argentina, Canada, Australia, Uruguay and Mexico.

The Cartagena Protocol is based upon the precautionary principle, which says that the possible risk concerning genetically modified agricultural corps has not yet been studied sufficiently and that caution is required. The Cartagena Protocol is meant to use the benefits of genetic engineering while protecting at the same time biodiversity and human health against risks. The protocol is based upon the prior thorough information of the destination country about the genetically modified agricultural crops intended to be imported into the country for the first time and to be introduced into the open field (Advanced Informed Agreement). Thus the country gets the opportunity to refuse the GM seed. The Cartagena Protocol does exclude the trade in GM food, cattle feed or commodities for further processing. The Cartagena Protocol is supervised by the Bio Safety Clearinghouse in Montreal under the United Nations Environment Program (UNEP).

The members of the Miami group – not by coincidence the countries that have massively adopted GM crops and in which GMO research is concentrated – do not endorse the precautionary principle. They prefer the principle of substantial equivalence. According to this principle GM crops are to a large degree normal plants. In fact they consider the many precautions imposed by the Cartagena Protocol only as obstacles for free trade.

GMOs and food aid.

In 2002 Zambia was hit by a serious drought and famine. The US offered 27.000 ton food aid, consisting of genetically modified maize. The Zambian government refused this aid because of the risk to lose European export markets, because it wanted to protect local maize varieties and because of possible health risks if weakened people owing to circumstances would be obliged to a diet of mainly genetically modified maize. Neighbouring country Zimbabwe got round the first two objections by only admitting ground genetically modified maize.

Free movement of genetic resources for selection of agricultural crops

In 1994 the International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA) was concluded under the umbrella of the Food and Agriculture Organization of the United Nations (FAO). It was concluded with the purpose to harmonize the CBD with the non-binding "International Undertaking" of 1983, that regulated the free movement of genetic resources for plant selection but that had been eroded by the evolution of UPOV and patent legislation. The CBD refers indeed to the "International Undertaking" for traffic regulations on gene banks and safeguarding the "farmers' privilege".
The objective of the treaty is the conservation and sustainable use of plant genetic resources for food and agriculture and the fair distribution of the proceeds from their use for the purpose of food and agriculture, and this in harmony with the CBD.
The parties endorsing this treaty "recognize the important contribution of local and indigenous communities and farmers from all quarters of the world, in particular of those who live in the centres of origin of agricultural crops. Their work consists in conserving and developing plant genetic resources as the basis of food and agricultural production all over the world". Local breeds are a source of agricultural biodiversity with a growing economic importance and a source for improving existing varieties. This international treaty entered into force in June 2004 when 55 countries had ratified it.

Africa reacts to TRIPS

The "African Model Legislation for the Protection of the Rights of Local communities, Farmers and Breeders, and for the Regulation of Access to Biological Resources" is a proposal for an appropriate legal protection system based upon UPOV 1991 and CBD, complying with the WTO requirements (TRIPS). It was adopted by the African heads of state in 1998 and is supported by the development cooperation of the EU and particularly of Germany. During the current ratification period the United States however try to withhold the African countries of endorsing this African Model.

Ugandan farmer's point of view

The Ugandan National Farmers' Federation (UNFFE) urges its government to be careful in dealing with topics concerning genetically modified food and seeds in Uganda. Farmers are worried that there might be a hidden agenda to destroy their traditional native breeds. Before GMOs are introduced into the country, the country should have a legislative framework and there should be a sophisticated local laboratory to monitor the side-effects of GMOs. (December 2003)

WIPO (World Intellectual Property Organization)

The World Intellectual Property Organization is one of the sixteen specialized UN agencies. It controls 23 international treaties with 181 member states on intellectual rights (including royalties). The WIPO has its headquarters in Geneva and the general director of the WIPO is at the same time secretary general of UPOV.
At the end of 1999 the discussion on the adaptation of TRIPS was passed on to the WIPO and its Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore.

Catalogues of varieties

Countries with a well-developed seed trade often regulate the sale of newly provided varieties of agricultural crops. In implementation of UPOV it first has to be studied whether the variety is distinguishable (D), homogeneous (H) and stable (S). This is the so-called DHS research.

Moreover during three years (sometimes two or four years) research is carried out about the agricultural and practical value in different agricultural areas and in locally relevant agricultural circumstances. Only varieties that after this research appear to be favourable in comparison with some existing witness varieties are allowed to be put on the market. The research on the agricultural and practical value provides farmers with an additional guarantee that the promised properties of the seeds are also adapted to their region and operational management. After admission to the catalogue of varieties a quality control takes place as well to check whether the seeds correspond with the labelling.

Coexistence

Sometimes countries regulate the coexistence of GM agriculture, conventional farming and organic farming. In order to avoid hybridization of agricultural products from the different systems, there has to be a certain distance between plots with GM crops and plots with the same non-GM crops. There are also regulations for harvesting and storing and there is an arrangement of liability for compensating any economic damages. The kind of this regulation of coexistence determines to a large degree whether GM farming is economically viable in a country or not.

Private contracts

Specific for GM seeds there are contracts between seed companies and the private customer for the purchase of GM seeds. These are the so-called “Technology Use Agreements” or TUA. With this agreement the user of the seeds agrees to strictly follow previously determined agricultural practices. Moreover a TUA always contains a rejection of liability for claims and the elimination of the farmers’ privilege, which means that the farmer never is allowed to reproduce his own GM seeds. Because of this last stipulation TUAs are often in contradiction to national legislation.

Step 6. Government funding for research remains more than necessary

The international community has consigned the care for the gene banks of agricultural crops to the CGIAR. This institution will keep playing an important role for agricultural crops in developing countries and for crops that do not have a commercial interest. The decreasing role of governments, the growing importance of multinational corporations in 'life sciences' and the urge to patent require special attention of the CGIAR centres.

The Consultative Group on International Agricultural Research (CGIAR) was established in 1971 by the World Bank in collaboration with the FAO (UN Food and Agriculture Organization) and the UNDP (United Nations Development Program). President of the CGIAR is the vice-president of the World Bank. The purpose of the CGIAR is "to contribute to achieving sustainable food security and poverty reduction in developing countries by means of scientific research and research related activities in the field of agriculture, forestry, fishery, policy and environment."

The CGIAR network

The CGIAR consists of a network of sixteen agricultural research institutions spread all over the world that manage the largest gene banks of plants that are important for developing countries.
De most important centres for tropical agricultural crops:
CIAT Centro Internacional de Agricultura Tropical, Cali, Colombia (beans, cassava, rice)
CIMMYT Centro Internacional de Mejoramiente de Maiz y Trigo, Mexico (maize and wheat)
CIP Centro Internacional de la Papa, Lima, Peru (potato, sweet potato and tuberous plants)
ICARDA International Centre for Agricultural Research in Dry Areas, Aleppo, Syria (barley, lentils, fava beans)
ICRISAT International Crop Research Institute for the Semi-Arid Tropics, Hyderabad, India (peanut, pearl millet, sorghum, peas and beans)
IITA International Institute of Tropical Agriculture, Ibadan, Nigeria (banana, soy, maize, cassava, yam)
IPGRI International Plant Genetic Resources Institute, Rome, Italy
IRRI International Rice Research Institute, Manila, Philippines (rice)
WARDA West Africa Rice Development Association, Boualé, Ivory Coast (rice)

Genetic diversity

The FAO commissioned the CGIAR by contract to supervise the genetic diversity of 22 authorized crops, with the explicit purpose that the material from these gene banks would belong to the public domain and that hence no patents must be taken for them. In total 600.000 plant samples of 3000 different crops are stored in the gene banks of CGIAR. Gene banks control the biodiversity in laboratories far away from nature and agricultural practices. This is called storing ex situ. The storage of local varieties on a farm by farmers and the conservation of the wild ancestors of agricultural crops in nature is called conservation in situ.
Within the CGIAR network of research institutions the IPGRI is playing a central coordinating part in supervising and maintaining genetic diversity in agricultural crops ex situ but also in situ.
Both within the board of the CGIAR and in that of the IPGRI there are people represented who have a high position in the agrochemical industry. This is a source of concern, because conflicts of interest may

occur. As the budgets for (cheap) conventional breeding are cut, the budgets for (expensive) genetically engineered improvement go up. Of course this has everything to do with increasing sponsoring by the agrochemical industry.

Potatoes and patents

Six Indian communities from Cusco, one of the centres of the former Inca empire, and CIP, the International Potato Breeding Centre in Peru, concluded an agreement in December 2004 that prevents companies to patent certain potato varieties. The agreement recognizes the rights of the Indians with regard to the unique potato varieties they have developed in the precious centuries. This does not mean that these communities now will protect their potato varieties themselves with patents. They are against patents – which represent a concept of property that does not fit into their world view. Indians are used to share information. Due to this agreement nobody else can claim the intellectual property rights on their knowledge.

The Peruvian Indians consider Peru as the cradle of the potato. “Potatoes are an important food crop here, but they are also a cultural symbol. Potatoes play a role in wedding customs and in religious ceremonies. Growing potatoes reaches back to thousands of years and we have developed ourselves together with the potato.” In Peru and the neighbouring Andean countries more than 2.000 potato varieties are grown – that is half of the total number of varieties that exist all over the world.

The strong reputation of the International Potato Centre gives the agreement international importance. The centre manages the largest gene bank of potato varieties and plays an important role in the international research on potatoes.

Decreasing role of governments

Until the nineties the CGIAR set the tone for the efforts in the field of government research. At hat time governments worldwide still provided 80% of funds for agricultural research. For ten years now the share of private companies in agricultural research has increased to over 33%. The implementation of IPRs in agriculture is the main incentive for the privatization of agricultural research. In 1998 Monsanto’s budget for research and development was fifty times higher than the budget of the CGIAR for selection and gene banks. The budget for plant breeding of developing countries for its part is often less than one twentieth of the CGIAR budget.

This evolution has a number of consequences for food security:

* The research priorities of private agricultural research do not necessarily correspond with the interests of developing countries, especially concerning food crops that are interesting for private research (maize, rice, wheat).
* The necessary technologies and useful genetic material are increasingly being patented and owed by the private sector.
* The commercial objectives of private seed companies, i.e. to sell as much agricultural seeds as possible and to control the sales channels, are completely at odds with the traditional use of farm saved seeds.
* The commercial objectives of private seed companies stimulate monoculture on the basis of their patented products (seeds and agrochemicals). This leads to a loss in genetic diversity and an adverse impact on the environment.
*In this connection there have been some cases of “biopiracy” in which genetic resources of CGIAR centres constituted the basis for (efforts to achieve) IPRs by private companies.

Patents are harmful for developing countries

In short, the urge to patent has started a race from which government research centres and universities cannot escape either. The slogan “to publish or to perish” has been replaced by “to patent or to perish”. Patent rights are a complex matter though. Only private companies from developed countries have the resources to attract experts and as a consequence weaker stakeholders like developing countries, their agricultural research centres and independent seed companies are driven into a minefield of often unknown rights and duties.

Two examples of biopiracy

In 1998 two Australian selection companies wanted to acquire breeders’ rights in Australia on chickpeas and lentils grown out of genetic material of the ICARDA collection in Syria. Other companies wanted breeders’ rights on beans from India and Iran, grown with material from the ICRISAT collection in India. The scientific magazine New Scientist attracted attention to these facts. As a consequence the companies withdrew their application for breeders’ rights.

In 1999 Podners, a seed company in Colorado, US, acquired a patent on yellow beans. Immediately Podners wrote a letter to all importers of yellow beans from Mexico saying that they had to pay patent rights to Podners if they still wanted to import yellow beans into the US. Some importers were brought to court. The import of yellow beans came to a standstill. The income of many small Mexican farmers collapsed. In January 2000 the Mexican government filed a complaint with the US Patent Office. In December 2000 CIAT declared that its gene bank contained 260 yellow beans, six of which were genetically closely related to the beans for which Podners had a patent. This did not prove that Podners was working with CIAT material, but it did prove that Podners had improperly received a patent on existing genetic material of Mexican origin. And that is a violation of the CBD treaty. The case is still being investigated.

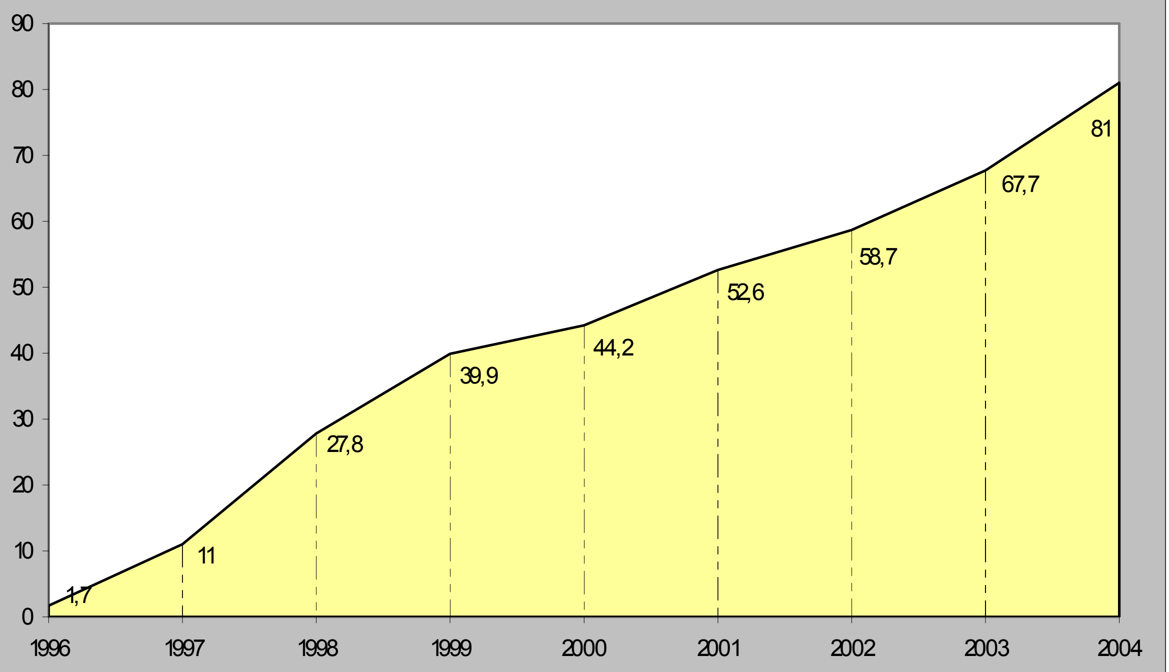
Step 7. Between dream and reality. Distribution of GM crops over the world.

What's the news of GM crops in the world? On the one hand there are a limited number of applications, on the other their share is growing strongly and GM crops have a real impact. The current use of GM crops at a large scale is limited to six countries, four crops and two modified traits. Today there are only two crops (maize and cotton) and one trait (Bt property) that are relevant for developing countries, if a number of prior conditions are fulfilled.
It is not possible today to predict whether it will be feasible to commercialise other genetically modified crops and traits that may be of potential importance for developing countries. China does promise a breakthrough for genetically modified rice in 2005.
(data according to C. James, Global Status of Commercialized Transgenic Crops: 2004, ISAAA Briefs, January 2005)

Current applications

In 2004 the overall surface of genetically modified agricultural crops worldwide was 81 million ha. 98% was situated in only six countries: the US, Argentina, Canada, Brazil, China and Paraguay (Figure 2). Other countries with more than 50.000 ha are – in order of importance – India, South-Africa, Uruguay, Australia, Romania, Mexico, Spain and the Philippines. The surface of farmland with GM crops has grown dramatically since the first commercial introduction in 1996. (Figure 1)

Figure 1 Worldwide surface of farmland with GMOs (in million ha) (James, 2005)



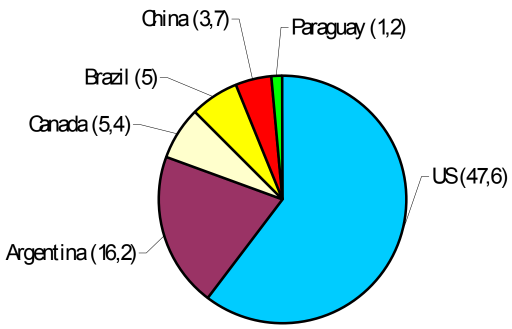
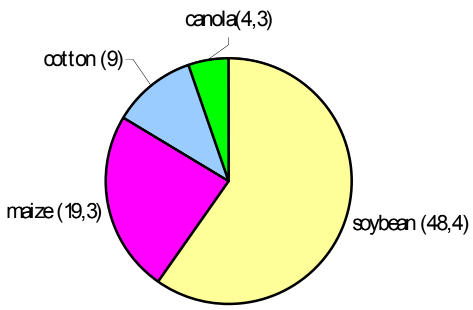


Figure 2 Worldwide surface of farm land with GMOs (in million ha/ country) (James, 2005)

Only four GM crops on the market

The only four commercialized GM crops are soybean, maize, cotton and canola (Figure 3).
These four crops are mainly used for industrial processing as a source of vegetable oil (soybean, maize, cotton seed and canola), as high-protein cattle feed (maize gluten, solids of soybeans, of maize, of cotton seed and of canola), as fibres (cotton) and as a raw material for glucose syrup (maize). Only very little of these crops are directly used for human consumption, with the exception of white maize in South Africa (155.000 ha). The expected introduction of GM rice in 2005 by China will thus be a breakthrough for GMOs in basic food crops.
Since the involved countries are large producers, this means that 56% of the soybean area in the world is planted with genetically modified soybean. For cotton this is 28%, for canola 19% and for maize 14%. In Argentina the share of GM soybean is 99%.



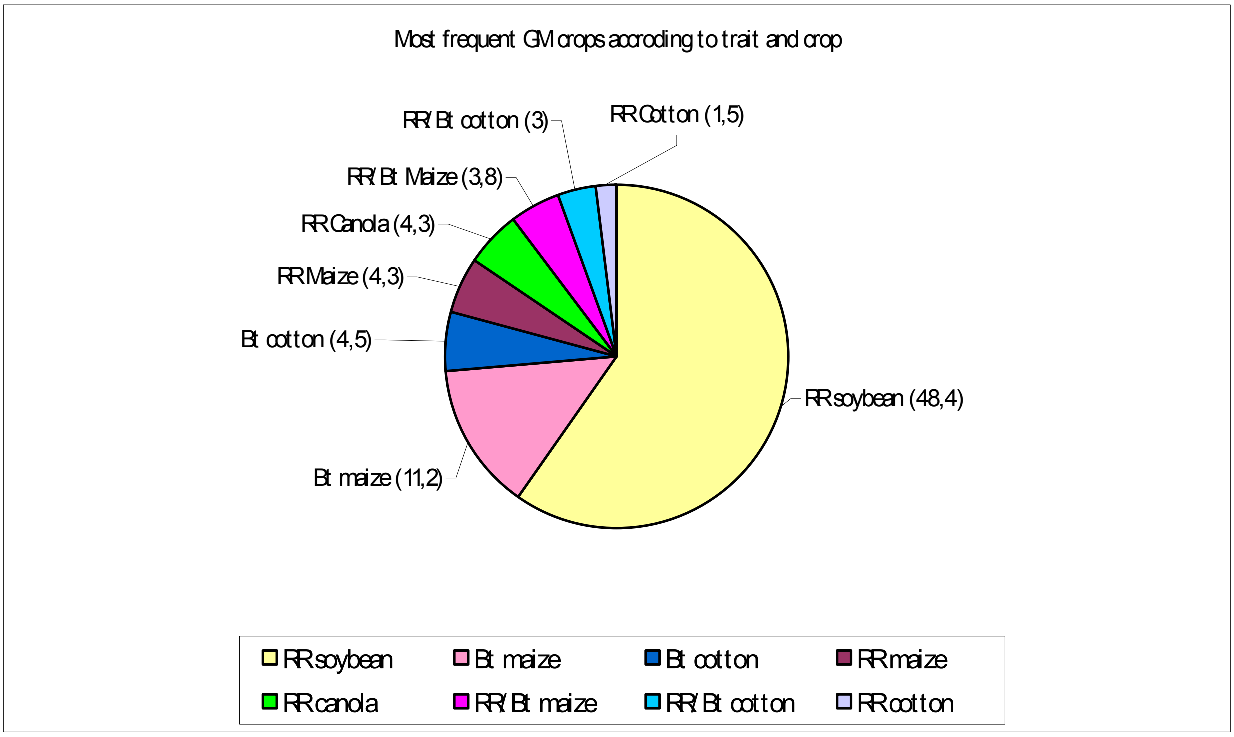
Worldwide surface of farmland with GMOs (in million ha/ crop) (James, 2005)

Only two modified traits on the market: RR and Bt

These four crops on the market have only been genetically modified for two traits. On the one hand there is the tolerance to glyfosate, a total herbicide known under the name RoundUp or Liberty Link, often called RoundUp Ready or RR. On the other hand there is the tolerance to a number of insects (various built-in genes of Bacillus thuringensis, hence the collective name Bt).
RR crops are of little importance for developing countries because weeding is often done by hand and weeds are no main reason for crop failures. Plagues of insects and plant diseases caused by fungi and

viruses are a bigger problem. Bt crops may be interesting if the plant variety and the Bt variety are well adapted to local conditions.
The biggest area with GM crops worldwide is planted with RR soybean (48%), followed by Bt maize (11%) and Bt cotton, RR maize and RR canola (Figure 4).

Most frequent GM crops			
Trait and crop	**(in millions ha)**	**%**	**countries**
RR soybean	48,4	60	US, Argentina, Brazil, Paraguay, Canada, Uruguay
Bt maize	11,2	14	US, Argentina, Canada, South Africa, Spain
Bt cotton	4,5	6	China, India, Australia, US, Mexico, Argentina, South Africa
RR maize	4,3	5	US, Canada, South Africa, Argentina
RR canola	4,3	5	Canada, US
RR/Bt maize	3,8	4	Canada, US
RR/Bt cotton	3	4	US, Australia, Mexico
RR cotton	1,5	2	Australia, South Africa
Total	81	100	



In the future or just a dream?

Just like for classic plant improvement, it is a long way from the development until the commercial production of GM crops. It seems like a knock-out race: many are called, but only few reach the finish. For GM crops the procedure is more difficult and particularly more expensive. It can be compared to the development and approval of new medicines: after a laboratory stage there are trials in the field and toxicological tests (comparable to clinical research). And afterwards there are still several hurdles to be taken such as the approval by the regulating authority and the launch of commercial production. After every stage there is a strict evaluation in which commercial and financial objectives play a decisive role.

What is in the pipeline?

Genetically modified agricultural crops

* soybean, cotton, maize and canola are in commercial production
* sugar beet, rice and flax have been approved
* wheat, barley, alfalfa, sunflower, clover and safflower are tested in the field
* <u>sorghum</u> and <u>cassava</u> are tested in laboratories and greenhouses

Genetically modified vegetables

* tomato, paprika and pumpkin are in commercial production
* potato has been approved
* beans, peas, lettuce, cucumber, cabbage, carrot, aubergine, onion, cauliflower, broccoli and spinach are tested in the field

Genetically modified fruit

* papaya is in commercial production
* melon has been approved
* banana, pineapple, apple, grapes, prune, strawberry, water melon, citrus, cherry, kiwi and raspberry are tested in the field
* mango and coconut are tested in laboratories and greenhouses

With both feet on the ground

Especially the crops that are important for the developed part of the world are the closest to commercial production. The shareholders of the five agrochemical companies that provide more than 99% of the GM seeds available on the market, do not consider their companies as charities and therefore these firms will not develop products for or sell them to non-creditworthy markets.

Some major countries like China, India, Brazil and South Africa stimulate government research into GMOs themselves and develop GM crops with properties that are a priority for their country. These countries consider GM crops as of national interest. China is expected to make Bt rice available for commercial production in 2005.

Potential traits for commercial research

The potential traits to carry out commercial research are divided into six groups:

1. Herbicide tolerance: this is the most used GM property all over the world. It is best developed for soybean, maize, cotton, canola, sugar beet and chicory.

2.Insect resistance: this trait is already well-developed too for cotton, maize, rice and potato.

3.Resistance to biotic stress: bacteria, fungi and viruses. These traits are being researched for a large number of crops like rice, coffee, bananas, manioc, potato,
sweet potato, beans, wheat, papaya, pumpkin and melon.

4.Resistance to abiotic stress: drought, heat, frost, acidity of the soil or salty soils.
These traits are being developed for cotton, coffee, rice, wheat, potato, cabbage, tomato and barley.

5.Enrichment of crops with nutrients. These traits are being developed for rice, <u>cassava</u>, <u>millet</u> and potato.

6.Improvement of technological properties: the starch structure of potato, the sugar content of sugar cane, the composition in fatty acids of soybean and canola.

There are promising developments with regard to resistance to insects, bacteria, fungi and viruses. The much talked-of properties of drought and salt tolerance will only be achieved in the far future (after 2010), because those properties depend on various genes. So genetic engineering keeps in store a lot of promises. This is fascinating of course. But it is impossible to predict now what traits will finally reach the market. We also have to wait and see whether plants and properties that are interesting for developing countries will be developed. This is mainly determined by government research in China and India. The development of such technologies is not to be the part of smaller developing countries.
A much talked-about example is the Golden Rice. This is rice which after modification contains a higher content of provitamin A. This rice was already developed in 2000, but is not yet distributed on the market. Only in 2004 the first field tests were carried out in the US. Still more scientific research is needed to determine how much Golden Rice people have to eat every day to achieve a significant absorption of vitamin A in the body.
Golden rice and other applications for developing countries are often announced with a lot of enthusiasm because these are indeed promising developments. The knock-out race to commercial products however is long and it is not sure at all that these developments will finally be brought onto the market.

Kenyan farmers

The Kenyan National Federation of Agricultural Producers (KENFAP) demands that government research centres and companies in consultation with farmers' organizations would develop seeds that provide an answer to the pressing problems of farmers in their country. The introduction of plant varieties with traits that provide an answer to challenges in other countries but that are not suitable for farmers in Kenya should be rejected.

Multinational companies and genetically modified agricultural crops

The most important producers of crop protection products are multinational agrochemical companies, which in the past decade have taken over a large number of seed companies.
The six most important according to turnover are: Syngenta, Bayer, BASF, Monsanto, Dow and Dupont (Figure 5). Only BASF has few activities in the field of agricultural and horticultural seeds, but it has invested in genetic engineering research about potatoes for example. Those companies call themselves "life science companies" or companies that specialize in sciences about life.
For the development of new GM plants the combination with agrochemical products often plays a prominent role, like for RR crops and the Terminator Technology. Breeders of improved plant varieties, which belong to agrochemical companies, thus attach a disproportionate amount of attention to the development of company dependent technologies at the expense of technologies that are relevant for society and for farmers. This also highly increases the dependence of farmers on expensive, brand specific technological combinations of seed and agrochemical products.
The major seed companies according to turnover are: Dupont, Monsanto, Syngenta, KWS, Groupe Limagrain, Sakata, Delta&Pine Land, Bayer Crop Science and Dow.
Monsanto says it has a world market share in GM seeds of 90%. Syngenta, Dupont, Bayer CropScience and Dow control together 9% of the market. Traditionally seed improvement companies used to be small and medium-sized unities. The fast concentration during the past twenty years raises questions: what about the strategies and priorities for improvement? Is there enough attention for local markets and specific technical problems? What about less important crops?

Below we publish information on the five major corporations that develop and sell GM seeds.

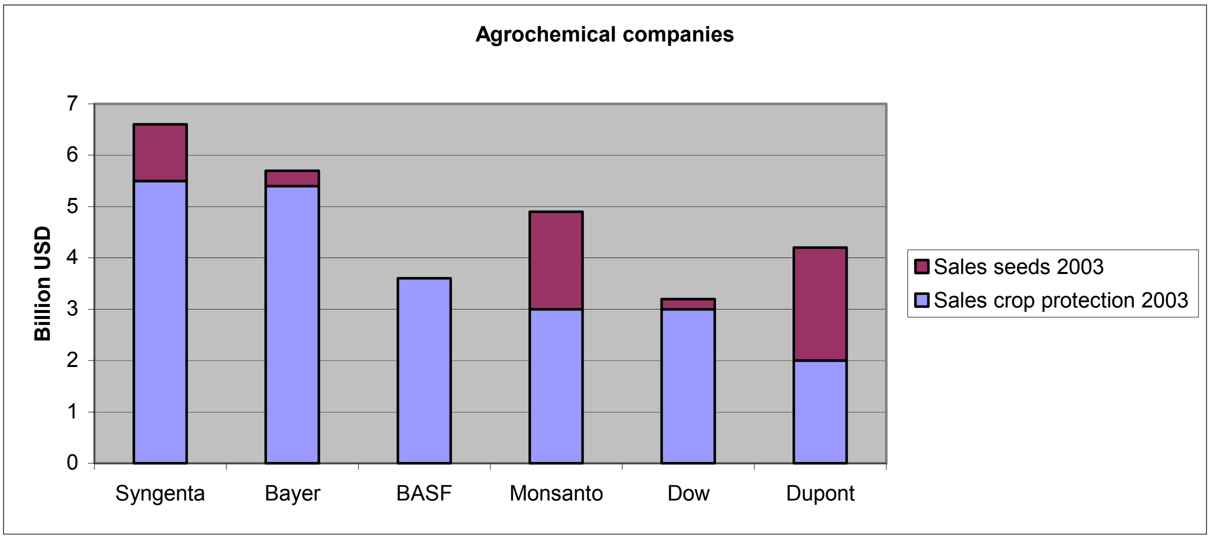
Monsanto (US) fourth in agrochemicals and second in seeds, staff 13.700.
Takes care of 90% of the GM market. Concentrates only on maize, soybean, cotton and canola. Roundup allows for 60% of sales in agrochemicals. Was restructured in the past five years after merging with and subsequently splitting off from Pharmacia-UpJohn in 2002. Acquired various seed companies, including DeKalb, Asgrow, Hybritech and in 2004 part of Advanta.
In January 2005 Monsanto took over Seminis, the number five among seed companies and world leader in vegetable and fruit seeds with 20% market share and 3000 employees. Seminis carries the brands Asgro, Bruinsma, Petoseed and Royal Sluis and possesses in its seed bank 1,5 million breeding lines of 60 vegetables and fruits.

Syngenta (Switzerland) first in agrochemicals and third in seeds, staff 19.000.
Created out of Ciba-Geigy and Sandoz (Novartis), of which the departments agrochemicals and seeds merged in 2000 with the departments agrochemicals and seeds of AstraZeneca. Promoter of golden rice. Member of the board of the CGIAR. Took over part of Advanta and six other seed companies in 2004.

Dupont (US) sixth in agrochemicals and first in seeds, part of chemical concern, total staff 55.000. Active in the field of polymers, paint, diagnostics and soy proteins. Pioneer Hi-Bred International, a subsidiary company, is the largest seed company in the world (staff 5000). Agrochemicals comes under DuPont Crop Protection

Bayer (Germany) second in agrochemicals and eighth in seeds, part of chemical and pharmaceutical concern, staff 113 600. Active in the field of human medicine, veterinary medicine, chemicals, polymers, paint.
At the end of 2001 Bayer acquired Aventis CropScience. This company was a combination of the agrochemicals department of Hoechst and Schering and the seeds department of the Belgian biotechnological company PGS, together called AgrEvo, with Rhone-Poulenc. Agrochemicals and seeds are since 2002 located at Bayer CropScience with 22.000 employees.

Dow (US) fifth in agrochemicals and ninth in seeds, part of chemical concern, staff 46.000. Active in the field of food, transport, health, plastics and polymers. Dow Agrosciences bought various seed companies, including Mycogen seeds, Brazil seeds, Cargill Hybrid Seeds and Rohm&Haas.



Source: ETC-group

Step 8. Between dream and reality. Advantages and risks of GMOs

The advantages of the existing genetically modified crops are concrete and mainly concern agricultural technical aspects. At the same time GM crops can also have a favourable impact on health and environment. Advantages must be assessed for every crop and for every modified property. Differing degrees of precaution are applied with regard to a risk that cannot be excluded and that is not quantified. Therefore there may be wide differences between the assessments of different experts.

Agricultural technical advantages and risks

Increase of proceeds.

Increased harvests are strongly depending on locally adapted varieties. Due to the lack of legislation on official catalogues of varieties and on comparative tests over three years it may be very risky to introduce GM crops in developing countries too hastily without the necessary support of government extension services. This may sometimes lead to crop insecurity and even crop failures.

Decreased or increased use of pesticides?

The latest research results on RR crops indicate that it is possible to save on herbicides in the first years, but that after some time resistant weeds and wildshoots cause problems. A better weed control with less agrochemical products results in less environmental damage, economies in sprinkling water and in labour. RR-technology allows for the use of less harmful agrochemical products and hence less danger for farmers and the environment. With Bt-technology it is important that the introduced traits are adapted to the kind of expected insect infestation. A better control of damage due to certain harmful insects can lead to a dramatic reduction of the number of sprayings, and thus a saving on crop protection products, on labour and on sprinkling water. At the same time this means diminished health risks for farmers, and diminished risks of residues in harvested products and in the environment.

Higher agricultural incomes

This depends if the higher cost for GM-seed is off set by an increased harvest and/or economies in field preparation and pesticide application. Subsistence farmers value more a secured harvest than the highest possible yield and income.

“Good agricultural practices”.

GM crops require other agricultural practices. With RR technology the timing of herbicide application is important for the effectiveness of weed control and for environmental effects. RR-technology allows also for sowing without ploughing also called seed drilling. This saves labour and has positive effects for soils that are susceptible to erosion but can lead to an increased crop disease pressure.
For Bt crops it is recommended to sow one part of the area of a farm with a non-Bt variety in order not to overincrease the selection pressure on undesirable insects. This requires appropriate agricultural extension services and monitoring. It is also necessary to increase knowledge on the different harmful insects and the pests they cause, in order to know when there is a threat and when it is still necessary to spray with insecticides. For developing countries with their small-scale family farms it is not so easy to come up with this knowledge and discipline.

Unwanted dissemination of pollen.

Pollen of GM cross-pollinators may fall on non-GM crops. To limit this pollen drift arrangements are made on measures of coexistence to limit the damage and to be able to determine and settle liability if necessary. It is not always technically speaking easy to separate GMO-free from GMO food in the food chain. This requires sophisticated legislation and hence expensive controls and labelling, which is beyond the reach of family farms in developing countries.

Decrease of agricultural biodiversity.

The massive introduction of GM crops entails an additional risk of reducing the agricultural biodiversity and the disappearance of valuable landraces. This risk is higher in the centres of origin of these crops, like for maize in Mexico or for rice in China.

Other advantages and risks

International markets

An important advantage of GM crops is the lowering of production costs of agricultural produce and hence an improved (inter)national competition position. In case of coexistence measures, GM , regular and organically grown products entail specific requirements with regard to labelling. Pollen drift or an accidental contamination between the period of harvesting and the different stages of the trade chain may have financial and legal consequences. Developing countries exporting organically grown products to Europe may suffer a considerable economic damage if those products appear not to be GMO-free. As a consequence these countries may lose markets.

Environmental risks

It is not an easy research question to ascertain if RR crops increase or decrease the use of herbicides. The latest research results indicate that less herbicides are used during the first years, but that after some time resistant weeds cause problems and lead to an increase of more harmful cocktails of herbicides. Roundup is among other products less harmful but has a negative impact on living organisms in the soil and in fresh water.
Pollen of GM cross-pollinators also may fall on wild plants of the same family. In case of RR-pollen this may lead to herbicide resistant wild plants and possibly to super weeds.
The Bt gene is also damaging for other non-harmful insects and insect-eating birds. The impact on the food chain and organisms in the soil has not yet been studied sufficiently.

Health

An unintended advantage of Bt-technology is a reduction of contamination of maize for human consumption and cattle feed due to poisonous fungi (mycotoxins).
It is doubtful whether the possible health risks have been mapped sufficiently. In general people think of allergic problems and of induction of antibiotic resistance through certain marker genes. As a matter of fact these marker genes have already been prohibited in a number of countries. In addition cases are known of people who got ill after breathing in pollen of Bt maize in the Philippines. But this has not yet been scientifically confirmed.

Social implications

Like for any technological innovation in agriculture the poorest groups of population are put at a disadvantage if the government does not take any accompanying measures. In the absence of an adequate agricultural policy, all too often the Matthew effect occurs, called after Matthew 25, 29: "For

unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath."
Examples are the big success of RR soybeans in large farms in Argentina, due to which farmers of small family farms are chased away from their land because legislation on tenure and property rights do not provide sufficient legal certainty.
In India Bt cotton has had a mixed success. There are success stories that are confirmed by the increase of the land grown with Bt cotton. But there have also been failures: cases of farmers who buy expensive (legal or illegal) GM seeds on credit, and then those seeds do not provide the desired yield. Those farmers get into a spiral of debt and poverty that may even lead to suicide.

If plant improvement has to contribute to food security in subsistence farming in developing countries, some questions of evaluation are very important.
Does the research provide an answer to an existing need of the farmers involved?
Is the research locally oriented?
Are the interests of the poor being taken in consideration?
Is the research cost-effective and institutionally sustainable?
In view of these criteria GM crops do not score very well, because the technology is very expensive and globally oriented and in most cases has been developed for strategic reasons by large multinational corporations that focus on the demands of customers with purchasing power.

A second Green Revolution?
Genetic engineering sometimes is called the second Green Revolution.
However, both revolutions are very different in structure.
The first one started with research in the public sector focusing on rice and wheat, which are important food crops for developing countries. The fundamental research was specifically aimed at developing countries and was freely available for local research, especially in government testing stations, so that varieties were made available that were adapted to local needs and local production requirements. The introduction of this technology was supported by agricultural extension and credit services supplied by the government. The state acted as a factor of stability on the markets for agricultural products.
The recent development of genetic engineering was primarily initiated by private companies and for industrial crops that are important for developed agricultural systems. Research is screened off by patents and is not freely accessible for local research by government stations and local breeders of improved varieties. Due to liberalization governments in many countries play a much smaller role or even no role at all in agricultural research, granting of credits, advice and the stabilization of agricultural markets. Private companies have only partly taken over those tasks.

Step 9. Some main lines of the ethical debate on GMOs

Ethicists interpret the debate starting from opposing basic attitudes: what attitude does each of us adopt towards nature? Most people who are active in agriculture think that animals and plants have no intrinsic value and are utility goods for the benefit of men. Some remarks and principles may provide some background for an open dialogue between people with differing basic attitudes.

Basic attitudes

Professor Johan De Tavernier of the Centre for Agrarian, Biological and Environmental Ethics (CABME) of the Catholic University of Louvain puts it as follows “Ethical considerations on biotechnological applications are highly determined by the fundamental question what moral status people want to give to plants. The different fundamental attitudes can be classified on a scale between the extremes of anthropocentrism and ecocentrism. Those differences in fundamental attitude explain why it will never be possible to achieve a consensus in society when talking about sustainability – like sustainable agriculture, sustainable development, sustainable economy, sustainable food production. “

Anthropocentrism versus ecocentrism and Christian ethics

“Traditional ethical views are human oriented or anthropocentrically coloured. The notion of intrinsic value is limited to people: only people are persons. Most people who are active in agriculture, think and act out of this tradition. Animals and plants have no intrinsic value and are utility goods for the benefit of men. Genetic modification for the purpose of an increase in productivity will not cause fundamental problems.

In a moderate anthropocentric view sustainable agriculture will be defined as agriculture that will also be able to exist in the future. In this case sustainability means, according to Van Bockstaele ‘an economically profitable production of sufficient food of a high quality, healthy and environmentally friendly, that safely meets the demands of society, the environment and agriculture.”

Ecocentrism embodies the notion of nature as an intrinsic value. Man is part of the whole ecosystem and hence surely is not setting the standards alone. The interests of the ecosystem always prevail over those of people. In such an ecocentric view there is in fact no fundamental difference between man himself and his environment. Man is totally absorbed by nature as it were and disappears as a subject. Ecocentrism is absolutely opposed to genetic modification in plants.

This view also colours the interpretation of the concept of sustainability. For ecocentrists only biodynamic farming can pass for an acceptable sustainable agriculture. Conventional agricultural techniques – however well they are applied – are not considered to be sustainable.

Christian ethics are moderately human oriented and speak about man as steward and as co-creator of God. This implies each time freedom to act with moral responsibility (justice for the current and future generations and care for the weakest) and with the obligation of responsibility.

Health as most important ethical requirement

The main ethical requirement is that products stemming from genetic engineering must provide absolute guarantees with regard to health.

The discussion on the acceptability of interventions of genetic engineering also concerns the important question of the ethical assessment of patents on living beings. The opinion on the desirability of granting patents obviously also depends on the fact whether genetic modification of plants is thought to be acceptable. Based upon the considerations mentioned above there will always be differing ethical views.

Concern for enough food, but …

From a moderate anthropocentric point of view a sufficient food supply for the growing world population is the most important concern. Genetic modification intended to make plants more tolerant to abiotic factors (cold, frost resistance, drought- and salt tolerance) is then acceptable. Also making plants resistant to biotic factors (diseases and pests), so that in the long run a clearly more limited use of harmful pesticides would be needed, may be acceptable to moderate anthropocentrism. The same is true for quality improvement, e.g. of nutritional value, storage life and baking quality, if all these purposes can be achieved more efficiently, more goal oriented and faster through genetic engineering technologies than by conventional plant improvement.

But at the same time enough attention should be paid to voices expressing fears for certain consequences. The objections are of a very different kind and therefore difficult to weigh up.

There are ecocentric objections, which have been mentioned above. Some fear an increased pressure on the environment: a future increase of the use of total herbicides, reduction of biodiversity: in general, of agricultural crops as such and more in particular in the centres of origin of the most important agricultural crops.
One could ask why so much money for research is spent on the production of herbicide tolerant plants, while other applications provide more evident social benefits.
The introduction of transgene plants will even more increase the concentration of control on the food supply in the hands of large multinational corporations, especially due to the acquisition of seed companies and genetic engineering companies by agrochemical giants. This implies that the autonomy of farmers will be further reduced.
Moreover biological engineering will also continuously increase the scale of farms.

Ethical considerations

The Swiss theologian Karl Hanke-Wehrle proposes a number of reflections that provide essential subjects for ethical considerations:

* Within an ethical assessment neither radical rejection nor uncritical approval can be accepted.
* Like any other technology genetic engineering should be accompanied by a risk assessment and an evaluation of the agricultural technical, ecological, social and economic consequences.
* Must developing countries be able to use genetic engineering as well?
* What objectives are aimed at with the introduction of genetic engineering and what risks are considered to be acceptable?

Principles

Karl Hanke-Wehrle wonders whether it is possible from a moderate anthropocentric point of view to agree about a number of ethical principles

* Man is able and allowed to use plants. Genetic engineering may be positive and useful for man and environment.
* In the interest of current and future generations the basis of life has to be safeguarded. Nature is not exclusively meant for man. Important interventions must be justified in advance.
* In the interest of man and nature it is not allowed to run an unpredictable risk if there is no urgent need.
* The end does not justify the means. If a technology seems to be problematic because of negative side-effects, it is necessary to look for other technologies that entail fewer risks.
* The use of genetic engineering should not only treat symptoms. It is better to address the causes of problems.
* Who is responsible, for what, with regard to whom and according to what criteria? Responsibility includes the evaluation of consequences of acting and not acting.

Step 10. Experiences with bananas and genetic engineering

A practical example is bananas, an important food crop for subsistence farming in developing countries. Networking between government research centres stimulates the exchange of young plants that are free of diseases.
For the time being traditional plant improvement still overshadows the possible introduction of the already existing genetically modified banana.
(according to E. Tollens, M. Demont and R.Swennen, Outlook on Agriculture, 2004)

There are many varieties
By nature there are about 1000 types of bananas: short, angular, round, straight, bent, green, yellow, pink, spotted, silvery or striped ones. There are dessert and cooking bananas. The centre of origin of bananas is situated in South East Asia and the Pacific. Bananas are now spread all over the world. Not so much the Chiquita or dessert banana is important for food security in Africa, Asia and Latin America, but much more the cooking banana or plantain that makes up 45% of production. 42% of production are dessert bananas for local consumption, and the remaining 13% are dessert bananas for export. After rice, wheat and maize, bananas are the fourth most important food crop in the tropics.

An interesting crop for subsistence farming
Bananas are an interesting crop: (1) the plant provides all year round food that is rich in energy, vitamins and minerals, (2) the plant has a multiple use as basic food, snack, vegetable, fruit, for beer, as fodder, the leaves as packaging material and source of fibres, (3) the plant has a low production cost, (4) bananas require labour all year through without high peaks, (5) the plant is adapted to a large diversity of growing conditions, is suitable for mixed culture and in combination with stock breeding. A banana plantation keeps the soil covered during the whole of the year.

Threatened by diseases
Since the beginning of the eighties Black Sigatoka, a fungous disease, is threatening the production of bananas in Africa and Latin America. As a reaction to this threat a network of research institutions was set up in 1985: the International Network for the Improvement of Banana and Plantain (INIBAP). Since 1994 INIBAP has become a programme of IPGRI, member of the CGIAR network. INIBAP has a mandate of the FAO for maintaining the largest gene bank for bananas. Developing countries have free access to the genetic material and disease free basic material is exchanged among 88 countries. The results of improvement are available and tested under local growing conditions in 24 countries. In vitro reproduction quickly provides disease free material.

The role of the Catholic University of Louvain
Within INIBAP a group of researchers around Professor Rony Swennen of the Laboratory for Tropical Crop Improvement of the Catholic University of Louvain plays a central role as keeper of the largest banana gene bank. This lab is active in the field of biodiversity and improvement of banana, in particular of improvement of resistance to fungi and bacteria. They also use in vitro cloning, cryopreservation and some technologies of bioengineering, like molecular markers. Moreover they develop diagnostics for diseases and pests. An important contribution is also to make the richness of the existing collection better known and to supply disease free basic plant material for further reproduction and improvement in developing countries.

The genetically engineered banana exists …

With the use of genetic engineering it has been possible to make an important progress in banana improvement in combination with minimal risks for the environment and biodiversity: the fact is that a banana plant is to a high degree sterile, the seed germinates only very badly and the plant knows a long cycle between sowing and producing seeds itself. As early as 1994 biologic engineering succeeded to improve resistance to Black Sigatoka in cooking bananas. The plants produced are sterile, and hence are reproduced vegetatively and do not produce any problem of coexistence. Those modified plants were toxicologically tested on rats, with a good result.

… but local distribution is not yet possible

However, the trial programme on local fields is running with difficulty in only two countries (Cuba and Costa Rica), because most developing countries do not possess the necessary capacity with regard to biosafety and legislation to be able to introduce biologically engineered material. This has to do with tests of toxicity, allergies and pollen drift and the legal framework to convert international treaties into national rules and regulations on the distribution of plant varieties, biodiversity and intellectual property rights (UPOV, TRIPS, Cartagena, etc.). The lack of scientific and legal capacity appears to be a major obstacle for the introduction of those genetically modified bananas and of GM crops in general in developing countries. Also the reluctant attitude of Europe frightens exporting developing countries off to introduce the technology, even for research purposes.

The role of government research

Some useful banana genes that have been used in this programme have been patented by private companies and thus have become their “property”. It has cost a lot of efforts to be allowed to use these genes freely for cooking bananas. Private companies are not interested in this crop from developing countries (they are only interested in very limited number of dessert bananas). The role of research by public institutions is of major importance for the improvement of food crops from developing countries to develop patent free young plants that farmers are allowed to replant and distribute without limitation.

In conclusion: what are the points of interest of the rural movements?

The rural movements in Belgium and Germany consider it as their task to interest many stakeholders in the theme of GM crops and food security. They want to point to the plight of the most vulnerable people in the developing countries.

Genetic engineering opens up perspectives and requires ethical actions.

Genetic engineering undeniably opens up some useful perspectives for farming and food (lower production costs due to economies in agrochemical products and labour, use of less harmful agrochemical products, improvement of resistance to harmful insects and plant diseases, resistance to drought, less contamination of food due to poisonous fungi, vegetable oils with healthier fatty acids). Therefore advanced research is desirable and justified. But this research concerns the fundaments of life so that sometimes there seem to be no limits to what is possible. For that reason research should be carried out within ethically justified borders and all parties involved should have their say in a public debate.

Under essential conditions genetic engineering may contribute to increased productivity in developing countries.

To fight hunger and to feed a growing population in developing countries it is necessary to increase productivity in the countries where there is food insecurity. Genetic engineering probably will be able to play a useful role in this. But two conditions are essential.
On the one hand the added value of GM crops should be studied case per case and country per country in comparison with land races and with crops that stem from conventional plant breeding. This added value should be tested very well under conditions of local practice. In case of a clear added value the introduction of GM crops should be accompanied by appropriate information on the corresponding agricultural practice.
On the other hand this requires a properly developed legal framework. If farmers' rights and breeders' rights are not included in national legislation, conventional breeding will not be durable. Without the development of patent rights and laws on biosafety it will be legally impossible to introduce GM crops. With increasingly opening country borders it is necessary to develop rules and regulations on access to genetic resources to protect family farming, which is the weakest link.

Farmers' rights are important and the government has a task to fulfil.

The overwhelming majority of farmers in developing countries are active in subsistence farming and use farm saved seeds. This reality should be taken into account. Restricting the right of these farmers to gain and use farm saved seeds would constitute a threat to food security. But the commercial sector will only respond in a limited measure to the actual needs of these farmers, because subsistence farmers do not or hardly buy improved seeds. Governments have to play an important part by enabling independent research to improve crops adapted to the needs of subsistence farming. Farmers' organizations should be more involved in the establishment of priorities for that agricultural research.

The growing concentration of multinational corporations will always be a subject of concern.

The growing industrial concentration in the delivery of agrochemical products and seeds for agriculture and horticulture by the same multinational companies leaves the farmers little choice. This is clearly illustrated on the commercial market of GM seeds.
Farmers all over the world have problems because a large share of the GM farmland worldwide is sown with material that is owned by the same company that also is a major actor in agrochemicals. Several sources confirm the claim of Monsanto that it has a market share of 90% in GM seeds for agricultural crops. This situation leads to higher prices for seeds and agrochemical products and also erodes the diversity of agricultural crops.

Abbreviations and glossary

A

agricultural system	all the agricultural practices and their mutual relations that are specific for a social ecological situation.
agrochemical product	pesticide

B

biodiversity	the variety of organisms in a certain area: this is the variety of genes, strains and ecosystems
biosafety	safety for the health of people and environment in case of use of GMOs
breeders' right	right (including a compensation) to which a breeder of a new agricultural or horticultural crop is entitled
Bt	Bacillus thuringensis, bacterial gene for insect resistance

C

Cartagena Protocol	international agreement on biosafety
cassava	manioc, tuberous plant, rich in starch
CBD	Convention on Biological Diversity
center of origin	area where an agricultural crop originally comes from
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture, Columbia
coexistence	the peaceful existence next to each other (in the case of this paper of different agricultural systems)
CIP	International Centre for Potato Research, Mexico
controversy	struggle between scholars, ideological dispute, argument
CIMMYT	International Maize and Wheat Improvement Centre, Mexico

D

DHS	(research whether an agricultural crop variety is) differentiated, homogenous and stable
diagnosis	determination of the nature and the location of a disease
diagnostics	tests helping to make a diagnosis
DNA	Deoxyribonucleic Acid, carrier of hereditary information

E

empowerment	give people and groups the authority to take their development into their own hands
EPC	European Patent Convention
EU	European Union

F

FAO	Food and Agriculture Organization (UN)
farmers' privilege	the right to gain farm saved seeds as recognized by UPOV, but not allowed for patented GM crops

food safety — the guarantee that food does not have any adverse effects on the health of the end consumer when it is prepared and eaten

food security — according to the FAO a situation in which all families have physically and economically access to adequate food for all their members, and in which they do not run the risk to lose that access

fungicide — agrochemical product to fight plant diseases caused by fungi

G

gene — piece of DNA that contains the instructions for the production of a certain protein by the cell

gene bank — storage facility for all material that may be used to maintain a plant variety, such as tissue cultures, seeds and tubers

genetically modified crop — or GM crop: plant used in agriculture of which the genetic material has been changed by means of genetic engineering

genetically modified food — food that consists of or has been obtained from a GMO or that contains (traces of) a GMO

genetic engineering — technology that directly changes the DNA or genetic material of an organism

GMO — Genetically Modified Organism

H

herbicide — agrochemical product to fight weeds

I

ICARDA — International Centre for Agricultural Research in the Dry Areas, Syria

ICRISAT — International Crops Research Institute for the Semi-Arid Tropics, India

IITA — International Institute of Tropical Agriculture, Nigeria

INIBAP — International Network for the Improvement of Banana and Plantain

IMF — International Monetary Fund

insecticide — agrochemical product to fight harmful insects

intellectual property rights — collective noun for rights on non-material property like patents, breeders' rights and royalties (copyrights)

IPGRI — International Plant Genetic Resources Institute, Rome

IPRs — intellectual property rights

IRRI — International Rice Research Institute, Philippines

K

KWS — German company for seed improvement

L

Land race — non-improved plant variety that has developed in a region as a consequence of local circumstances – native breed or variety

lupine — papilionaceous crop, cattle feed and green manure

M

Miami group	group of six countries that do not endorse the Cartagena Protocol
millet	subtropical cereal crop
molecular marker	piece of DNA that together with the desired gene is added to the hereditary material of an organism to be able to check quickly whether a genetic modification has been successful
moratorium	temporary suspension
mRNA	messenger Ribonucleic Acid

O

ownership	the promotion of involvement through which people take an organization or a development in their own hands

P

paradox	apparent contradiction that upon closer examination, appears to be true
patent	exclusive right to make and sell a certain product. This right is usually restricted to twenty years and often limited to certain countries
PCR	Polymerase Chain Reaction, bioengineering technology
pesticide	chemical product to protect plants against fungous diseases, insects, weeds, nematodes, rodents, snails, etc.
PGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
plant breeding	applied science that has the object to systematically win a new plant variety by crossing and selection
polarization	stressing of the differences between parties
precautionary principle	"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation " (Rio Declaration Environment and Development, 1992)
public domain	as opposed to private property of companies protected by IPRs

Q

quinoa	"cereal"crop from Peru

R

resistance	natural opposition to a certain substance, disease or pest
RR	RoundUp Ready, resistant to a certain herbicide

S

SAP	Structural Adjustment Programme
sorghum	subtropical cereal crop
SSA	Sub-Saharan Africa
structural adjustment	measures to achieve the (only) purpose of the IMF: financial stability in the world, because this leads to economic growth,

	and according to the IMF growth is the best means for poverty reduction
subsistence farming	family farming that mainly produces food crops for private use
sweet potato	tuberous plant, also called batata

T

taro	tropical tuberous plant
terminator technology	code added by means of genetic engineering that makes the involved organism infertile
threshold of tolerance	limit to where GMOs are allowed
TUA	Technology Use Agreement
tumour	pathological swelling in a living organism
TRIPS	Trade Related Intellectual Property Rights

U

UN	United Nations
UNEP	United Nations Environment Programme
UPOV	Union for the Protection of New Varieties of Plants, international convention determining and protecting breeders' rights
US	United States of America

V

vaccine	or inoculum, preparation of living or dead micro-organisms used to vaccinate against a certain disease
VELT	Association for Ecological Ways of Living and Farming, Flanders
VODO	Flemish Platform Sustainable Development

W

WARDA	West Africa Rice Development Association, Ivory Coast
World Food Summit	Meeting of heads of state and government, organized by the FAO in 1974, 1996 and 2002 to discuss solutions for the problem of hunger in the world
Wervel	Working Group for Fair and Responsible Agriculture, Flanders
WHO	World Health Organization (UN)
WIPO	World Organization for Intellectual Property (UN)
wildshoots	crop that grows without being sown or planted on purpose by man (e.g. seed that falls from lorries and that grows on the verge of roads or seed that during harvesting falls on the field and germinates the next year)
WTO	World Trade Organization

Y

yam	tropical tuberous plant