Genetically Modified Food against Hunger

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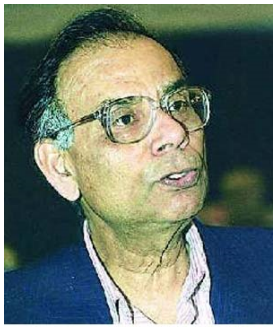
1. Preface

When we heard that we had to write a semester work about a topic which is related with genetics at the first the time, we panicked. Genetics is huge topic and we were lost in the sheer endlessness of thoughts and ideas. But suddenly one of us remembered a reportage which he had once seen in television about scientists creating a new corn which could survive a drought. Both of us were fascinated of the idea to use genetics in the fight against hunger. About one billion people are starving all around the world; is genetically modified food the solution of this problem or is it counterproductive? What are the consequences for human and nature? Is it okay to modify living organisms for a better world or is still the profit the mainspring for genetics?

2. Introduction

History and recent events

Gene technology is a very young science and therefore not very known yet. It was born and developed in the 1970's. 1981 Ananda Mohan Chakrabarty was given the patent for a genetically modified organism. It was the first patent for a living organism. 1985 it was possible for everyone to get a patent for genetically manipulated plants in the USA.
The first genetically modified plant that was planted extensively was the so called Flavr-Savr tomato. It was a tomato that didn't decay as fast as “normal” tomatoes do.
The import of genetically modified soya beans from the USA to Germany (1996) lead to heavy discussions in Europe that last until today. 2013 will be the next voting about the accreditation of genetic engineering in Switzerland.



Ananda Mohan Chakrabarty

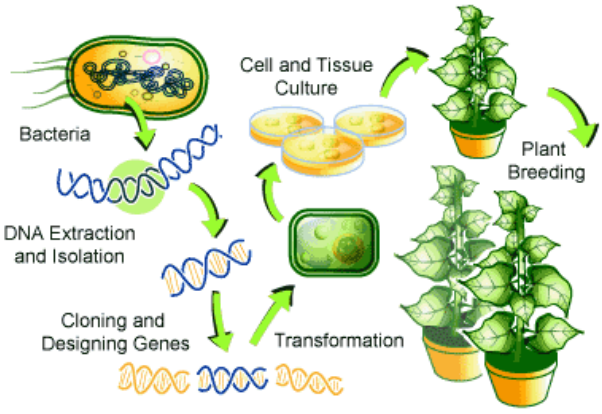
Usage of genetic engineering

Genetically modified plants are most often used in places, where there's enough space to develop the advantages of the technique. It is absolutely necessary that there are no relative plants around the planted area. Otherwise there could be mutations or unplanned spread of the manipulated plants.
Examples of countries that plant genetically modified organisms: USA, Spain, India, China.
These are the most important users of gene modification but also parts of Africa.

The technique is most often used to fight against diseases like damaging insects and crops or droughts. But not only agricultural diseases are fought: A scientist from Zurich developed a rice called “Golden Rice” which contains pro-vitamin A to help people in e.g. China.
Especially poor people in China eat too much rice so there is not enough vitamin A in their bodies leading to blindness and a higher mortality of small children.
With the interdiction of genetically modified plants in Europe, people tried to find alternatives.
They tried to get the same results as scientists got with gene manipulation but with normal growing. The scientist we talked to in our interview said that this is not possible.

3. Description of engineering technique

The basic idea in genetic engineering is very simple: you modify an organism’s genetic material with DNA sequences from other organisms to transfer some (positive) features of the second to the first organism. The product of this process is normally recombinant DNA which is taken to produce genetically modified organisms. Normally the man-made composing of genetic material is done in a test tube but it is also possible to insert changed DNA directly into organisms. With genetic modification it is possible to transfer nearly all genes of every single organism to another organism because all organisms, with only a few adaptions, use the same genetic code. So it is possible to transfer the gene which is responsible for the bioluminescence of the firefly and put it in a pig. The pig now starts to glow in the dark. The same with plants: If you know a bacterium which has a resistance against herbicides you only have to know which of the genes are responsible for this and transplant them to an agricultural crop. Sounds easy but in the reality it is much more complex. First you have to isolate the gene which you want to transfer in the other organism. For this you need to know which gene effects that what you want and then isolate it. Normally this concludes multiplying the gene using the polymerase chain reaction. If you are lucky the gene already has been isolated and you can find it in a genetic library. If not you have to decode the whole genetic code and then you synthesize the gene artificially. To insert the gene into the organism, the gene has to be combined with other genes from your organisms to make it work properly. This is called a construct. Normally a construct contains a promoter region, a terminator region and a selectable marker gene. These are needed to control the whole construct and its influence on the cells of the organism. To build a construct you use recombinant DNA techniques e.g. molecular cloning. To insert the construct



Overview of how genetically modified plants are created

into an organism, this process is called transformation the gene gun (plants) or techniques like microinjection (animals) are applied. The gene gun shoots with DNA coated gold or tungsten particles into young plants. The plant cells will grab some genetic material and transform. If you use microinjection you take a glass micropipette insert your construct in a single living cell. In transformation not every cell is transformed. With the help of the selectable marker it is possible to distinguish between transformed and untransformed cells. Given that mostly only a single cell is transformed with genetic material, the plant has to regrow from this cell. With bacteria it is a different thing. They consist of only one cell so it is no problem for them to reproduce. The last step which you have to do is to test if the gene is working correctly and get a license for selling it.

The Gene Gun

4. Documentations and pictures of research institutions visited

To complete our work we did an interview with Jan Lucht. He has done basic research in genetic engineering for 15 years. The interview lasted about one and a half hour so we decided to shorten it. Some of the answers in this interview are just summaries of the original answer Mister Lucht gave us.

Mister Lucht, you have been working for years with genetic engineering, but what exactly is this and how do you explain this term to a layman?

Genetic engineering are processes which permit to change pieces of an organisms DNA with genetic material from another organism to transfer some characteristics of one to the other animal. For example it is possible to put some genetic material of a pesticide producing bacterium in to corn, so the corn is no able to produce this pesticide by its own.

This corn what we are talking about is Bt-corn, isn't it? It is the most successful genetically modified plant. For genetically modified plants you have to buy the seeds every year, critics bash the coming into being dependency between farmers and the companies and the higher prices for the seed. What is your opinion?

Today especially with corn it is normal to buy every year the seeds anew, because today mostly all farmers use seeds of hybrid corn. Hybrid corn is the first offspring of two different species of corn. It is stronger and more fruitful, but the disadvantage is that the hybrid seed it is very difficult to produce and not lucrative so the farmers prefer to buy it every year anew. This is valid to mostly every crop. Only peasants in the third world use a part of the old crop for the sowing.

So genetic modification is only made for big farmers in industrial countries?

In general the agribusiness companies are not really interested in evolving plants for

peasants in the third world, it is too expensive and the profit is moving towards zero or even it is a losing deal. But there are some companies which try to adapt some of their plants for industrial countries to the requirements of the third world. There are also foundations which pay researchers to invent a better crop for the third world; a good example for this is the golden rice. (Editor: the “golden rice” is genetically modified rice which contains the provitamin A.)

The “golden rice” was evolved ten years ago by scientists from the ETH Zurich, but the market license is not expected until this year. Why does this take so long?

Well, that is a problem of the money and the extremely difficult approval procedures. To get a license for the plant you have to do many different field tests and this very expensive. Besides this test are different from country to country and you have to do them for every single introgressed rice specie, this is very expensive and it takes very long.

Is genetic modified food the solution of the famine in third world countries?

For famines there are so many factors that not only one technical, social or political invention or change could completely erase famines but every step is a step in the right direction and can help to ease the hunger in the world. There are some important projects which try to create better crops for the third world, some with the financial support of famous foundations.

Wouldn’t it be possible to get similar results with conventional breed and without genetic modification?

No, it wouldn’t. With genetic engineering it’s possible to use a giant gene pool for modification. You can use almost every genetic material for your modification. With conventional breed you can only use mutations in the same species.

In Switzerland and also in Europe the people are very critical against genetically modified food, in some countries it is even forbidden to plant genetically modified plants on a grand scale. Why?

Not in every European country the people are very critical against genetically modified food; in Spain and the Eastern Europe countries this plants are very established and are accepted by the people. In Switzerland the ignorance of the people is too big. Almost all people don’t know exactly what it is and are afraid of it. It is now my job to enlighten them.

What would be the advantage of genetically modified crop in Switzerland?

In Switzerland the advantage of genetic modified crop wouldn’t be very significant.

Is it possible that a genetically modified plant end up in nature where it will destroy the normal flora and fauna?

The advantage of modified plants in the fields is mostly a disadvantage in nature. Besides many of the genetically modified plants (Editor: e.g. corn) are very difficult in taking care of them so they would grow in nature without their special fertilizers.

There are some projects in the US with genetic modified animals, what if one of this ends up in nature?

It is very difficult to appraise what is an advantage in nature and what not. So it’s hardly possible to appraise the consequences. But normally genetic modified animals are sterile. The companies assure a ratio higher than 98% of sterile animals. So the

damage for nature would be very small.
Thank you very much!
You're welcome. It was my pleasure.

5. Discussion

- What progress was made with the application of the chosen technique
- What future research steps?
- Discussion:
  Advantages/disadvantages

Introduction
Speaking about advantages and disadvantages of genetic engineering in plants you have to know about the difficulties in agriculture. There are two different sorts of stress: biotic stress and abiotic stress.

Biotic stress describes the disease of agriculture caused by pest plants, damaging insects, viruses and microorganisms. According to a study made in 2008 about 14% of the yield of corn, rice, barley, wheat, soya beans, cotton, coffee and potatoes is lost due to pest plants. There's even a bigger crop loss caused by damaging insects (15%) and a little smaller loss caused by mushrooms (13%). With the help of gene technology (on its present status) these losses could be minimized.

Abiotic stress also leads to crop loss but the causes aren't competing plants or insects. It's droughts, heat, frostiness, or a high salinity.

Advantages
The goal and a big advantage of genetic engineering is to fight against those diseases.
It's possible for example to make plants poisonous for damaging insects so people have to use much less pesticides leading to a better economic system and to smaller costs (no need to buy pesticides anymore). Using manipulated cotton in India lead to a higher income for countrymen and a higher yield. China wants to improve its ecology with the help of genetically modified plants.
Scientist also succeeded in genetically manipulating plants to make them resistant against herbicides. So you can kill the pest plants and crops to make the important plants grow faster and better leading again to a higher income and better feed.

Genetic engineering seems perfect to erase the biotic stresses on the first sight. But we always have to keep in mind that evolution is constantly working. This means that pest plant and crops can build a resistance against herbicides or damaging insects can suddenly resist the poison of genetically modified plants. So new methods have to be invented all the time. It's a race against evolution. Is it really possible to win this race?

Abiotic stresses are a big problem in e.g. Africa because of many droughts and therefore famines. But not only in Africa. Due to climatic change scientists expect the weather to be more extreme also in Europe and North America.
Gene technology can help to solve an upcoming problem with droughts or frosts. Further it enables agriculture on places where normally it was impossible to do agriculture.
Conclusion: It is important to know that gene modification on plant does not make the plants bigger but helps countrymen to raise their income and stabilize it. Also the industries producing genetically modified seeds profit and therefore global economy.

Disadvantages

A big advocacy of the opposition is Greenpeace. Their most important argument is the following: Famines are caused by the bad social circumstances, political instability of a country, poverty and no availability of water.
The motive to help poor people is only said to convince the public and media of a very risky technology. In the 1990's big parts of Africa fought against gene modification in their countries. Helping poor people in Africa was only an excuse to try out the new technology. It doesn't matter if something goes wrong. It was also said that gene modification destroys the biological diversity of Africa and more important: African people can't feed themselves. They are always depending on the industries producing genetically modified seeds. This leads to a disadvantage in the developing of African states and a fortification of the rich West. Plants could spread uncontrolled and through a possible advantage erase other not manipulated plants leading to a smaller biological diversity.

Undesired gene exchange can lead to different times of ripeness. Therefore more work and a less stable income for farmers.

Genetically manipulating plants has to be seen with care because every changing of the DNA is a change in nature and therefore in evolution. Scientists don't know enough about evolution to interact with it.
There's also an ethical discussion about gene modification: if one farmer does use for example Bt corn but his neighbor (distance up to 1 kilometer) doesn't. Then there's no possibility to fully separate the fields. So there's genetic exchange. Therefore it's not possible that only one farmer makes use of genetically modified plants. Everybody would have to even if some people didn't want to (big profit for companies who produce the plants and farmer's dependence).

6. Summary

Is genetically modified food the solution of the hunger problem or is it counterproductive? After having a closer look at how genetic engineering with plants works, we were able to discuss the advantages and disadvantages of genetic engineering. The biggest advantage is that it's possible for countrymen to raise their income. Whereas the biggest disadvantage is the following: everyone using genetically modified seeds is depending on those who produce them. Therefore there are industries that are very interested in pushing this new technology and maybe do not pay enough attention on what could happen (comparable with nuclear power industry). Even though there are some big advantages we have to say that genetic engineering cannot solve the hunger problem. The biggest problems in countries where people starve are political instability and insufficient education. Maybe those countries need their time to get the same stability as European or North American countries have. Another problem are concerns or industries who take advantage of poorer countries and hinder their development. So we say: No genetically modified plants can solve the hunger problem but it can certainly help developing countries to develop a little faster.

The fear of genetically modified food in developed countries is anyway not completely understandable. We think that this technology has a big potential and if it's not misused it can be a big advantage. More publicity and bigger belief in the industry could help to disperse the technology. It's not a fear of modified plants but a fear of people who misuse them.

7. References

http://duboule-lab.epfl.ch/
http://www.vnr.de/b2c/gesundheit/ernaehrung/genfood-warum-sie-gen-nahrung-auch-weiterhin-meiden-sollten.html
http://www.globalissues.org/issue/188/genetically-engineered-food
http://farmergene.wordpress.com/2010/05/06/genetically-modified-food-and-the-global-fight-against-hunger/
http://www.greenpeace.de/themen/gentechnik/welternaehrung/artikel/gentechnik_keine_hoffnung_fuer_die_hungernden/
http://www.bpb.de/publikationen/BCZE3F,4,0,Mit_Gr%FCner_Gentechnik_gegen_den_Hunger.html#art4
http://www.initiative.cc/Artikel/2005_07_30%20Gentechnik.htm
http://www.kahunablog.de/informationen/afrika-und-der-hunger/gen-food.html
http://www.focus.de/politik/ausland/neue-idee_aid_82603.html
http://en.wikipedia.org/wiki/Genetic_engineering
http://www.internutrition.ch/internutrition/who/index.html

Pictures

http://www.scq.ubc.ca/transgenic-crops-how-genetics-is-providing-new-ways-to-envision-agriculture/
http://www.bio-rad.com/prd/en/US/adirect/biorad?ts=1&cmd=BRCatgProductDetail&vertical=LSR&catID=42e9d6be-369a-49f8-8fbb-281a0fea6df8
http://person.yasni.ch/jan+lucht+100468/alzheimer
http://connect.in.com/ananda-mohan-chakrabarty/profile-17991.html
www.uk.edu/Ad/krn/krn_09/pm_091704.html