GENFOOD

1. Preface....2
2. Introduction....2
2.1. General Information....2
2.2. Historical Background....2
3. Description of engineering technique....2
3.1. The concept....2
4. Interview with Syngenta about Bt-Corn....4
5. Discussion....4
5.1. Progress made with the technique....4

5.2. Future research steps?....4
5.3. Ethical aspects 5
5.4. Advantages/ Disadvantages....6
6. Summary....6
7. References....6

1. Preface

The idea to write a term paper about genetically modified corn came up in January. Benjamin remembered a discussion of his last summer holidays as he was with his family in the Philippines. One day they went on a trip to a farmer-friend of their family. The farmer Mr Sarong, Benjamin remembered, talked with his father about some genetically manipulated crops. At that time his interest was stirred on this topic. Then, this year, when Benjamin asked Felix to write the term paper together, Felix liked the idea. He got also some materials of last years 'Schwerpunktfach Biologie' about the gene transfer to bt (*Bacillus thuringiensis*) corn . Interesting in this topic is, that the corn on its own is already herbicide resistant. You don't have to spray insecticides on it. The corn is already genetically modified.

Picture 1: Benjamin at the farm of Mr Sarong

2. Introduction

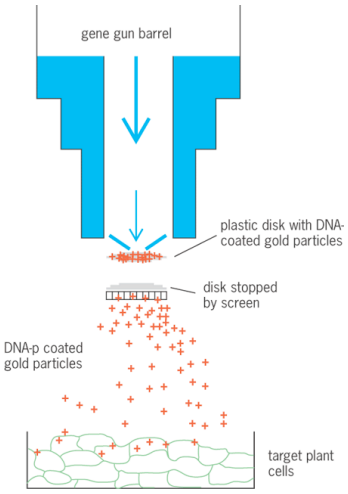
2.1. General Information

Corn plays crucial role in the world nutrition. It isn't only used for food and as fodder plant,but also is now more than ever an important ingredient for biofuels. Over 850 million tons ofcorn is produced annually. This is about 34% of the whole cereal production in the world. So it's important to maximize the harvest of corn since insects especially the corn borer destroy about 40 million tons of corn harvest per year. And for that sake some smart guys came up with the idea of producing a genetically modified corn called bt-corn (*Bacillus thuringiensis*), which is herbicide resistant. Bt-corn can produce so called *crystal toxins* and *cytolytic toxins* which are proteins who kills the attacker in our case the corn borer.In the United States over 85% of the maize planted is transgenic maize (genetically modified).

2.2. Historical Background

The toxic effect of bt-protein was already known for quite a while. In 1901 the Japanese scientist Shigetane Ishiwatari discovered the harmful impact of bt on insects. The first utilization of bt-corn took place in the year 1920 where farmers used it to get rid of a plague of moth larvae and sprayed it on the plants .Bt-proteins were used as a pesticide. The problem was that the insecticide could have been easily washed away so it wasn't really useful for a permanent protection. In the year 1956 the scientists Fitz-James Hannay and Angus Hannay discovered, that bt could kill the insects due to their protein crystals and so the basis was set for a much better way of using the bt.

In 1985 a Belgian company made it possible to produce the first genetically modified plants which contained the bt-proteins. Bt-proeteins were now directly linked to the DNA of the plant. It was therefore resistant against the insects, which died by contact with the surface of the plant. Since 1996 bt-corn is in use in the United States and also in African, Asian and South American areas .But it is not allowed in all countries to produce gene manipulated corn. For example in some European countries like Germany or France it is forbidden since 2009. Newest study from the year 2011



showed that some rootworm developed a resistance against the bt. The findings of insecticide resistance to bt led to a major new critic on transgenic corn. There has been a backward going trend for the use of common insecticides. Frequently articles are published which are related to bt-corn. The main producer of bt-corn are Pioneer Hi-Bred , Mycogen Seeds, Monsanto and the Swiss company Syngenta

3. Description of engineering technique

3.1. The concept

Bt corn has a built-in protection against corn borers, achieved through modern biotechnology, where the *Cry1Ab* gene has been added. The *Cry1Ab* gene produces a Bt protein (Cry1Ab) that protects the plant from insect damage. This gene was derived from the common soil bacterium Bacillus thuringiensis.
Additionally, a marker gene (*pat*), has been added which gives the plant a tolerance to phosphinothricine, the active ingredient of glufosinate ammonium herbicides. This gene is derived from the soil bacterium *Streptomyces viridochromogenes*. The herbicide tolerance gene allowed selection of transformed plants in the development stage. There are three different ways to transfer this Cry1Ab gene to the corn. You can do it either with the gene gun, the electroporation or with the *agrobacterium tumefaciens.*

-The gene gun is a construction that shoots metal projectiles into a living cell. These projectiles are coated with the Cry1Ab gene that will be transferred to the living cells.

-Electroporation works basically with electric shocks hitting the cell's membrane. With these shocks the cell membrane becomes permeable and the living cell can absorb the Cry1Ab gene.
Picture 2: Simplified
diagram of the gene gun.

-The *agrobacterium tumefaciens* is a bacterium that transfers for its own reproduction its gene material into cells of living plants. So in this method the Cry1Ab genes are inserted into this agrobacterium. The bacteria then act as they usually do but they now transfer the Cry1Ab gene sequences into the living plant.

Picture 3: Microscopic view of the agrobacterium tumefaciens

4. Interview with Syngenta about Bt-Corn

We took an already done interview from the internet because our contact person wasn't able to respond to our questions on time.

Why does corn need protection from corn borers?

It is estimated that, each year, 40 million tons of corn never reach the market because of damage by the corn borer - equivalent to the entire production of Brazil. Damage and control costs in North America alone are thought to exceed US$1 billion per annum.

Chemical insecticides and biological control methods are available to control outbreaks of corn borer, but the nature of the infestation makes it difficult and expensive to control. The adult corn borer, a moth, lays its eggs on the corn plant and then the young larvae tunnel into the corn plant, eating it as they go. Eventually, the larvae eat so much of the inside of the corn plant that the plant can fall over or stop growing. If corn borers are not controlled, the larvae will eventually turn into moths and the cycle continues. To be effective, pesticides must be applied when the larvae are exposed on the surface of the plant. Once they start burrowing into the plant, conventional control methods are often ineffective.

Bt corn produces a protein that gives Bt corn built-in resistance to the corn borer - offering protection throughout the plant where the insect attacks.

What are the benefits of Bt corn?

Bt corn offers many benefits. It represents an environmentally sustainable way to control devastating insect pests and, therefore, to ensure yield. Also, grain from Bt corn is often of better quality than grain from conventional corn hybrids, since insect damage reduces grain quality. Studies show that there is a significant economic return from growing Bt corn, with yields protected in years when there is a heavy outbreak of corn borer. There is also evidence that Bt corn provides a form of protection to non-Bt corn by reducing the overall population of corn borers. In some areas, the moth can go through three generations in one summer, and controlling the first generation larvae in Bt corn means fewer moths emerging to start the second and third generations. The benefits of reducing the corn borer population are not limited to decreasing the direct damage caused by the larvae. The tunnels that the

larvae bore in the ears also provide an entry point for other pathogens, particularly fungi. These fungal infections affect the quality of the grain and reduce yields. One in particular, *Fusarium*, or "ear rot", produces molds that are unhealthy for animals eating the infested grain meaning that Bt corn is also in a position to make an important contribution to grain quality and safety.

How do you know Bt corn is safe?

Countries across the world have worked together to develop very strict food safety assessment procedures. These require a thorough analysis of scientific data by independent government experts prior to approval. The extensive information required in order to address the food safety assessments covers many areas.
The plant biology of Bt corn and its characteristics have been determined to be comparable, or substantially equivalent, to non-Bt corn. These tests assess the composition, nutrition, and general wholesomeness of Bt corn compared to non-Bt corn. Before Bt corn was approved for sale, it had to be demonstrated that any minor differences that were observed in scientific testing were within the range of normal variations in corn.
The safety of Bt corn for human and animal health has also been thoroughly addressed. These assessments considered and tested the possibility of allergic reactions. The assessments also evaluated the possibility that earlier techniques, which were used to select transformed plants, could be linked to antibiotic resistance. This extensive research led to the conclusion that Bt corn is as safe as non-Bt corn for human and animal health. Bt corn has a long history of safe use in many countries. Since Bt corn was first planted commercially in the United States in 1996, acreage has grown to about 12.3 million hectares (approximately 30 million acres).

What about the possibility of allergic reactions?

Bt corn has a long history of safe use and consumption.
Included in the regulatory process is an assessment of potential allergic reactions that carefully examines all introduced proteins to evaluate their potential to cause allergies. The question of whether Bt corn could cause a food allergy, centers on the fact that Bt protein is not normally found in corn.

Proteins that cause allergies have a very specific and well-characterized structure that "locks" onto the body's immune system, prompting the allergic reaction. If an introduced protein shows a similar structure to a known allergen, then a series of further tests is required to provide more information on the protein's potential to actually cause an allergy. This makes it possible to assess the likelihood of a new protein causing an allergy by comparing it with known allergens. Such evaluation is a requirement for the registration of genetically enhanced plants. The analysis conducted on the Bt protein in Syngenta Bt corn did not demonstrate any allergenic potential.

Does growing Bt corn have any adverse effects on the environment?

Before Bt corn could be approved, regulatory authorities thoroughly considered a wide range of research examining the possible impacts of Bt corn on non-target organisms including bees, ladybirds, butterflies, beetles, birds and small mammals. The mechanism whereby Bt protein controls the corn borer is highly specific, and most non-target organisms in the field are not affected by it. Rather, these animals digest the protein along with all the others in their diet.

Do the corn borer develop resistance to the built-in pesticide of Bt corn in the same way as some pests have become resistant to chemical pesticides?

The Bt protein that protects the plant against the corn borer is the active ingredient of a number of pesticide sprays employed to protect conventional and organic corn. In the decades they have been in use, there has been no evidence of the corn borer becoming resistant to Bt sprays in the field.

However, pests do find ways around plant control mechanisms. This is a well-known natural phenomenon, and can occur regardless of whether the protection is chemical or biological.

In order to prevent corn borers developing immunity to Bt protein, planting systems have been introduced in which Bt corn is grown surrounded by refuges, or blocks of non-Bt corn. These recommendations were developed based on the results of independent scientific recommendation. Even if any corn borers on the Bt corn are resistant to the Bt protein, they are likely to mate with non-resistant moths from the conventional corn, and the resistance will not be passed on to future generations.

In addition, in areas where Bt corn is grown commercially, insect populations are monitored to watch for resistance. In the many years since Bt corn was first planted, there have been no signs of resistance developing in target insects due to the use of Bt corn in the field.

5. Discussion

5.1. Progress made with the technique

By genetically modification of plants a huge progress was made. It is possible to directly modify the plant in the desired ,successful results. So laborious work by getting the same result by crossing is avoided. Another aspect is that the technique of crossing is limited, only closely related plant can share their gene-pool. So it can be said that by genetic engineering the whole process is much quicker, easier and precise.

5.2. Future research steps?

Future researches will include the improvement of transgenic corn, so that a resistance of the insect is minimized. The efficiency and the variation in term of using genetic manipulated corn is researched. So there may be probably new so called “supercorn”, which show many different traits e.g. better taste, bigger size etc. Also the implanting of the used DNA (the different techniques) will probably be improved. But very important is that in the future there must be an improvement of bt otherwise it can't be any longer be used, due to the rising resistance of insects.

5.3. Ethical aspects

Huge discussion were made over the past years if genetically modified plants are ethical. The one who are against it argue that human manipulate nature and therefore destroy nature by implanting something unnatural. Environmental activists made the gene manipulated corn responsible for the death of the bees but newest studies may have showed that bt-corn had no impact on the bees.
A greater problem is the discussion about the harmfulness to humans. Gilles-Eric Séralini showed in his study published in 2012 in the Journal *Food and Chemical Toxicology* the explicit harmful effect of bt-corn on rats. But the reliability of this study

is severely questioned, there may be some heavy unscientific methods used.

5.4. Advantages/ Disadvantages

Pros:

-No Insecticide spraying is needed on bt-corn.

-The use of bt-corn is very easy.

-By the larger harvest of corn, through using bt-protein the prices of the corn may also sink.

-Very specific, only attacks the bad insects.

-Bt-corn is also known for it's genetic stability, ,substantial equivalence, nutritive properties, -toxicity and allergic potential.

-Can also be engineered to have more vitamins and minerals.

-solve hunger world wide

Contra:

-There has been resistance found!

-Genetic pollution, leading that other plants get contaminated.

-Bt-corn may also kill beneficial insects like butterfly and bees

-Harmfulness to humans.

6. Summary

Through genetic engineering it is now possible to develop bt-corn, a plant that is protecting itself against pests. The concept of the bt-corn is very easy. Already a long time ago the effect of bt-proteins was known and developed. Today the process is very fast and is keeping improving.

A certain DNA sequence out of the bacillus thuringiensis is needed . In this DNA sequence the Cry1Ab gene is present. The *Cry1Ab* gene produces a Bt protein (Cry1Ab) that protects the plant from insect damage, for example by the European corn borer.

The DNA sequence from the *bacillus thuringiensis* can be transferred into the corn's DNA using different methods; some examples are by a gene gun, the electroporation method and the indirect transfer with *agrobacterium tumefaciens.*

There are different opinions about the use of bt-corn. There are critics and also praises. In the end science and nature must show what the right way is to go.

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