Bt-corn

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Biology Term Paper
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1 Preface

We asked ourselves how one could decrease the damage made by pests in an efficient way. We had already learned some basic facts about different ways of pest control in the advanced biology class. So we were interested in the methods of pest control using applications of genetic engineering in order to learn about the advantages and disadvantages of our chosen technique compared to the methods we had already learned something about. That is why we decided to write our term paper about the bt-concept focusing on bt-corn.

2 Introduction

Every year about 40 million tons of corn are destroyed by the European corn borer. So it is clear that you have to protect the corn somehow against this insect. One method to limit the damage was developed thanks to genetic engineering, bt-corn. It protects itself against the corn borer by producing bt-protein, which is toxic to the corn borer and kills it. In the following paragraphs we are going to explain how bt-corn works, how it is produced and we are going to discuss the advantages and disadvantages of this method.

2.1 History

It has been known for a while, that bt-brotein produced by bt-bacteria is toxic to many *Hexapoda.* And so bt-based insecticides have been used since the 1920s to protect crops. Because of their high specification these insecticides are environmentally friendly. The problem with these insecticides is, that they are only effective on the surface of a plant. As soon as, for example, the European corn borer is inside the corn plant, these insecticides have no effect on the corn borer any more.

In 1985 a Belgian company developed the first genetically engineered tobacco plant, which produced toxic bt-protein by itself. They managed to transfer the part of the gene that produces the toxic protein to the plants DNA. In the USA in 1996 farmers started to grow the first bt-corn. In 1997 the first bt-corn came on the market.

Nowadays there are more than 100 patents on different types of genetically modified plants. Famous companies that produce bt-corn are, for example, Syngenta and Monsanto.

Not in all country is it allowed to plant bt-corn ore even to allow it as food for humans and animals. These laws differ from county to country. In Switzerland genetically modified crops are allowed as food for humans and animals. In the USA there are specific laws about the farming of bt-corn. 20%-50% of the crop (depending on the Sate) has to be normal. This law tries to prevent the European corn borer building up a resistance against bt-protein.

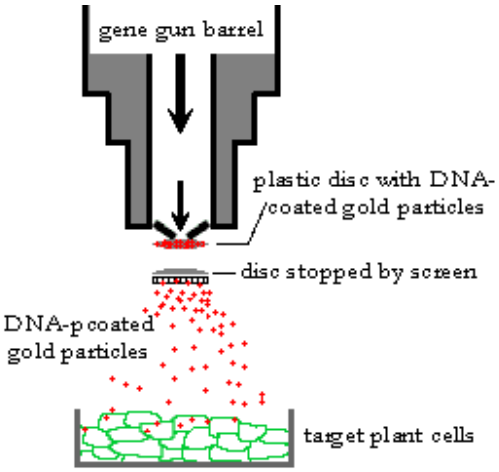
3 Description of engineering technique

The bt-concept is used for a lot of different plants and corn is one of them.
There are different techniques to transform the corn genetically to bt-corn
One is called the gene gun, another the electroporation/PEG method and a third works with the *agrobacterium tumefaciens*. The first and the second methods transfer the gene material directly into the cell. The third method transfers the gene material firstly into a bacterium (*agrobacterium tumefaciens*), which then transfers the gene into the plant cell.

3.1 The bt-concept

The bt-concept works in a genetically modified way. A gene sequence from a bacterium called *bacillus thuringiensis* is needed for this. This gene sequence is used for the production of a crystal protein (Cry protein). This protein is toxic to lots of insects. The basic concept is that the specific gene sequence from *bacillus thuringiensis* is taken and put into a plant's DNA, so that this plant then produces the Cry protein. When an insect eats from a bt-plant, the crystal protein gets into the insect's gut. There it is split through enzyme reactions into Cry toxins. The high pH-value then activates the toxin. The Cry toxin gets inserted into the gut cell membrane of the insect and there it produces a pore. Through this pore the gut content can escape into the insect's body and can causes a bacteria septicamia. This leads, in most cases, to the death of the infected insect.
(The following methods are all used to transfer the specific gene sequence from *bacillus thuringiensis* into the DNA of corn to produce bt-corn.

3.2 The gene gun



The gene gun is a construction that shoots macro projectiles made of heavy metals into a living cell. These macro projectiles consist mostly of gold or tungsten (silver is also used) and are coated with the gene material that should be transferred to the living cells. When such a particle penetrates the cell, gene material is transferred. Although many cells receive gene material only few of them receive a complete gene sequence that works perfectly. This gene material also contains a so-called marker gene. This marker gene usually contains some kind of antibiotic resistance. The cells, which have been transformed successfully, develop such a resistance. Later on all the cells, which were shot with the gene gun are exposed to antibiotics and only the ones with a complete gene sequence (containing the marker gene) survive. These cells can be reproduced in order to form a single plant.

3.3 Electroporation and PEG method

Electroporation works basically with electric shocks hitting the cell's membrane. To achieve this, the cells are put into a salt-free solution. This cell solution is put into a small vessel with an aluminum electrode on each side and is shocked by an electroporator, an apparatus that can generate an electromagnetic field in the cell solution. Through this process the cell membrane becomes permeable and DNA can be absorbed by the living cell. Afterwards the cells are put into an optimal environment to regenerate perfectly. The PEG method works basically in the same way with the difference that the cell membrane is made permeable with chemicals instead of with electric shocks.

3.4 Indirect transfer with *agrobacterium tumefaciens*

The *agrobacterium tumefaciens* is a bacterium that transfers its gene material into cells of living plants for its own reproduction. In this method the harmful gene sequences are ''cut out'' and the bt-genes with the marker gene are inserted. This is done to the bacterium because it is much easier to transform genes into a bacterium than into the cell of a living plant. The cells that should be transformed, are exposed to such *agrobacteria tumefaciens*. The bacteria then act as they usually do but they now transfer their transformed gene sequences into the living plant. The plant then produces the necessary protein crystal for the bt-concept. The transformed plant cell is then reproduced in order to form a single plant.

4 Interview

We interviewed Jan Lucht on the 11th of April in the Unternehmen Mitte Basel. He worked 14 years as a researcher in genetic engineering and molecular biology. Nowadays he works for science industries and as a contact person for questions concerning genetic engineering, agriculture and nutrition.
We did the interview in German and translated it into English, so the interview is not translated word for word, but the content is the same.

What are the advantages and disadvantages of bt-products?

The advantages are that you can create plants with special abilities, which you couldn't reach with methods like crossing over. For example creating plants with resistance against insects. There is no corn that is naturally resistant against any insects. One advantage in the production of genetically modified plants is that you can increase the speed of producing a plant with new characteristics compared to the method of crossing over. With the procedure of crossing over it can take several decades to create a plant with new characteristics. With genetic engineering it takes only one generation.
The disadvantages are that lots of people, especially in Europe, are concerned about bt-products because they are genetically modified and they think that genetically modified products have negative impact. Because of this negative attitude from European society a lot of companies active in genetic engineering have moved their research activities out of Europe.

At the moment planting bt-corn in Switzerland is forbidden. It is only allowed to import and sell it.
Do you think it would make sense to plant bt-corn in Switzerland?

At first, in general, you have to check whether a plant is in danger of being attacked by pests and then you have to find out if a bt-plant exist that can solve the problem in a efficient way and is suitable to be planted in Switzerland and, if so, in which region.
Now if you take a look at the corn planted in Switzerland, the European corn borer (which can be fought against with bt-corn), occurs and sometimes does some damage, but it is not such a big threat that bt-corn is needed.
In Switzerland the European corn borer is fought with biological pest control (with *Ichneumonoidae*)
There were some model calculations if it's worth to plant bt-corn in Switzerland but the results showed that it is not.

Where does it make sense to plant bt-corn in your opinion?

It makes more sense to plant bt-corn in warmer regions, where the European corn borer is more common, because there the corn borer causes much more damage, for example in Spain, where a high percentage of the corn planted is already bt-corn.

Do you think it could be a problem that farmers could depend on bt-corn producing companies? For example that they could not be competitive enough if they did not use bt-corn, or that they had to buy the seeds from the company every year.

Firstly, what a lot of people do not know is that in industrialized countries farmers buy their seeds every year anyway because out of these seeds grow plants, which are more profitable than the seeds, which they produce form their own corn. The seeds, which you can buy from these companies, are more likely to grow into profitable plants because they are tested for diseases and are grown specifically.
The farmer also profits from utilising of bt-plants and it's not that he is forced to plant them.
A negative side effect is that bt-seeds are more expensive. Normally you would still make a higher profit, because bt-plants are more efficient than normal pest control. However, if a bad harvest occurs because of bad seasonal weather, for instance, the farmer looses much more money because of investing more money with no return.

What could still be improved concerning the technical aspects and society's acceptance of bt-corn?

Concerning the technical aspects: companies are working on different types of bt-toxins in case a pest forms a resistance to one bt-toxin. In order to prevent or avoid this resistance some companies count on bt-toxin combinations (also known as stacking) which means it takes much more time for pests to build up a resistance.
Regarding society's acceptance: in general, to be accceted a product is needed that works as a good example to show that bt-end-products do not differ from normal products such as taste or appearance. Basically this product needs an advantage for the consumer compared to regular products in order to get general acceptance. One example would be that it was a lot cheaper or that it tasted better. As soon as bt-products are accepted grocery markets would sell bt-end-products.

5 Discussion

5.1 Progress made with the application of the chosen technique

Actually great progress has been made. Before genetic engineering, plants must had to be crossed in order to achieve better resistance or a bigger crop yield for instance. This process took many generations to bring it to perfection. Nowadays, with the help of genetic engineering, it is easier to generate plants with the advantages you need. Not only this, but you can also cross plant DNA with the DNA of bacteria to get even more genetic advantages. This was never possible with the process of crossing plants. The speed of generating the plants you need has also increased very much.
Therefore the possibilities and the creation of artificial genetic variety has increased and speeded up, which has led to a greater efficiency on agricultural levels.

5.2 Future research steps

Future research steps will probably be concerned with advancing the efficiency of the mentioned techniques (see 3.1) or maybe also the development of new, more efficient methods for transferring or modifying useful gene sequences or even creating whole gene sequences.
The possibilities of advancing genetic are numerous.
In future, genetically modified products will probably also be accessible at a lower price and to a bigger group such as developing countries.

5.3 Advantages and Disadvantages

The usage of genetic engineering has advantages and disadvantages and can bring great success but may also lead to some dangers. It is the same with bt-corn and in the following paragraphs we give some pros and cons regarding farming with bt-corn.

5.3.1 Pros

bt-corn is very specific as to pests. It only targets insect that attack it. There for, almost no other insects are damaged as a side effect. Because of this, there is no need for any extra insecticides that would also cause more side effects. Of course, because no other chemical products are used, bt-corn is perfectly biodegradable.
Because bt-corn is extremely effective against the European corn borer, which causes the most damage in corn plantations, it saves a lot of corn so farmers can produce corn more efficiently and this could lead to cheaper price for consumers.

5.3.2 Cons

The more bt-corn is planted, the higher is the possibility that the European corn borer will form a resistance against the bt-toxin and this risk is always present.
There is also always the risk that the marker gene, which is needed in the production of genetically modified corn, has side effects on humans. And in general it is not really known if genetically modified plants are safe for human consumption. According to some researchers bt-corn has caused allergies to humans, but only in a few cases.
Then there is always the risk that genetically modified genes could be introduced into wild plants, which could lead to variety of problems.
And lastly, when a high producing corn is developed, the farmers of developing countries would depend on the production companies, which again would lead to different problems.

6. Summary

Thanks to genetic engineering and *bacillus thuringiensis* it was possible to develop bt-corn, plant protecting itself against pests. The bt-concept sounds quite easy. You take a DNA sequence out of *bacillus thuringiensis*, which is used for the production of the bt-protein. This bt-protein is toxic for some insects and leads to death when it is absorbed, for example, by the European corn borer. This DNA sequence is introduced into the DNA of the corn, so that the modified corn can produce the toxic pt-protein. Then when an insect starts to feed on this modified corn it also absorbs the pt-protein and dies, and doesn't do any damage to the plant.

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

bt-corn was commercially planted in the USA for the firs time in 1996. Today in some countries such as Spain or the USA already a high percentage of the corn planted is bt-corn. In some countries though (mostly in Europe) it is not allowed, because a lot of people are quite skeptical regarding genetically modified plants. They are scared that genetically modified plants like bt-corn could have side effects on humans. They could also be against it because they think it is not good if farmers become depended on companies producing genetically modified plants. Because of some of these disadvantages, it does make sense not to plant bt-corn everywhere also because then insects could become resistant to it more quickly. However, in regions where a lot of the corn is destroyed by the European corn borer it is a good way to fight against this insect. As it is a very efficient method, farmers can be more efficient and no other pesticides are needed.

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