by Cormac Klaar, Gabriel Steiner,Jon Wenger

Bt-corn

A few weeks ago we got given some insight into the topic Bt-corn in our Schwerpunktfach biology class. In the beginning we were quite clueless as to which topic we should choose that's why this short introduction was a welcome incentive to analyse this topic even further seeing as what we did in our Schwerpunktfach was really quite limited. It also seems quite relevant to everyday life. For example next time you go to a grocery store you might look at the label of the maize or other vegetable you're buying and think twice about getting it. The interesting part for us is how this technique of replacing or adding genes to a species works and how effective it is. I mean the whole Idea is pretty ingenious as it is. The mechanics of this will obviously be explained in great detail later on. In the following paper we aim to give you, the reader some insight into the whole GMO and especially the Bt-corn topic. We will list advantages and disadvantages and include a short interview with an expert.

Introduction

Bt-corn is a genetically modified organism or GMO for short. GMOs are plants or animals which have artificially been given a specific and intended trait by adding genetic material from other plants or animals which have that trait. In Bt-corn and other genetically modified vegetables and fruits the trait mostly acts as a substitute for insecticides and pesticides. Bt-corn is specifically called this because of the Bt delta endotoxin which was added to its genetic material through molecular techniques. It is basically a poison which becomes part of the corn and only kills the larvae and caterpillars which ingest parts of the corn. For everything else it is harmless.

Bt was discovered in 1901 by a Japanese biologist. He was actually investigating a disease that was killing silkworms at the time. since then lots of different strains of Bt have been discovered. Each of these has a different effects for example the strain in Bt-corn is specifically intended to kill caterpillars and larvae of the corn borer and nothing else. Today government and private industries fund Bt research because of how environmentally friendly and effective it is.

As mentioned above this technique of manipulating genes is widely used in GMO research. There are many different vegetables, fruits, pulses and other crop types which have been genetically modified. The overall aim is to increase crop yield by making the crop poisonous to whatever is trying to eat it.

The alternative to Bt are common pesticides and insecticides. These are generally not as environment-friendly and as effective as Bt and other genetical modifications. And they are also less healthy for the consumer.

Technique

Fundamental for a successful development of a genetically modified crop is to have an organism that contains the desired trait, in our case the toxic Bt protein. The shortcut Bt comes from the bacteria *Bacillus thuringiensis* which contains the toxin.

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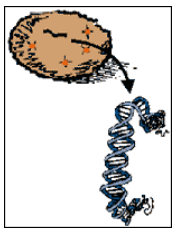
The Bt toxin was first discovered roughly 100 years ago by oriental silk worm farmers that had lost many worms due to the bacteria. Scientists found out that it's the soil bacteria *Bacillus thuringiensis* killing the worms with the protein. The European corn borer caused big problems for farmers in Europe and same as the silk worm it belongs to the order of the Lepidoptera meaning Bt proteins resist them as well. This initiated the development of Bt-corn.

The genetic engineering process of Bt-corn crops can be described in 3 steps:

Step 1 : DNA extraction

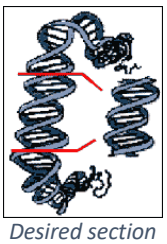
To be able to work with the desired trait of a DNA it must be separated from the rest of the cell. The process of DNA extraction is used. First one breaks open (lyse) the cell containing the desired DNA. After that DNA associated proteins and other cellular proteins are degraded with the addition of the enzyme protease the DNA gets isolated in ice cold ethanol due to its insolubility in alcohol.



Extracted DNA from an organism

Step 2 : Gene cloning

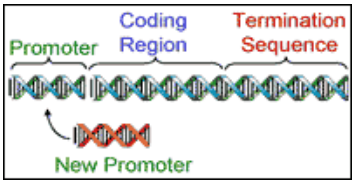
Now that all the DNA is extracted the next step called gene cloning is applied. The purpose of cloning is to separate the desired gene containing the trait from the rest of the extracted DNA. Cloning works through a series of techniques including the breaking by enzymes. Further processes require a deeper understanding and more experiments with the sample which is why it has to be copied multiple times to test it properly.



Desired section

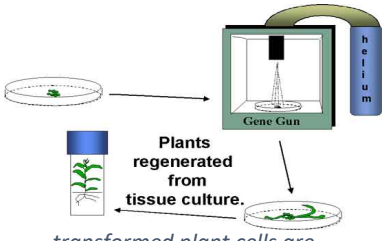
Step 3 : Gene design and transformation

The aim of gene design is to make a certain gene work, in our case the one responsible for the Bt protein, once its inserted into a new DNA. This is done by cutting the gene open with enzymes in a test tube and replacing certain parts of the strand to find out what`s best.



Replacing existing promoter with new promoter

Once the gene is modified the transformation can begin. To propagate many undifferentiated plant cells called callus, tissue culture is used. The main goal of transformation is to transport the modified gene delivering it into the nucleus of a cell without killing it. There are various methods one of the most common ones is gun shooting gene-coated microscopic gold particles at plant cells to deliver the DNA into the nucleus. The new DNA may or may not be successfully inserted into a chromosome. The receiving cells are the product and called transgenic and when grown contain the desired trait. Finally backcross breeding is used. Transgenic lines are crossed with elite lines to make high yielding transgenic lines.



transformed plant cells are regenerated into transgenic plants.

Gene gun in usage

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Documentation

Interview with Dr. Dominik Klauser

Research & Development

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1) What recent progress was made with Bt-corn?

Bt is a gene from a soil microorganism that produces a compound (protein) that is toxic for insects. It has been transferred into the plant so that plants can produce this compound themselves and therefore better defend themselves from feeding insects. This for instance reduces the need for insecticide application. Bt itself is a rather old trait, with Bt-corn first being approved in 1996 in the US. Therefore I do not assume that there has been a lot of research in recent years, apart from maybe getting it into other crops (Bt for instance has also been introduced into cotton, soy, canola) and combining (stacking) it with other traits, such as herbicide resistance.

2) What are future research plans?

Transgenic crop breeding such as for instance for Bt is very costly as thorough environmental assessments have to be fulfilled. I therefore believe that these costs currently outweigh the benefits of transgenic crops and that breeders are looking at alternatives for breeding. This could for instance include traditional breeding approaches, molecular breeding and new tools, such as genome editing. Target traits will include better growth, better resistance to drought and diseases, to name a few.

3) How much is Bt-corn used in Switzerland and Europe?

One is not allowed to grow Bt-corn in Switzerland as well as in most parts of Europe. However, there might be some Bt-corn being imported into Switzerland for animal feed but I lack the data (the Bundesamt für Landwirtschaft or the Eidg. Zollverwaltung should know). What I know however is that for instance Bt-cotton is broadly used in Switzerland and that most of the T-shirts, jeans, etc we wear are made of it.

4) What is the primary danger with genetically modified species and what consequences are visual?

The initial danger was that the antibiotics resistance gene would get transferred into the crop together with the Bt gene. This was necessary to check whether the gene

transfer was successful. This led to the fear that this antibiotics resistance gene could then be transferred to pathogenic bacteria and make them resistant to antibiotic treatments (and thus making certain infections untreatable). However, technology has become far more sophisticated over time and no antibiotics resistance genes are transferred into the crops today. Also, there is a similar belief that genes, such as the Bt gene could be crossed out to wild species but to my knowledge, this has not really occurred so far. Another danger is that upon excessive use of a trait, insects could become resistant. This is for instance observed for certain herbicides, where weeds have become resistant and thus weed management has become very difficult (for example with Glyphosate and corn in certain areas of the US). Lastly, there is a general scepticism that transgenic crops can only profitably be produced and sold by a few big, multinational companies and farmers would become dependent on them.

5) What is the main goal in research of Bt-corn?

The main goal was to make plants more resistant to feeding insects so that insecticide application could be reduced. It also reduces the workload of farmers.

6) Are you a supporter of Bt-corn respectively of genetically modified species in general and why?

I am not against transgenic crops per se but would say that they would always need a rigorous analysis on whether they are needed and beneficial to farmers and how they impact ecosystems.

7) Where did Bt-corn already have a negative influence on the Biodiversity?

There are massive corn monocultures in the Midwest of the US (the so-called corn belt) where hardly any ecosystems have prevailed. However, I am not sure whether they are the result of Bt-corn or of agricultural intensification itself.

8) Where are genetically modified species the most meaningful and where are they unnecessary?

One has to see that genetic modification does not only occur in plants, but also in microorganisms and animals. In this context, I think that genetic modification for instance really helped the production of medicine. For instance, insulin is produced from transgenic bacteria today whereas before, insulin was extracted from horse-blood (a truly bloody business). So for the sake of the diabetics and the horses, I believe that this is a great achievement. For plants, I believe that certain traits really helped growers, for instance in the case of Bt-cotton and Indian smallholder farmers. Potentially other transgenic crops, like vitamin-rich (golden) rice, could also be very beneficial for people in Asia without negatively impacting the environment. For Bt-corn, I have mixed feelings as although I do not see any clear danger from using it, it serves very intensive agriculture in mostly developed countries. Moreover, probably 99% of all Bt-corn produced goes into animal feed, therefore not directly feeding us

but helping us to meet our ever-increasing and environmentally unhealthy appetite for meat. Lastly, what I do not approve of is transgenic animals for the food industry (such as for instance the recently released transgenic salmon that grows much quicker) - I do have strong ethical concerns that we should not use this technology on organisms with nervous systems as we do not know whether introduced genes have any complications.

Discussion

Advantages of Bt-corn:

For the biodiversity:

Bt corn does not harm harmless and benefitial Insects. The protein bacterium called bacillus thurigiensis, or Bt doesn't affect the insects which are harmless and beneficial for the crop. Broad-spectrum insecticides kill all the insects, Bt on the other hand specifically kills harmful crop destroying larvae like those of the stem borer. It's better for the environment. Due to the smaller use of pesticides, less chemicals leak into the surrounding area.

For the farmer:

Bt corn has higher yields. The study *Crop Science* which got published in the year 2013 showed that the genetical modification doesn't only make the crop resistant to pests. The Bt corn crop uses the nitrogen in the ground more efficiently than normal corn too.

It's cheaper. The Bt-corn seeds aren't much more expensive than those of normal corn and because the farmer doesn't have to buy chemical pesticides, the cost of production is lower and the farmer earns more by it.

It's healthier for the farmer because the farmer isn't exposed to the hazardous chemicals which usually get sprayed over the corn fields.

Because Bt-corn needs less pesticides and the fact that it uses the nitrogen in the ground more efficiently it is much more profitable for the farmers. Especially for those in African countries. It helps the farmers to survive and get a surplus which helps to strengthen the local communities

For the consumer:

It's healthier. Because of the smaller usage of the pesticides, there are less poisonous chemicals on the corn.

Disadvantages of Bt-corn:

For the consumer:

It can lead to allergic reactions. Even though the U.S. Food and Drug Administration and the Environmental Protection Agency have stated that Bt-corn is safe to eat, many scientists don't believe in the safety of the crop. Because the DNA of the corn

has been altered, in every bite of the corn there is Bt. This can lead to allergic reaction due to the introduction of new proteins into the food supply.

For the biodiversity:

The biggest disadvantage of Bt-corn is the unknown future. Even though Bt-corn has already been in use for nearly two decades, there are no studies about the long-term effect of the Bt on the environment. For example monarch butterfly populations have big problems with the toxic pollen of Bt-corn.

Another disadvantage is that even though most of the pests get killed some survive, due to a natural resistance. These survivors reproduce and pass this trait on to the next generation, which leads to a resistant generation. This can lead to a bigger usage of pesticides.

The future of the Bt-corn

Bt is relatively old, and is one of the only widely used genes in transgenic research. Transgenetic crop breeding for Bt-corn is very expensive, because many environmental assessments have to be fulfilled. For quite some time there hasn't been much progress, because the costs for a licence are too high for further research.

However, Bt-corn is still relevant. Bt-corn is widely used all over the world except Europe. In the U.S. especially most of the corn is genetically modified. Bt-corn also gets used more and more in Africa to stop the hunger crisis. For example the agriculture in Kenya has a bright future because of the success of the project WEMA (Water Efficient Maize for Africa) by the AATF (African Agricultural Technology Foundation). There Bt-corn gets used a lot because of its resistance against the two biggest pests, the spotted stem borer (*Chilo Partellus)* and the African stem borer *(Busseola Fusca).* Since it also increases yield it helps the farmers to nourish their families and gives them a surplus which they can sell to get bigger. This helps the local communities to develop and get stronger.

Kenyan Harvester
with Bt corn in his hands.

Summary

Overall Bt-corn is a great substitute to regular pesticides. It is much more environmentally friendly and effective. We found the whole idea and process very interesting. To summarize shortly: Bt-corn is a genetically modified organism. The Bt delta endotoxin is extracted from a type of bacteria. The corn cell is then infused with it and backcross-bred. This Bt-corn is then planted as a normal crop. The whole point of it is to not use pesticide. Instead it kills specific corn eating insect larvae when these ingest it while at the same time being harmless to other organisms. The advantages out way the disadvantages but Europe still doesn't plant it. Therefore it has quite a bright future in third-world-countries especially in Africa because of its higher yield and overall lower cost.

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