Genetic Engineering in Trees

Biology Term Paper

by

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Saturday, 17 April 2010

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1. Preface

We spontaneously had the idea to investigate the topic of fast growing trees. Finally we found the topic too narrowed, thus we decided to elaborate the theme of genetically engineered trees in general. Our idea emerged from one of our grandfather's statement, who worked for the Basler Zeitung, as he told us, that we will face a lack of paper, if we don't do something against the decline of forests. We read about fast growing trees which produce a lower amount of lignin and therefore may be used to produce paper easier. It seemed to us to be very a interesting topic and therefore we decided to do our biology work about this topic.

It will also be interesting because, by using genetically engineered trees, we may act against the upcoming climate change, what may be very useful in the near future. The other interesting part is that genetically engineered trees can be used for the production of bio-fuel to replace non renewable energy resources.

Our questions are:

- For what are genetically engineered trees used?
- How are trees genetically engineered?
- Is it realistic to use them to protect our environment?
- By using them, is there any harm to the environment?

There exist many other fields on which researches are made with genetically engineered trees. Examples for such research goals are better tolerances against temperature variations, growth in high salinity or drought, and phytoremediation, what stands for the cleaning of the soil from heavy metal pollution by genetically modified trees.

2. Introduction

Most of the used energy for transportation and heating is derived from fossil oil. But the resources have limited amounts. By using fossil oil, carbon dioxide, which is harmful to the environment, is produced in big amounts and because of that a climate change appears. Against this effect some scientists had the idea to create trees with special engineered genes that make the trees growing faster. They can be used for bio ethanol production, another possibility of energy supply.

The wood market is rising up. The wood is used for renewable energy, for paper production or for building materials. The area for wood planting will increase in the next ten years to a double. There is no other solution than genetically engineered trees. Fast growing trees for example will partially cover the demand. The IUFRO, International union for Forest Resource Organisation, thinks that the higher storage of carbon dioxide in the trees will counter act the greenhouse effect.

In the US are the most genetic engineered trees used. Most of them are poplar. They have a different quality of the wood, and have an increase of the biomass production. Other genetically engineered poplars are kept sterile. The US plans to plant eucalyptus with resistance to cold temperature, because until now these trees only grow in Florida but the US would like to be able to plant the trees in the whole country. Therefore they need the genetically engineered eucalyptus.

Also in Europe mostly poplars are planted. The first experiments were done in Belgium in 1988. Now there are some outdoor tests in France, Germany, Sweden, Great Britain, Spain, and Norway. In Belgium are some tests for poplar with combustion of lignin, a macromolecule which is the most important content of wood, and cellulose, which is modified for an easier production of bio ethanol. The production is not only easier but also polluting chemicals are less used.

Between 1993 and 2009 sixty genetically engineered trees were approved by the authorities. The trees are poplar, birch, spruce, pine, apples, cherries and plum.

In France poplars are planted with engineered genes, which make the trees resistant to herbicides and insecticides.

In China poplars which are resistant to *“Raupenfrass”,* were planted. Over time the poplar trees show some special reaction. The older ones create bigger leaves and change the structure of the bark.

In 2005 the Chinese wanted to afforest big regions, part of the plantation will be Bt-poplars (Bt = with the help of Bacillus thuringiensis genetically modified plants). The Bt-poplars are free for a commercial cultivation since 2002. The idea was to plant a part of the plantation with normal poplars and the other part with Bt- poplars, mainly because the Bt-poplars decrease the amount of the vermin. But too much of the Bt- poplars cause that the vermin will create resistances. Another problem is that the Bt-poplars will give their genetically modified genes to the next generations. To solve that problem, two different kinds of Bt-poplars, poplar-12 and poplar-741, were produced. Both of them don't produce pollens so they won't accrete. The Bt- poplars create seeds if they are pollinated but the poplar- 741 aren't germinable. The poplar- 12 cultivate fertile seeds but they are not able to survive in the region where the poplar plantation is located as it is to dry. If there are any saplings, they will be eaten by cows or sheep, or they will be destroyed by cultivation.

3. Descriptions of Engineered Technique

There exist several methods to introduce foreign genes into tree cells. One method is to use Agrobacterium, a bacterium living in the soil and causing diseases. Two different species of the genus Agrobacterium are used:

- *Agrobacterium Tumefaciens:*
  The bacterium Agrobacterium tumefaciens normally causes crown gall disease by invading the plant's cell through the roots. By using that feature the bacterium can be used to transfer foreign genes into trees.

  After having removed the bad genes of the bacterium's plasmid, a vector plasmid is introduced into the bacterium and used to deliver the desired genes into the tree. When the bacterium gets into the tree, part of the bacterium's DNA (called t-DNA) is transferred into and expressed within the plant's nuclear genome. By that way it is possible to introduce any gene into the tree. Using these modified seedlings, transgenic trees can be regenerated and grown.

- *Agrobacterium Rhizogenes:*
  The bacterium Agrobacterium rhizogenes normally causes hairy root disease. The hairy root disease causes a change in the roots which makes them bigger. That can be used in trees fro helping establishment or surviving drought stress. Out of plants suffering from hairy root disease others can be regenerated. These often are smaller and also have other special features. Through that they can be attractive for people searching trees with those properties.

Another method to introduce foreign genes into trees is the use of a gene gun. The gene gun is an apparatus that shoots very small particles, consisting of tungsten or gold, with a diameter of less than 1 µm and which are coated with DNA into the cell. The DNA on the projectile is taken up into the cell nucleus. With that method it is possible to introduce for example disease or pest resistance into the tree.

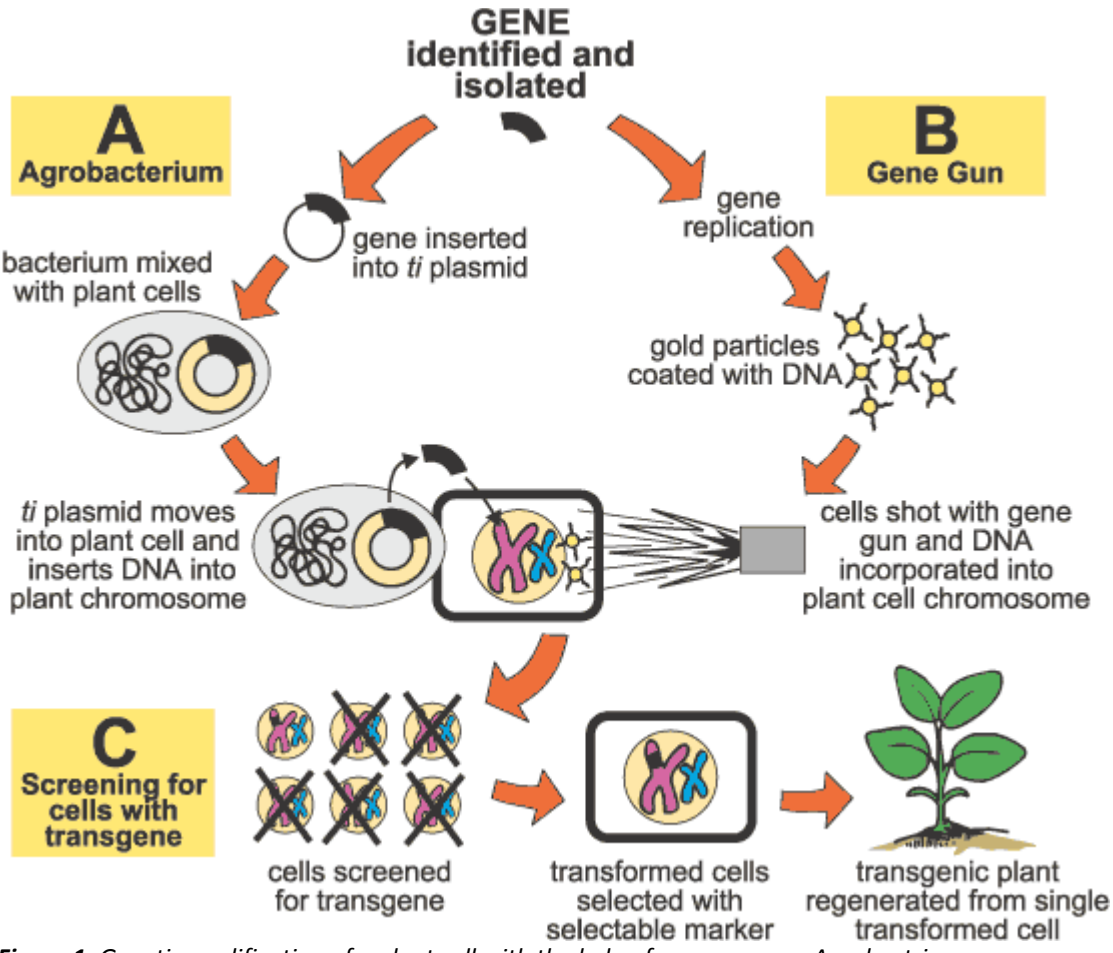

Figure 1: *Genetic modification of a plant cell with the help of a gene gun or Agrobactrium.*

To identify the genetically modified cells, often a selectable marker is introduced together with the gene of interest. Most of the used selectable markers include a gene which causes a resistance to the antibiotics kanamycin and G418 or to herbicides such as glyphosate.

4. Interview

We couldn't find an interview partner but we found an interview from BioSicherheit with PD Dr. Matthias Fladung in German. We thought to translate and that we put shortened parts of it into this paper.

Question: Which traits of the polar are important to optimize the raw material and to make the cultivation commercial?

Answer: For the breeders is the mass benefit of outermost importance. They want to optimize the growth rate and the building of wood and of course create resistance, often against funguses.

Question: With genetically methods are new possibilities accrued. Where is the beginning?

Answer: Important is the transport of genes e.g. resistance. Another possibility is to change the amount of lignin for the production of paper, increase of the growth rate, to change the bloom trait or to create tolerances against temperature variations, growth in high salinity or drought, and phytoremediation.

Question: There is a big discussion about genetically modified trees, is an acceptant possible?

Answer: If there is no change with the environment, yes and it must be sure that there is no contamination of the gene pool with the transgene. It is proved that sterility can be induced but more studies are necessary.

Question: Are there other benefits of genetically engineered poplars?

Answer: Yes, especially lignin. To produce wood they need aggressive chemicals and the waste water and the acids lade the environment e.g. the creeks are too warm. And the demand of paper is higher than ever. If there is a possibility to produce wood easier then it is something for the ecology.

Link to the entire interview: http://www.biosicherheit.de/de/gehoelze/pappel/596.doku.html

5. Discussion

There exist different kinds of genetically engineered trees. There are trees with less lignin to ease the production of bio-fuel and paper out of it, trees with a higher growth rate, others with a resistance of herbicides, insecticide, fungicide or a resistance to vermin or pests and diseases.

Trees with Less Lignin

In the production of bio fuel, lignin is a matter that cannot be used and has to be removed. Because of that the production of bio fuel is much easier when there is the possibility to use genetically engineered trees with a smaller amount of lignin. In the paper production as well lignin is a matter of no interest which has to be removed with chemicals which are harmful to the environment. When these trees can be used, the used amount of those chemicals drops. Through that the environment also can be protected because of those trees. Another possibility is to change the structure of lignin. That is useful because it is easier to split off the lignin from the cellulose and the production of paper can be simplified.

Fast-Growing Trees

There exist genetically modified trees that have a higher growth rate than normal ones.

Scientists hope that in few years it will be possible to use those trees to counteract the greenhouse effect. To do so they want to plant many of these fast-growing trees to use their ability to convert carbon dioxide into oxygen.

Trees with a Resistance

There exist genetically modified trees that are resistant to several substances, vermin or transmittable. Important is that the trees are robust to diseases and predators, herbicide resistance plays just a minor role in tree improvement because it is much less important to trees to antagonize pest plants than it is for crops. For forest trees it is important that they have insecticide- and fungicide resistance and for fruit trees the resistance against bacteria, fungi diseases and virus is more important.

Future Research Steps

Scientists are searching for methods to elongate the cellulose strings with the help of genetic engineering.

Sanofi, a large pharmaceutical company in France, wants to create a chestnut tree which is resistant to the Monsanto-Herbicide “Round up”.

Pros and Contras of Genetically Engineered Trees

Pro	*Contra*
Possibility to counteract the greenhouse effect	Needs much space
Renewable energy resource	Big amounts of water are used
Less chemicals may be used for the production of paper	No one can foresee the consequences
	The gene can be passed to the next generation
	If a problem will take place there will be no possibility to fix it
	Likely to be harmful for insects, for the soil and for other plants

We think that genetic engineering is a very interesting part of biology and opens completely new possibilities. Because of that it is very important to make further research progress in that field and not to prohibit everything concerning genetic engineering. But it's also very dangerous. Trees which are planted today will live for many years and the scientists don't know anything about what will happen. Additionally there are many scientists that aren't as confident as the people pronounced above that it will be possible to fight the greenhouse effects with fast-growing trees. For that reason it is important to take safety measures.

6. Short Summary

During the work on that term paper we found out that there exist many different kinds of genetic engineering in trees, e.g. trees with less lignin to simplify the production of paper and bio-ethanol, fast-growing trees, trees with resistances for several agents, trees with higher tolerances e.g.to temperature variations and drought and trees which should be used for phytoremediation. We dealt with different methods of genetic engineering in trees: First by the use of plasmid transmission with Agrobacterium and second with the use of a gene gun. To the end of this work we elaborated with advantages and disadvantages of genetic engineering in trees. The most important point to mention is that with the help of genetic engineered trees it would theoretically be possible to counteract the greenhouse effect. But there is still too few research done to definitely state that it will be possible to do so. A big disadvantage is that it is not known whether these trees will be harmful to any animals and plants. There are still many unknown issues and because of that it is important to progress safely to ensure that when something will go bad, the environment will not be damaged.

7. References

http://www.greenpeace.de/themen/gentechnik/nachrichten/artikel/kanada_gegen_ein_verbot_von_gentechnisch_veraenderten_baeumen/

http://www.transgen.de/aktuell/1063.doku.html

http://www.nature.com/nature/journal/v433/n7026/images/433583a-f2.2.jpg

http://de.wikipedia.org/wiki/Antisense-RNA

http://de.wikipedia.org/wiki/Lignin#Ligninsynthese

http://de.wikipedia.org/wiki/Gr%C3%BCne_Gentechnik

http://www.biosicherheit.de/de/gehoelze/59.doku.html

http://www.biosicherheit.de/de/gehoelze/pappel/325.doku.html

http://www.biosicherheit.de/de/gehoelze/pappel/596.doku.html

http://www.biosicherheit.de/de/gehoelze/pappel/54.doku.html

http://www.biosicherheit.de/de/sicherheitsforschung/214.doku.html

http://www.biosicherheit.de/de/sicherheitsforschung/215.doku.html

http://joa.isa-arbor.com/request.asp?JournalID=1&ArticleID=102&Type=2

http://de.wikipedia.org/wiki/Genkanone

http://www.rff.org/News/Features/Pages/Genetically-Engineered-Trees.aspx

http://umweltinstitut.org/agro-kraftstoffe/allgemeines/energiepflanzen_gentechnik-571.html

http://www.naturalnews.com/020766_trees_ethanol_research.html

http://www.sierraclub.org/biotech/trees.asp

http://www.eco-world.de/scripts/basics/econews/basics.prg?a_no=18845

http://www.vti.bund.de/de/institute/fg/forschung/genres.htm

http://www.vti.bund.de/de/institute/fg/forschung/biodiv.htm

http://www.falter.at/web/heureka/archiv/00_1/02.php

http://www.wrm.org.uy/subjects/GMTrees/text.html (<-the downloadable .pdf document on that page)

Link to Figure 1: http://www.ag.ndsu.edu/pubs/plantsci/crops/a1219-2.gif