Green genetic engineering – a controversial future technology

Green genetic engineering comprises a plethora of methods that enable the production of genetically modified (i.e. transgenic) plants by introducing extra genes, which are often foreign to the species into which they are introduced, into a plant genome. The number to be introduced can vary from one single gene to several genes. For example, in order to establish a new and foreign metabolic pathway in a particular plant, several genes need to be introduced. The first field trials with transgenic plants were carried out in the USA in 1986 and the worldwide cultivation of transgenic plants has increased year on year ever since.

Depending on the goal of any particular genetic modification, transgenic plants are divided into first-, second- and third-generation plants. In first-generation transgenic plants, one or two plant genes were modified in order to improve the agronomic properties of the plant, but not the quality of its product. First-generation genetically modified plants include plants that have a higher resistance to pests, herbicides, drought and cold. Rape, maize, soybean and cotton, i.e., crops that have been able to gain in economic importance, are the main plants in this category. However, the modification of rice is also becoming more and more important. In first-generation plants, the advantages of green
genetic engineering are that it is less labour-intensive and less costly to cultivate the plants, and it also generates an increase in yield and quality.

In second-generation plants, several genes were modified in order to alter existing metabolic pathways to obtain new food properties. Second-generation plants include plants with substances that are beneficial to human health (better known as functional food). Examples of plants with qualitatively enhanced properties are rape and soybean varieties with a healthier composition of oils, as well as fruit and field crops with a reduced number of allergens or an improved vitamin content. A well-known example of second-generation plants is "golden rice", which is engineered to produce beta carotene (pro-vitamin A). Such plants help wage the war against starvation and nutrient deficiency in countries with a shortage of dietary vitamin A, for example.

Plants used to produce non-plant products are referred to as third-generation plants. This involves the creation and cultivation of transgenic plants that are able to produce high-quality compounds of therapeutic value (pharmaceutical substances, diagnostic products), in a process that is also referred to as "molecular farming". "Vaccine bananas" or the "production of antibodies in plants" are impressive examples of this type of application. The production of pharmaceuticals in plants leads to huge cost savings over the currently used production of such substances in microorganisms or mammalian cells.

Green genetic engineering: A future technology?

Opponents of genetic engineering have repeatedly destroyed fields with genetically modified maize.
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From a scientific point of view, green genetic engineering has enormous potential: plants become the providers of vaccines or nutrients that they are not actually able to produce under normal circumstances. The objectives of scientific research focus on the ability to alleviate world hunger or to provide the third-world population with access to essential vitamins or trace elements. However, in order to be able to further develop plants that are shown to have major potential in basic research, comprehensive research needs to be guaranteed.

However, while the development of transgenic plants is increasing on a global level, it is decreasing in Germany and other EU states. In many cases, laboratory investigations carried out as part of basic research requires the subsequent testing of the transgenic plants in field trials since the plants are only economically feasible when they can be grown on large areas. However, field trials, and hence the progress of science, are currently being hampered by both legislation and vandalism.

The goal: coexistence of the different types of agriculture

Besides the cultivation of transgenic plants, there are two further types of agriculture: conventional and ecological farming. The latter refers to the production of agricultural products based on production methods that protect the environment (bio-products, organic products), i.e. methods that enable the farmers to refrain from using certain pesticides, growth promoters or mineral fertilisers as is the case in conventional farming. Genetically modified plants or organisms are not used in either of the two aforementioned types of farming.

The European Union has declared its political intention to support the coexistence of all three types of farming. However, it has proven difficult to implement this goal, which is at present far from being reality: The cultivation of genetically engineered plants must not cause any damage to conventional and ecological farming and, at the same time, must not impede the progress of research.

There are many questions to which there is, as yet, no final solution: who is responsible for guaranteeing safety when transgenic plants are grown on agricultural land? Is the coexistence of ecological and conventional farming and the cultivation of transgenic plants possible? Who is liable for damage to conventional and ecological farmland as a result of contamination with genetically modified organisms (GMO)? Can the risks for humans and the environment really be assessed?

Green genetic engineering has been the subject of controversial and emotionally heated debate for many years. The fear of incalculable dangers for human beings and nature generates vehement public opposition and reservations. Around three out of four Germans disapprove of genetically engineered food. The inability to reverse the release of genetically modified plants is a particular and huge cause of concern.

Environmental monitoring, safety research and approval

The Directive 2001/18/EC on the deliberate release of GMOs into the environment, which took effect in the EU in 2002, stipulates the compulsory monitoring of the potential long-term effects of GMOs released into the environment. The Directive introduced minimum distances between fields containing genetically modified plants and other types of farming. Moreover, the Directive holds farmers liable for economic damage arising from the outcrossing of genetically engineered plants, even when the farmers have complied with all the legal requirements. Economic damage is defined as the contamination of fields that are found to have a GMO content exceeding 0.9%, which represents the level at which products produced from crops grown from non-genetically modified seed are required to be labelled. In such cases, the farmers affected risk economic losses because they are no longer able to market their products as non-GMO products.
The regulation on the joint and several liability became effective in June 2004. This regulation reads as follows: "In cases where GMO contamination cannot be traced back to a single source, all neighbouring GMO farmers are jointly liable for the damage." Liability insurance is not yet available. Small conventional and ecological farmers live in fear of their plants being damaged as a result of the new technology, which would then lead to the loss of the commercial basis of their business. The small farmers believe that only the big groups of companies benefit from farming involving genetically engineered plants. In addition, liability regulations make it difficult for smaller organisations to cultivate transgenic plants because the risk of having to pay for any damage is too high.

Since 2001, the www.biosicherheit.de website, funded by the German Ministry of Education and Research (BMBF), has been providing increasing quantities of information to the German public on the subject of biological safety research in plant biotechnology. A similar initiative existed on the European level between September 2006 and July 2009 (BIOSAFENET). Funded with European taxpayers' money, this network was designed to inform the interested public about new findings from green genetic engineering as well as to bring researchers together.

It is difficult to assess the long-term effect of genetically modified organisms prior to their release. The Directive 2001/18/EC (October 2002) on the release of GMOs requires environmental monitoring to be put in place to monitor the impact of new GMOs on the environment at regular intervals. When potential risks are identified, the cultivation of a specific GMO can be banned with immediate effect. Pollen monitoring is used to monitor the gene flow on agricultural land in order to enable the identification of the uncontrolled and undesired spread of genetically modified plants. In summer
2007, the BMBF announced the provision of funds totalling 10 million euros over a period of three years for safety research. These funds are being used between 2008 and 2010 to develop methods that help prevent the spread of genetically modified plants.

Authorisation for the cultivation of GMOs is given on a case-by-case basis. In order for a genetically modified plant to be placed on the European market, it must not have any detrimental effects on human or animal health. Due to the strict legislation and high safety regulations, the number of GMOs released has been on the decline since 2001. A major reason for this decline is also the resistance to planned releases. The destruction of GMO trial fields renders safety assessments impossible and can delay approval processes for many years. The authorisation to grow GMOs is given by the Federal Office of Consumer Protection and Food Safety following a detailed assessment of safety research, in which the German state authorities supervise the trials.

Germany – industry and science location

Genetically modified plants have huge economic potential. The starting point is a sustainable increase in productivity. In 2008, the genetically modified potato variety Amflora (a pure amylopectin potato) was estimated to give an annual added economic value of 100 million euros for the potato cultivation and industry in Europe. The BASF, which developed the potato variety, estimates that the global market potential of green genetic engineering will reach 50 billion dollars by 2025. But Germany does not fully exploit this potential. Other countries are not subject to the strict EU legal regulations. Front-runners among the countries that grow transgenic plants are currently the USA, Canada and Argentina; Germany is increasingly losing its attractiveness. About 114 million ha of genetically modified plants were cultivated worldwide in 2008; with around 4,500 ha, Germany was only able to make a marginal contribution to this huge area.

On the international level, Germany is one of the leading countries in basic research into green genetic engineering, and a huge amount of money has been invested in this type of research. Whilst this research area is still being funded, it is difficult to justify the huge research efforts in the long term if they do not lead to economic success. Many companies are leaving Germany in order to grow genetically engineered plants abroad because the current strict legal situation renders the cultivation of GMO plants impossible in Germany. "Nobody will invest money in new and safe ideas and technologies if the market chances are a priori blocked by existing legislation," declared representatives of the Baden-Württemberg BioRegions in their statement on the Genetic Engineering Law in 2004.

Some scientists regard current German laws as the killers of innovation. According to a statement from the German Research Foundation and the German Agricultural Society in May 2009, scientists at universities, public research institutions and small- and medium-sized companies feel increasingly obliged to reduce their research in the field of green genetic engineering or to give it up completely.
The stagnation of already started research projects as a result of the banning of field trials might cause Germany to lose international connections, in turn destroying long-term investments in research and development and leading to the loss of jobs and growth potential.

Cultivation in the EU impossible? Cultivation of MON810 banned

With the de-facto moratorium of the European Commission on the approval of new transgenic plant varieties in 1998, politicians have strongly intervened with the freedom of research in the EU. The number of field trials have diminished by 80% since then. Subsequent Genetic Engineering Law amendments have led to further research restrictions. And despite comprehensive inspections prior to the approval of MON810 (Bt-maize; Monsanto) in 1998, the cultivation of the only genetically modified plant approved for cultivation in the EU was nevertheless banned in April 2009 in Germany. The ban was issued by Ilse Aigner (Federal Ministry of Nutrition, Agriculture and Consumer Protection) on the basis of the environmental monitoring required by Directive 2001/18/EC. She stipulated that there was founded evidence for the assumption that the genetically modified maize variety posed a risk to the environment. Prior to its approval, the European Food Safety Authority (EFSA) had rated the maize variety as safe, further confirming this result following a subsequent, more comprehensive study in July 2009. At the end of July 2009, the Central Commission for Biological Safety (ZKFS) regarded the temporary ban as "scientifically unfounded". Nevertheless, the ban is still in force today.

According to scientists, this raises a number of problems. At a panel discussion on green genetic engineering in June 2009 in Ulm, Prof. Dr. Klaus-Dieter Jany, chairman of the "Grüne Gentechnik" (green genetic engineering) association commented as follows: "I am not frustrated that I am unable to carry out my experiments. I can do them - abroad. I am frustrated about the path being taken by Germany." Concluding with "we must not close ourselves off", Jany highlighted the importance of making progress in the field of green genetic engineering.
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