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Editorial news and events

Book review

Genetically Engineered Crops: Experiences and Prospects

authored by Committee on Genetically Engineered Crops: Past Experience and Future Prospects; Board on Agriculture and Natural Resources; Division on Earth and Life Studies; National Academies of Sciences, Engineering, and Medicine. The National Academies Press, Washington, DC (USA), 2016, Paperback, 420 p. Prepublication: 71.00 $; ISBN 978-0-309-43738-7; DOI:10.17226/233955

More people need more food for their nutrition, feed for animals and plants for many technological processes. Therefore, plant breeding can be considered to be the starting point of the whole human food chain and for human well-being. During the last few years, new methods of plant breeding, including bioengineering, were introduced and used as breeding techniques. For the last 20 years, the commercial cultivation of Genetically Engineered Crops (GEC) has increased globally in 23 countries from 1.7 (1996) to about 180 million hectares (over 70 million ha in the USA) in 2015. This cultivation area is equivalent to about 12% of the global cropland. Maize, soyabean, cotton and rapeseed were the most important GEC cultivated during this time.

The anniversary of 20 years of commercial GEC cultivation was the reason for the Committee on Genetically Engineered Crops (CGEC) to examine the evidence regarding potential negative effects and benefits of currently commercialized GEC. The CGEC acts as author of the study: 'Genetically Engineered Crops: Past Experiences and Future Prospects'. The members of the Committee, boards and divisions are mentioned in the introduction of the volume (altogether 112 scientists chaired by Fred Gould; National Academy of Sciences; North Carolina State University, Raleigh, USA). The three National Academies of Sciences, of Engineering and of Medicine worked together as National Academies of Sciences, Engineering, and Medicine to provide independent, objective analysis and advice to solve complex problems and inform public policy decisions makers.

Apart from past experiences and future prospects, the Committee was also asked to assess emerging genetic-engineering technologies, with regard to how they might contribute to improvements, and what technical and regulatory challenges they may present. The Committee members studied relevant literature, heard from 80 speakers, and read more than 700 comments from members of the public to broaden their understanding of issues associated with GEC. The report has been reviewed by 26 scientists, mainly from US-universities. Many constructive comments and suggestions were considered in the volume.

After the summary (16 pp.), the volume is structured into nine chapters, and seven appendices, including biographical sketches of Committee members, some technical information about gathering sessions, workshops and comments received from members of the public, and finally a glossary. The summary takes a stand on tasks and reviews the Committee`s process. Agronomic and environmental, animal and human health, and finally social and economic effects are analysed. Moreover, prospects of genetic engineering are discussed and recommendations about these topics provided. Finally, the regulation of current and future GEC are analysed and discussed.

The first Chapter (12 pp.) deals with 'The study of genetically engineered crops by the National Academies of Sciences, Engineering, and Medicine'.

The Committee has been involved in assessing and recommending science policy regarding GE since the advent of this technology in the 1970s. In the meantime, the Academies have often been called in questions concerning the usage of the technology in agriculture. In 2014, the Academies formed the CGEC: Past Experience and Future Prospects, to undertake a broad examination of the technology and to assess its future role in agriculture. The authors described the purpose and the structure of the report.

'The framework of the report' (12 pp.) is the title of the 2nd Chapter. The authors discuss the Committee's approach to the assessment of risks and benefits, and review what is known about public attitudes towards GEC. They introduce the concept and factors involved in the governance of GE in agriculture, and define some of the terms used in the report. The authors conclude in later chapters that technologies, traits, and contexts of development of specific GEC varieties are so diverse that generalizations about them as one single defined entity are not possible.

The 3rd Chapter is entitled 'Genetically engineered crops through 2015' (21 pp.). In this chapter the development in the application of GEC, including a short primer on the mechanism recombinant-DNA technology and on how plants were initially transformed through GE are reviewed. The authors of the chapter conclude with a short introduction to regulatory approaches to GEC. In the first 20 years of GEC cultivation, most commercially available traits were aimed at providing herbicide resistance to the crop (e.g., glyphosate resistance) or protecting the crop from insect damage (e.g., *Bt*-corn). Other types of traits, such as improved nutritional qualities or a better composition of plants for biofuel production, were to a smaller extent part of commercial production, but a wider variety of traits can be expected.

'Agronomic and environmental effects of genetically engineered crops' (51 pp.) is the title of Chapter 4. Economic, environmental, and social effects of GEC are discussed in this and in the following two chapters. The cultivation of *Bt* crops or herbicide tolerant crops did not result in substantially reduced farm biodiversity. *Bt* crops have had increased yields when insect-pest pressure was high and decreased the insecticide application. The quantitative assessment of yields of GEC and non-GE-varieties is not possible because of differences in land quality and management measurements. The Committee found no evidence of cause-and-effect relationships between GEC and environmental aspects. It offered a number of recommendations regarding investments of public resources with the purpose to conduct careful experiments and analyses. Economic, environmental and social effects of GEC are also discussed in this chapter.

Chapter 5 deals with 'Human health effects of genetically engineered crops' (68 pp.) and examines mechanisms for testing the safety of GEC and foods derived from GEC in the United States and in other countries. Risks and benefits associated with GEC and related to human health, such as nutritional effects, insecticide and herbicide use, allergens, gastrointestinal tract issues, diseases, and chronic illnesses are discussed. Research has been conducted on chemical composition of GEC and many feeding studies with laboratory animals and food producing animals reveal no significant differences that would implicate a higher risk to human health from eating food from GEC than from their non-GE counterparts. Also in long-term feeding studies, the Committee could not find persuasive evidence of adverse health effects directly attributable to consumption of GE-feeds. There is some evidence that GE insect-resistent crops have had benefits to human health by reducing insecticide poisonings and decreasing exposure to mycotoxins. The Committee could not evaluate crops with expected 'health benefits' (e.g., higher content of valuable constituents, lower content of undesirable substances), because such crops were introduced only shortly before writing this report.

Chapter 6 is entitled 'Social and economic effects of genetically engineered crops' (75 pp.). Having reviewed the literature available on social and economic effects of GEC, the Committee came to the conclusion that there is not sufficient research on this topic. One reason for this may be the tremendous amount of diversity of farmers in the world. Basing on the research that is available, the Committee concludes that existing GEC have generally been useful to large farmers of cotton, soyabean, maize and canola. To contribute to alleviation of hunger and malnutrition in food-insecurity populations, more GEC will need to be developed in ways that increase potential yield and protect yield from biotic and abiotic stresses, and improve nutritional quality. In addition, the ability of GEC to alleviate will depend on the social and economic contexts. Public investment in basic research that does not offer strong market return for private firms should be increased.

Chapter 7 deals with 'Future genetic-engineering technologies' (35 pp.). The authors summarize new genetic-engineering approaches. Some of these

approaches are already used to develop crops for commercial production. Also, the utility of '-omics' technology to detect alterations in plant genoms is assessed. Modern plant breeding and genetic engineering are complementary methods for improving crop yield, production efficiency, and composition. Both GE and conventional breeding have been greatly enhanced by increases in basic knowledge about plant biology and by technical innovations.

'Future genetically engineered crops' (33 pp.) is the title of Chapter 8. The authors describe a number of new traits and discuss their relation to sustainability and food security in the future. The Committee analysed input traits and yield, such as biotic stress tolerance (microbial resistence, insect resistance), abiotic stress tolerance, nutrient-uptake and -use efficiency (e.g., N, P, CO_2) and postharvest improvements. Also, output traits, such as enhanced nutritional content, food safety, forage quality and biofuels and industrial bioproducts are explored. The genetic basis of complex traits, such as drought tolerance, water use efficacy and nitrogen-use efficiency is presently not yet fully understood. Only continued public founding of basic research will enable further advances in understanding of the physiological, biochemical and molecular basis of these important traits.

The last Chapter (9) deals with 'Regulation of current and future genetically engineered crops' (45 pp.). The authors compare the regulatory systems concerning GEC in the United States, the European Union, Canada and Brazil. Current international agreements and national regulatory systems reflect a variety of political and regulatory approaches to GEC and foods. All regulatory systems examined in the report use similar risk-assessment methods to analyse the feed/food-safety and environmental risks posed by GEC on the basis of a comparison with similar existing crops, feed and food. Regulatory systems differ in approaches and policy decisions related to risk management and the level of 'acceptable' risk in the country/region.

In conclusion, many reviews have indicated that feeds and foods from GEC are as safe as feeds/foods from non-GEC. The Committee re-examined the original studies on this subject and came to the conclusion that design and analysis of many animal feeding studies were not optimal, but a large number of experimental studies provided reasonable evidence that animals were not harmed by consuming feed from GEC. In addition, long term data on livestock health before and after introduction of GEC showed no adverse effects associated with GEC. The Committee also examined epidemiological data on incidence of cancers and other human-health problems over time and found no substantial evidence that GEC were less safe than foods from non GEC. In addition, the available evidence indicates that GE soyabean, cotton and maize have generally a favourable economic outcome for producers who have adopted these crops, but outcomes have been heterogeneous depending on pest abundance, farming practices and agricultural infrastructure. In regions where resistance-management strategies were not followed, damaging levels of resistance evolved in some target insects. Sustainable cultivation of *Bacillus thuringiensis* (*Bt*) and herbicide-resistant crops require the use of integrated pest-management strategies. The Committee also analysed the social and economic effects of GEC and came to the conclusion that the results depend on the GE traits, the plant variety and the quality and the cost of GE seeds. The Committee underlined the importance of public founding of basic research for further advances in understanding of the physiological, biochemical and molecular basis of important traits.

A detailed description and assessment of the content of this very valuable document would exceed this review´s scope. In a short summary, the book brings together the most recent scientific work in the field of Genetically Engineered Crops in an excellent way. Each chapter is well structured and finished with an extensive review of updated literature.

This book is recommended as a helpful tool for researchers and graduate students working in the fields of plant breeding as well as animal and human nutrition, for all scientists in the fields of natural and social sciences, but also politicians, teachers, priests and all people interested in global future developments.

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