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Genetically Modified Crops – Indian Perspective

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Introduction

The science of agriculture has significant impact on human food supply via direct and indirect ways. Due to increasing world population and urbanization the agricultural land is decreasing. In order to meet the increasing demands of consumer's, global agricultural productivity must increase to mitigate the challenges in food production. Various abiotic and biotic factors influence nutritional status and productivity of crops. Biotechnology has played significant role in food sector through the production of additives and ingredients as well as the improvement of more resourceful and less costly operations. The advancements in biotechnology and molecular biology have revolutionized the traditional plant breeding techniques at the global level. In addition, biotechnological interventions have been focused on modifying and editing the genes for insect and disease resistance, herbicide and abiotic stress tolerance, enhancing shelf life, taste, aroma, texture and nutritional value of food products. The genetically modified (GM) crops are produced by transfer of genes carrying specific trait of interest between organisms using laboratory techniques. The crops derived from this method are called GMOs (Genetically Modified Organisms) or genetically engineered or transgenic crops. Genetically engineered crops are one of the most rapidly adopted technologies in the history of agriculture and have now reached about 25 years of commercial production. It has provided significant economic and environmental benefits and adopted by millions of farmers in developing and developed countries. Transgenic crops are produced by using direct and indirect (*Agrobacterium*-mediated) gene transformation methods and the inserted gene (transgene) may come from bacteria, virus, fungus, or an animal species. In the year 1983, first transgenic antibiotic-resistant tobacco and petunia, were developed. In 1994, Calgene (Monsanto) developed first transgenic tomato, 'Flavr Savr' with longer shelf life and it was approved by Food and Drug Administration (FDA) for sale in the USA. The area under transgenic crops has increased significantly in past 25 years.

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According to ISAAA database, a total of 525 transgenic events in 32 crops have been commercialized till date. The maximum proportion of transgenic crops includes soybean (50%), maize (31%), cotton (13%), and oilseed rape (canola 5.3%), with herbicide and disease resistance are among the most common traits conferred by the transgenes.

Besides this transgenic crops have been facing lack of public acceptance in many parts of the world including India due to certain limitations. Transgenics involves the transfer and modifications in the genome at random locations in between unrelated organisms. Instead of this, several unintended traits (UTs) are also known to be introduced in GM crops. To overcome these concerns two techniques i.e., cisgenesis and intragenesis, were developed that deploy genes from sexually compatible gene pool. In the recent years with the advent of the breakthrough technology of genome editing has opened up new paradigms that enable modifications in crop genomes with an unprecedented ease, precision and accuracy. Genome editing techniques uses various site-specific nucleases (SSNs), viz., Zinc Finger Nucleases (ZFNs), Transcription Activator-Like Effector Nucleases (TALENs) and Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)/ Cas system. The gene editing tools have great potential to address many of the regulatory issues associated with transgenics.

Indian perspective

The GM crops are produced for different traits such as extended shelf life and disease resistance. In India, Bt Cotton is the only transgenic crop in the market, while Bt Brinjal and GM Mustard are waiting in line. With certain advantages of the GM crops, many issues are also there to be addressed but only through proper assessment and scientific approach. Till now total 11 events has been approved in India i.e six in cotton and five in soyabean. Most of the commercialized events in cotton focus on introduction of Lepidopteran insect resistance traits. Lepidopterans mainly eat the cotton bolls and are called bollworms. In India polyphagous American bollworm (*Helicoverpa armigera*) and the oligophagous cotton-feeding pink bollworm (*Pectinophora gossypiella*) are known to cause severe damage. Instead of this several other insects such as spotted bollworm (*Erias* sp.), cotton leafworm (*Spodoptera litura*), leaf hopper (*Amrasca devastans*), whitefly (*Bemisia tabaci*), cotton aphid (*Aphis gossypii*), mealybug (*Phenacoccus solenopsis*) and mirid bug (*Creontiades* sp.) etc results in significant reduction in yield.

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There was a rapid adoption of transgenics crops, during 1996 to 2015 all over the world by both large and small farmers. In the year 2002, genetically engineered cotton (*Bt* cotton) for insect resistance has been released for commercial cultivation in India by Genetic Engineering Approval Committee, Government of India. This practice has revolutionized cotton industry in India. Since then the cultivation and production of *Bt* cotton has grown at an exponential rate and India has become second largest producer of cotton and leading exporter in the world. Bt cotton is the only GM crop under commercial cultivation in India and covers around 95% of the total cotton growing area and ranks 4th in world. The adoption of *Bt* cotton has initially showed great reductions in pesticide use and it was found to be a poor indicator of yield trends. Cultivation of *Bt* cotton has continued to control one major cotton pest, but later on *Bt* resistance in other pests (superweeds) started emerging as a new challenge for farmers. Therefore, farmers now spend more on pesticides today than before the use of *Bt*. As far as the long term impacts of Bt cotton in India are concerned the situation is likely to deteriorate. Adoption of GM crops for commercial production is faced with biosafety issues that are based on the argument on using potentially risky technology in which genes are transferred between unrelated organisms and random locations. In India, the Cartagena Protocol on Biosafety describes biosaftey regulations for LMOs (transgenics, GMOs and Genome editing) in detail and suggests the standard biosafety requirements for genetic modification in plants and its role during commercialization and deregulation process. Transgenics crops are under the purview of the Union Ministry of Environment, Forests and climate Change (MoEF & CC) under the Environment Protection Act (EPA) 1986 and rule 1989. GM crops have the potential to reduce worlds hunger by genetic improvements. Yet there are many socioeconomic challenges ahead for governments in the areas of safety testing, regulation, industrial policy, food labeling etc. Moreover, due to the complexity of genome editing new crop product in India are not released, although many examples exist outside the country. As there is no clear road map, fresh investments are not available due to the past experiences from GM crops. Now, India has come up with a draft regulation for genome editing. Further, other interested parties like ICAR and NAAS have shown a positive response to make the road map simple and clear for commercialization purpose. Some new genes and edits are likely to be less regulated, barring few traits like herbicide tolerance and can show up in farmer's field hopefully soon. Food security is paramount for the world's

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second most populous country. Thus, it is hoped that GE tool kit can be employed in the plant breeding strategies sooner than later. There is a need for adopting adequate safety measures for the development, release and use of transgenic crops and their products. Basic and precise research should focus on development and simplification of biosafety protocols.