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The Safety of Genetic Modification Technology

A Policy Brief by the Open forum on Agricultural Biotechnology (OFAB) Nigeria

Introduction

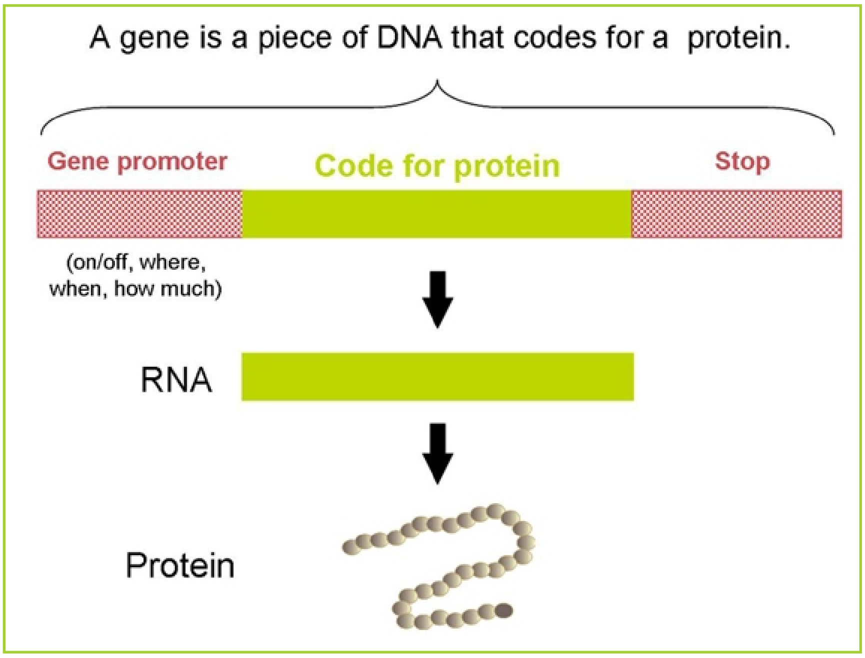
Genetic modification is the use of modern biotechnology techniques to change the genes of an organism, such as a plant or animal. This is also called genetic engineering and it is the technologies that are developed by the use of recombinant DNA technologies and traditional breeding methods both for plant and animals. This technology involve genes which is a component of all living organisms, they are located on chromosomes encode the hereditary information that are passed from generation to generation (Grumet, 2010).

What is a Gene?

All plants and animals are made of billions of tiny cells. Inside each cell is a nucleus that contains DNA. DNA is passed on from one generation to the next and with it all the information to make the organism and keep it functioning.

Genes are made of DNA, and DNA is an information library, genes are like individual instruction books. The coding capacity of genes is derived from their helical molecular structure of nucleotides (adenine, thymine, guanine, cytosine). The arrangement of the nucleotides indicates the sequence of amino acids for each kind of protein. The instructions in genes allow them to make proteins – which are the building blocks of life. They make up the structural parts of the organism and make other sorts of molecules like starch, oil, fibre, or fat, which are used within the organism. The critical factor underlying genetic engineering is that the language of DNA is universal regardless of the type of the organism that produces it.

An organism is mainly made up of proteins. Genes make up much less than 0.1 per cent of the weight of an organism, but they control everything else (Figure 1).



Source: http://www.csiro.au

Figure1: Diagram to show what gene is.

Genetic Modification (GM)

Genetic modification, genetic manipulation (GM) and genetic engineering (GE) all refer to the same thing – the use of modern biotechnology techniques to change the genes of an organism, such as a plant or animal. A genetically modified organism (GMO) is a plant, animal or other organism that has been improved with additional trait by the use of genetic engineering technologies.

Traditional breeding of plants and animals aims to tailor the plant or animal for a certain character/trait improvement. For example, a new crop variety might be bred for drought tolerant or resistant to diseases. The process of traditional breeding involves the use of germplasm from the pool of the ancestors with desirable traits of interest and crossing them with each other – with the aim that the progenies output will carry through heritability have the favourable traits from both parents. But since the progenies carry half the hereditary trait from both the parent, both desired and undesired from their parents, will be passed on and it takes a number of breeding cycles (backcrossing) to eliminate the undesired traits and build on the desired traits.

The final new plant variety or breed of animal after several years of selection will have the desired traits (this only applicable to heritable traits), which it will have inherited from its ancestors along with the associated genes for those traits. Traditional breeding is a way of harnessing the genetic resources of an organism by selective breeding.

GM breeding is used as an extra tool in the toolbox to enhance breeding for traits that can not be passed from parent to the progenies through traditional breeding techniques providing opportunities for new plant varieties and animal.

GM includes using genes from one organism and inserting them into another (trans-gene). For example, insect resistant GM cotton uses a gene from a naturally occurring soil bacterium to provide it with built-in insect protection. It is also possible to use cis-gene technology where the problem of incompatibility within the ancestral parent cannot be hybridized with their cultivated progenitors either as a result of pollen sterility. The use of insect resistant GM cotton has reduced pesticide use over 80 per cent in Australia.

However, GM does not necessarily mean that a gene from another organism has to be used to create the GMO. GM can mean that the organism's own genes are changed (cis-gene).

For example, gene silencing turns down the activity of certain genes already within an organism, such as in oilseed crops where it is being used to turn down the production of unhealthy oils. GM is also used for purely research purposes, for example, to discover genes.

Human directed genetic modification has been occurring since, first domesticating organisms in 12 000 BC while the first genetically modified plant was produced in 1982, using an antibiotic-resistant tobacco plant. The first field trials of genetically modified plants occurred in France and USA in 1986, when tobacco plants were engineered to be resistant to herbicides. In 1987, Plant Genetic Systems founded by Marc Van Montagu and Jeff Schell, was the first company to develop genetically engineered (tobacco) plants with insect tolerance by expressing genes encoding for insecticidal proteins from Bacillus thuringiensis (Bt).The People's Republic of China was the first country to commercialize transgenic plants, introducing a virus-resistant tobacco in 1992. Advances have allowed scientists to manipulate and add genes to a variety of different organism and to induce a range of different effects. Since 1976 the technology has been commercialised, with companies producing and selling genetically modified food and medicine.

In 1994, the European Union approved tobacco engineered to be resistant to the herbicide bromoxynil, making it the first genetically engineered crop commercialized in Europe. In 1995, Bt Potato was approved safe by the Environmental Protection Agency, after having been approved by the FDA, making it the first pesticide producing crop to be approved in the USA.

In Nigeria, Confined field trials on genetically modified crops have been on-going. Example is the African Biofortified Sorghum (ABS) CFT Project in Institute for Agricultural Research (IAR) Zaria (Figure 2).

Genetic Modification (GM) Plant Breeding

Breeding using genetic modification (GM) involves insert of gene of interest into the genome of the plant to express the encoded information in the plant and a preferred variety is developed. It is done for the same reasons as conventional breeding. The key difference is that instead of randomly mixing genes, which occurs as a result of a sexual cross (hybridization where parents are compartible), a specific gene, which is associated with a desirable trait, is selected and inserted directly into the genome of the plant of interest. This saves breeding time and reduces the chance of undesirable traits in the new plant variety.

Genetic engineering also allows breeders to use genes from unrelated species and sometimes other organisms into a new variety. This means breeders can access and use a wider choice of genetic diversity to develop new plant varieties since DNA is a universal language. This is possible because all genetic information is stored in DNA – which is the same chemical in all organisms.

Figure 2: African Biofortified Sorghum under confined field Trials in IAR Zaria.

Another is the Cowpea Project, which involves the engineering of cowpea with a maruca resistant gene (Figure 3).

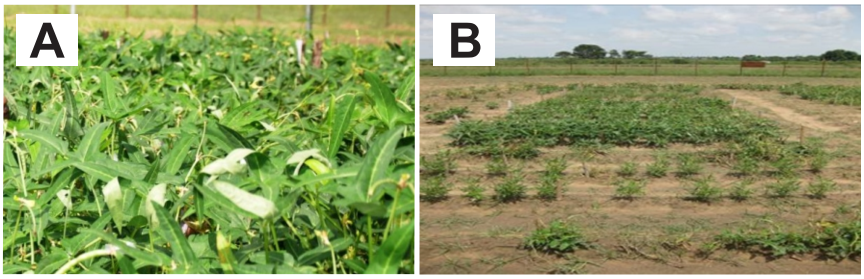


Figure 3: (A) Cowpea CFT at IAR, Zaria (B) Sectional view of the Cowpea CFT at IAR, Zaria.

Another example is cassava to improve the accessible protein for human health at National root Crop Research (NRCRI) Umudike and other useful trait in collaboration with Danforth Centre, St Luis Missouri, USA.

Figure 4: (A) Scientists inspecting improved cassava variety at NRCRI, Umudike (B) Sectional view of the area.

Is GM a Natural form of Breeding?

No, it is just an extra tool in the toolbox to improve and increase productivity with characters that are not heritable naturally. For thousand of years farmers altered the genes of their crops. By selecting plants with desirable traits like higher yields and tastier produce, farmers inadvertently excluded undesirable genes and included desirable genes in each new generation of crop.

In figure 5, the genetically modified cowpea has the same feel and colour with the traditionally bred one.

These days even conventional breeding employs techniques to cross plants that could not occur naturally in the wild.

For example, conventional breeding uses chemical and physical means to 'mutate' plant genes. These gene mutations may give the plant different, and even desirable, traits. Plant breeders can then select for these desirable traits caused by the mutated gene, mutation introduce variation which produces new plant varieties. Mutations also occur naturally (although very rare) and these are also used in breeding.

Conventional breeding can also benefit from GM. For example scientists may think a particular gene is responsible for a certain desirable trait. To confirm this they can develop a GM plant using the gene in question. If this GM plant displays the desirable trait then it is likely the gene is responsible.

Breeders can then go back to the original plant and start breeding to include the desirable gene using techniques like DNA markers that 'flag' the location of the gene (marker assisted breeding) making it easy for breeders to know if the gene is present or not in each new generation of plant (when the trait is heritable). This method speeds up the breeding of new plant varieties.

The unique power of GM however lies in its ability to incorporate novel genes into new plants to develop plants with properties that would not be achievable through conventional breeding. This may mean using genes from unrelated organisms such as in the case of golden rice. GM is one of a suite of breeding tools that future generations can use to help tackle environmental and human health challenges.

The basic argument put forward in favour of genetically modified (GM) crops is that they can provide at least solution to the problem of feeding the world's growing population. Even with improved food distribution and access, this cannot be achieved without dramatic increases in crop production. Converting more land for agricultural use is environmentally unsustainable. Genetic engineering has opened up opportunities for increasing crop yields, reducing crop losses to insects, disease and post-harvest storage problems, and enhancing the nutritional value of some crops. In addition, crops are now being developed to resist abiotic stresses, such as drought and soil salinity. This will allow increased crop production on marginal land and therefore bring possible benefits to poorer rural areas. Traditionally, new varieties of specific crops have been bred by mutation and cross-pollination of two strains, usually of the same species, in order to transfer desirable traits from each into the new variety. These traits might include higher yield, greater resistance to certain pests or diseases, slower ripening, or better tolerance of drought or soil stresses. Genetic engineering allows the selective transfer of one or more genes that code for desired traits from one variety to another, which means that it is a faster and more accurate method of breeding new varieties. It also allows the transfer of genes between species, which in most cases cannot be achieved by traditional breeding. For example, some of the first commercial releases of GM crops were modified with a gene from a bacterium, *Bacillus thuringiensis (Bt)*, which codes for a toxin against some crop pests. *Btinsecticide* sprays have been in use for several decades, and are approved for organic farming. However, introducing the *Bttoxin* gene directly into a plant genome raised many concerns about the genetic engineering of crops, and food products derived from them.

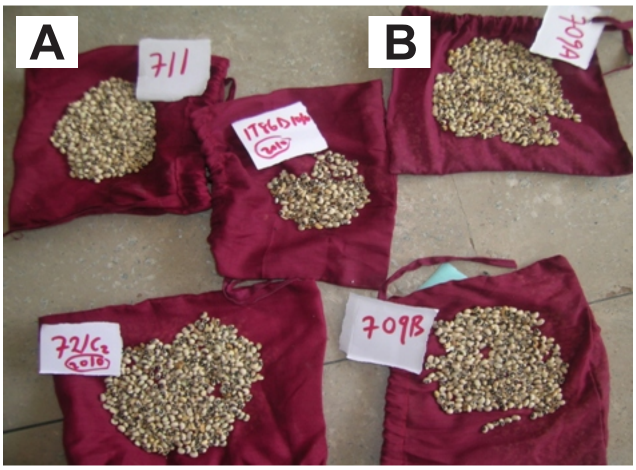


Figure 5: (A) Non-Transgenic Cowpea, (B) Transgenic Cowpea (Bt).

Figure 6: This picture (A) is normal rice while (B) is a golden rice that contains vitamin A. The vitamin A producing gene was taken out of red pepper and inserted into rice. This can help to save millions of children world wide suffering from colour blindness.

Are GM Crops Safe for Human and Animal Health and the Environment?

In real life nothing is absolutely safe but a degree of certainty is assured compared to other conventional breeding procedure. Yes, it is a safe and the technology in which through it was developed is highly regulated to ascertain the safety required by human and environment. Two European Commission reports covering 25 years' worth of research on the effects of GM crops on health and the environment have shown no scientific evidence associating GMOs with higher risks than conventional plants and organisms. More than 2 trillion meals containing GM ingredients have been eaten over the last 15 years by hundreds of millions of people without one health incident having been identified. All GM crops that are currently on the market have proven to be safe for health and the environment. GM products all have to go through a rigorous safety assessment by the European Food Safety Authority (EFSA).

Most developed nations do not consider GMOs to be safe, according to the Non-GMO Project. "In more than 60 countries around the world, including Australia, Nigeria, Japan and all of the countries in the European Union, there are significant restrictions on the production and sale of GMOs."

However, many scientific organizations believe the fear-mongering that runs through discussions of GMO foods is not scientifically proven but sentimental without evidence. "Indeed, the science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe," the American Association for the Advancement of Science (AAAS) said in a 2012 statement.

"The World Health Organization, the American Medical Association, the U.S. National Academy of Sciences, the British Royal Society, and every other respected organization that has examined the evidence has come to the same conclusion: Consuming foods containing ingredients derived from GM [genetically modified] crops is no riskier than consuming the same foods containing ingredients from crop plants modified by conventional plant improvement techniques," according to the AAAS.

"Since GM crops were first commercialized in 1996 … regulatory agencies in 59 countries have conducted extensive scientific reviews and affirmed the safety of GM crops with 2,497 approvals on 319 different GMO traits in 25 crops.

Conclusion

Genetic Modification technology can be an important component in a broader food security strategy. Ensuring plentiful and affordable food around the world requires every tool available in the toolbox, including good policies that are put into action, better incomes for farmers, improved irrigation, stable food prices, among many other factors. GM crops' benefits, like higher yields on smaller areas of land, lower pesticide costs for farmers, and crops that grow better in local conditions, are very important in producing a food secured nation.

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