AGRICULTURAL BIOTECHNOLOGY IN NIGERIA: BENEFITS, CHALLENGES AND PROSPECT

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Abstract

Technology has brought much progress to the world, including the agricultural sector and it is implemented from the very start of cultivation to post-harvest handling. Biotechnology is a major force for development in developing countries such as Nigeria. It is found to contribute to solving human problems like water and food insecurity that impede national development and threaten peace wherever it is applied. This study identified the benefits, challenges and prospects of agricultural biotechnology in Nigeria and the need for enlightenment through Agricultural and Extension programs to Nigeria farmers. On the part of rural farmers, there is lack of adequate knowledge or awareness of biotechnology despite the fact that they constitute the bulk of Nigeria farmers. On the part of government, the problems include: lack of adequate implementation of government policy on bio-safety and genetically modified products, inadequate funding of education as well as research and development of products related to biotechnology. Other problem includes: inadequate infrastructures (including laboratory), poor funding and lack of national strategies needed for development and running of agricultural biotechnology. In spite of all the challenges associated with agricultural biotechnology, its prospects still remain great, if Nigeria is to meet with the food needs of the country's ever increasing population. The introduction of genetically engineered products will lead to the high productivity needed for commercialization and food security. Insect, virus and other related disease resistant crops and livestock are another viable area of contribution of biotechnology to agricultural production. In conclusion, agricultural biotechnology will not only ensure security, but in addition, will ensure that the local farmers utilize appropriate technology needed for large production, leading to the prosperity of the farmers and national economic growth and national economic growth, provided government plays its role of adequate funding and good policy implementation.

Keywords: Agricultural biotechnology, Benefits, Challenges and Prospects

Introduction

Biotechnology is a cross-cutting technology encountered in wide application across several sectors of development in science, Agriculture and Engineering. It involves the use of biological process in industrial production. (Kidel, 2014). Agricultural biotechnology is a range of tools including traditional breeding techniques that alter living organisms or plants of organisms to make or modify products, improve plants or animals or develop microorganisms for specifics agricultural use. Since the beginning of creation, man has been using agriculture as the most important means of meeting the three basic needs of life which are food, shelter and clothing (Woodward and Oludaunsi 2015). Hence, Agriculture has been the mainstay of the economy of many developing nations including Nigeria. Biotechnology is a major force in solving problems like food and water insecurity that impedes national development and threatens peace in developing world. This advance in life science offers opportunities for revolutionizing human welfare activities primarily through improvement in the quality and quantity of healthcare and it has found its usage in Agriculture, Engineering and Medicine (Edgar, Elias and Aduan, 2017). In Agriculture, biotechnology has led to improved seeds, resistance to diseases and increased yield. It has prospects to remedy the problem of food shortage, as research in this field aims to develop plant variety that provides reliable high yield at the same or lower cost by breeding in qualities such as resistance to disease, pest and other factors that can contributes immensely to food production, while maintaining a healthy environment which reduces the amount of Fertilizer, herbicide and pesticide used in farming (Ojo 2016)

Agricultural biotechnology holds enormous expectation for the significant increase in food production, and the relatively already strained land and water resources. The utilization and application of science and technology to agriculture, so as to modify and improve gene of crops and animals to withstand climatic changes and environmental stresses, and increase in production and nutrition value, is called agricultural biotechnology. Usually it involves the manipulation of crops and animals for the production of value-added products for the use of man. According to Kidel (2014),

recent scientific advances in genetics have opened up a range of potential new application of modern biotechnology in agriculture, these includes the ability to manipulate genetic materials and transfer genes between organism in order to promote desired traits and suppress unwanted ones leading to propagating disease-free planting materials in the laboratory that support traditional breeding techniques.

Other latest development in agricultural biotechnology includes genomics (mapping of complete organisms) and bioinformatics (computer processing of masses of genetic data) (Nicholas 2018). In many developing countries, biotechnology has become a sort of economic development and social progress, providing access to technology in credit and peer market, especially to rural poor entrepreneur (Dasilver 2018). Nigeria, Africa's most populous nation with over 170 million population, is a food deficit country; formally a net exporter, Nigeria imported more than 17.6 billion dollars' worth of food products and agricultural commodities in 2013 (Olito 2014). Agricultural practice in Nigeria has sharply declined, contributing little to the economy of the country. This has been blamed on a number of factors, among which, are the inability of the peasant farmers who dominate the agricultural industry to utilize an efficient modern technology that are geared towards massive food production, processing and preservation, poor orientation and training, illiteracy and ignorance in the rural communities that impede production, adverse climatic conditions, and inadequate budgetary allocation to agriculture. In view of the enormous potential of agricultural biotechnology in solving many challenges and problems facing agricultural practices in Nigeria, this article looks at the current development of biotechnology and the prospect it portends in reducing poverty and enhancing agricultural productivity in the country.

Benefits of Agricultural Biotechnology

Modification of crop plants can be organized into two main categories: those that benefit the producer and those that benefit the consumer. Modification that protect the crop from either biotic or abiotic stress or increase total crop yield benefits of the producer are called input traits. The majority of modified crops in commercial use fit in this group. Scientists have just begun to tap the large potential of biotechnology to produce varieties of plants that confer a wide spectrum of advantages to consumers. These varieties are modified without output traits.

One of the most publicized uses of biotechnology in agriculture is the modification of corn to express proteins produced by the common soil bacterium, *Bacillus thuringiensis* (BT). Organic farmers have been using BT as an insecticidal spray for over 40 y. BT organisms have been modified to express a class of insecticidal proteins called Cry. These proteins are effective against certain insect pests but are harmless to humans, mammals and birds. BT corn was introduced as a commercial crop in 1996 and has been describe as "the most important technological advancement in insect pest management since the development of synthetic insecticides" because of its inherent resistance of infestation by one of the most serious corn pests, the European corn borer (*Ostrinia nubilalis*) (Obrycki, Losey, Taylor and Jessey 2021).

In addition to decreasing yields, infestation of corn by the European corn borer facilities spoilage by the mold, fusarium, which forms a mycotoxin, fumonosin, in corn (Munkvold, Hellmich and Rice 2019). Fumonosin is a toxic substance that, among other things, has produced liver damage in all animals studied. Although currently inconclusive, some evidence suggest that it may also play a role in human esophageal cancer (Food and Drugs Administration, 2020). Studies challenging maize hybrid with European corn borer found decreased fumonism concentratuion for transgenic maize varieties expressing specific cry protein, 2.1 ug/g compared to 16.5 ug/g for nontransgenic maize hybrid (Woodward and Oludaunsi 2015). Beyond the health benefits to livestock and consumers, infected corn becomes an economic problem. Corn that exceeds levels allowable for the intended use must either be discarded or used for another purpose, causing a loss of profit. In fact, overall losses to farmers as a result of the European corn borer-infested crops (including crops, cotton, sorghum and other vegetables) total 1 billion dollars a year (Kidel, 2010). On the whole, BT corn and BT cotton have improved farm efficiency (11-13). A report by the U.S. department of Agriculture concludes by saying that even though the benefit and performance of genetically modified crops varies depending on many factors including region and pest infestation levels, the adaptation of crops such as BT cotton in the Southwest and herbicide tolerant soybeans led to significant increases in net yield, and a significant decrease in the application of insecticide (Dinali & James, 2017).

Other traits have been added to a variety of crops to defend them from biological insults. Tomato, potato, squash and papaya are among a variety of crops that have been modified to resist infection by viruses or insect pests (Food and Drug Administration 2021). In addition to biotic stressors, plant productivity is

influenced by abiotic factors such as herbicide, soil composition, water supply and temperature. Therefore, conferring plants with genes that will help them withstand a wider range of environmental conditions could increase productivity. Plants are also being engineered to withstand drought heat, cold temperature and poor soil condition such as salinity and aluminum contamination.

Increased total yield of harvest also can be achieved by enhancing efficiencies in the metabolic and photosynthetic pathways. Examples of pathways that could be improved to increase crop yield include nitrogen assimilation, starch biosynthesis, and modification of photosynthesis. After harvest, time to market is an important economic factor due to the perishability of produce. Changing the rate of ripening would seem to be a benefit to both the farmer, by decreasing post-harvest losses and to the consumer by increasing shelf life. To prevent delivering spoiled fruit, mature tomatoes are harvested while still green and ripen during delivery by exposure to ethylene, a ripening hormone in tomatoes. In 1994 the Food and Drugs Administration approved a brand of tomato that had a genetic solution to this processing problem (Food and Drug Administration 2014). The producers of the tomato used antisense technology to silence a gene that produces polygalacturonase, a pectin degrading enzyme found in ripe tomatoes, thus slowing the ripening process (FAO, 2015)

Consumers stand to gain more than just produce with longer shelf lives. While still in its infancy, the technology is being used to produce plants that will have a whole range of output traits including increased nutritional value, medicinal properties, industrial utility, and novel taste and aesthetic appeal. Many of our common food crops could be improved to better meet the nutritional requirements of human and animals. Protein, starch and oil composition and content as well as micronutrient content can all be improved to make food and feeds more nutritious. For example, a new stain of potatoes containing 30--60 % more starch has been developed by inserting a bacteria gene for an enzyme in the starch biosynthetic partway. These high starch potatoes have less moisture and therefore absorb less fat during frying. Enzyme biotechnology also is being used to develop specialty oils containing more favorable fatty acid profiles such as high oleic acid and peanut oil (Woodward & Oludaunsi, 2015).

We have known for a long time that vitamins and minerals elicit biologic responses and have positive effect on health. Carotenoids are another class of nutrients that may be associated with risk for certain cancer and muscular degeneration. Among other plants they can be found in papaya (carotene), tomatoes (lycopene), kale and spinach. (Dinali & James 2017).

Beta-carotene has already been expressed in a genetically engineered rice cultivar, named Golden Rice by addition of genes for three enzymes in the phytoene synthase pathway (two genes from a daffodil and one from bacteria - erwinia uredovora). This strain was also crossed with a high iron strain of rice to produce a strain with both qualities (Gura, 2019). Golden rice has been the subject of much attention because it represents the potential of future biotechnology crops to benefit people in developing countries. This variety of rice could decrease malnutrition and blindness associated with vitamin A deficiency. However, there have been questions raised about the effectiveness of this rice because of many biological, cultural and dietary barriers that must be overcome (Nestle, 2021). This question will need to be answered as the product is further developed prior to introduction.

Other phytonutrients with purported health benefits includes glucosinolates, phytoestrogens and phytosteroids found in a wide variety of food sources, these compounds could selectively be over expressed to therapeutic levels (Beecher, 2019). In a much different way biotechnology is poised to completely change another aspect of preventive health care. Methods are being developed to produce vaccines in plants by introducing genes that express a protein antigen in crops such as corn, potatoes and bananas. When eating these antigens elicit an immune response and has been shown to provide protection against subsequent challenge from pathogens (Streatfield, 2021).The feasibility of this approach was demonstrated when mice was fed with Hepatitis B surface antigen expressed in potato tubers showed in a primary immune response by producing antibody specific to the antigen (Richter *et al,* 2020). Companies are positioning themselves to become suppliers of a wide range of biotechnology products, including bioactive therapeutic proteins, blood proteins, animal health products and industrial enzymes.

There are many other industrial applications for genetically modified organisms. For example, researchers at University of Georgia engineered yellow popular trees to have the ability to extract toxic mercury from the soil and convert the toxin to a relatively inert form. The genes were acquired from mercury- resistant

bacteria that are soil-borne and thrive at sites polluted with heavy metals. In one study the engineered plants were capable of ten times the rate of mercury removal as compared with nonengineered plants (Food and Drug Administration, 2021). This is just one example of how phytoremediation, (the use of plants to clean up contaminated areas), combine with biotechnology is a promisingly efficient, economical and environmentally friendly technique that could restore soil health and revegetate contaminated waste sites.

Clearly, consumer preference is playing a role in the industry's choice of product development. Just as consumers have appreciated seedless oranges and watermelon, the industry is developing other fruiting crops that do not require fertilization to produce seedless fruit. Novel produce, such as seedless tomatoes, squash, eggplant, pepper, strawberries, melons and cherries, to list a few of the possibilities would be attractive to many consumers. Additionally, these fruits would have improved taste due to increased total soluble sugar compared to seeded fruits and maybe of economic value to the processing industry as well (Rotino, 2017).

Also, in development is a sweet protein found naturally in the fruit of the African vine, Pentadiplandra brazzeana. This heat stable protein is 500 times as sweet as sucrose at higher concentration and as much as 2000 times as sweet in a two percent (by weight) solution. Lacking bitterness, it has a lot of potentials as an alternative low energy sweetener (Eckles, 2019. It is clear that plant biotechnology has the potential to have huge effect on tomorrow's society. Already over 50 biotechnology crop products have passed the regulatory review process and have been commercialized, ranging from corn and potatoes to tomatoes and squash (Food and Drug Administration, 2019). It is interesting to note that crops modified by biotechnology are the mostly rapidly adopted technology in the history of agriculture. In 1996 0nly 4.3million acres of biotech crops had been planted; by 2000 that number increased to 109.2 million acres (James, 2021).

Challenges Facing Agricultural Biotechnology in Nigeria

The implementation of agricultural biotechnology in Nigeria is currently moving at a slow pace despite the fact that agricultural biotechnology holds enormous promises for increasing food production wherever it is applied, it has become an emotional issue among some consumers, environmental groups and societies. As this science continues to develop, it clearly presents numerous challenges which hinder its development throughout the food chain (Nicholas, 2018). The major challenges of biotechnology in Nigeria include: - lack of awareness on the development and adoption of agricultural biotechnology. This was evident in the national survey conducted in 2014, investigating public awareness of agricultural biotechnology. This was carried out prior to the launching of Nigeria Agricultural and Biotechnology Project (NABP). The survey results suggest that Nigerian public is only marginally aware of biotechnology (Nicholas, 2018).

- Lack of funds and inadequate budgetary provision. Research and development require a lot of funding to acquire modern equipment and training of personnel in key biotechnology techniques (Ojo, 2016)
- Poor institutional capacity building; most of Nigeria's higher institutions and research institutes lack capacity in scientific DNA manipulation and laboratory management (Olaito, 2014). There is a need to equip our institutions with adequate laboratory facilities and manpower in biotechnology.
- Lack of research and development in this key economic area. Although Nigeria has commenced research in cassava, cotton, cowpea and maize, much work still needs to be done on economic plants such as cocoa, palm oil and rubber. This will give Nigeria economic advantage and boost the nation economy (Nicholas, 2018).
- Inadequate human resource and expertise. Agricultural biotechnology is an intensive research area which needs high capacity of human resources to achieve substantial benefits. In Nigeria, the number of full-time equivalent researchers at government research institutes declined in the late 1980s and early 1990s, partly, due to lack of funds and the drifts to university with higher wages (Beintema & Ayoola 2017). Thus, government should encourage and support researchers in the area of biotechnology.
- Safety problem: Although, no report of ill effect has been documented since the adoption of GM food, the perceptions of people are that it may cause adverse effects in the long run (Ojo, 2016)
- Inadequate regulatory measure: a major issue that will affect successful application of biotechnology in Nigeria is the regulatory climate governing the release of new products.

A safe and efficient regulatory process, able to ensure public health and environmental safety, is in itself a comparative advantage in biotechnology when properly applied (Nicholas 2018). The rules governing the trade of biotech-derived products and indeed all products must be based on scientific risk assessment and risk management.

Prospects of Agricultural Biotechnology in Nigeria

Agricultural Biotechnology with its enormous potential is yet to be fully adopted in Nigeria. Even though, the Federal Government has established the Bio-safety Agency with the mandate to regulate and coordinate all biotechnology activities in the country, not much has been accomplished. However, if good management can be adopted by the existing Bio-safety Agency in Nigeria, achievement in solving the food shortage and other agricultural-related problems will know no bound, as connecting to this scientific development means of solving agricultural problems has proved to be of great value wherever it was applied.

Presently, the country's National Bio-safety Management Agency (NBMA) approved the general release and marketing of BT cotton in 2016, as well as confined field trials of BT maize (Nkechi, 2017). Recent activities on agricultural biotechnology have also witnessed massive enlightenment and awareness workshops that engaged Nigeria on a personal and cooperate level.

The high print of the recent development was the endorsement of the genetically modified organism (GMO) by Nigeria reputable science—based professional body, the Nigerian Academy of Science (NAS). The Institution declares that (GMO) are beneficial for crop improvement and for the overall improvement of agricultural sector.

No doubt the biotechnology sector will exploit the wealth of opportunities available in the Nigerian agricultural sector to achieve food security for the masses. Much progress is being recorded on BT cowpea. The emphasis now is on concluding research and field trials of the Maruca-resistant BT cowpea and insect resistance BT cowpea in order to facilitate the commercialization of these crops (Nkechi, 2017). BT cowpea has undergone location trials and still going through on-station trials. It worth reporting that after the on-farm field trials, certification for seed will be obtained before final release of the obtained varieties. It should also be noted that BT Cotton seed has been approved for release. Other crops currently at various stages of confined field trials (CFTs) in Nigeria include the Nitrogen use efficient, water use efficient and salt tolerance (NEWEST) rice and African bio-fortified sorghum (ABS) (Bennelt, 2017).

Field trial of the bio-cassava plus or vitamin of cassava (developed in the United State by the Plant Danforth Centre, Missouri) was formally launched in Nigeria on July 31st 2013 under the agricultural transformation of the Federal Government. Biotech cowpea was also developed in Australia with significant participation of Nigerian scientists. Nigeria farmers have also shown great interest in the production of genetically engineer crops such as transgenic insect resistant cotton developed in Burkina Faso, bioengineered cotton and drought tolerant corn (Olaito, 2014).

There are also plans to begin CFTs for BT Maize, herbicide tolerant, soybeans and virus resistant cassava bio fortified with iron and zinc. This project will be carried out by the mandate institution for the crops in collaboration with the National Biotechnology Development Agency (NBDA). With the approval of the National Biosafety Committee, the National Root Crops Research Institute, Umudike and the Institute of Agricultural Research (IAR), Zaria, are carrying out confined field trials on transgenic cassava, sorghum and cassava (Nkechi, 2017).

Stakeholders in the biotechnology sector are also committed to continue their efforts to engage policy makers, government institutions, councils, professional bodies, religious organization, individuals and academia in the quest to improve the public understanding of the science behind GM crops and ways that agricultural biotechnology can profitably contribute the economic development of the country (Bennelt, 2017).

The Nigerian government, over the last seven years, is building capacity and outreach with other relevant agencies. The USDA has helped to fund scientists to work on biotechnology at the International Institute for Tropical Agriculture (IITA) under its technical assistance program. Due to the special skills required in this section, the government has directed its agency to recruit experts in the field to train existing staff on the techniques of biotechnology (Bennelt, 2017).

Although there are still challenges of funding, infrastructure development and laboratories, the effort of the Nigerian federal government in the establishment of seven bio resource centers in Odi, Ogbomoso, Katsina, Jalingo, Iselu, Owo and Arochukwu is a major step in the realization of the biotechnology development revolution. The government is also partnering with the private sector such as Bill and Melinda foundation for the funding of biotechnology research in the country. It

is believed that Nigeria has taken a giant step toward ensuring that biotechnology is well established and accepted in Nigeria (Bennelt, 2017).

Conclusion and Recommendations

Nigeria and other developing nations face the problem of food shortage, which is due to global warming, erosion, desertification, health and poverty. These problems require the urgent solutions that biotechnology can provide. Brazil, India, and China with their huge population rely on biotechnology for their agricultural needs. Nigeria with similar challenges can also use the same technology to revive its agricultural sector that has been experiencing low turn-out over the years.

In order to improve the contribution of the agriculture to the national economy and reduce or eradicate the imminent food shortage in the country, biotechnology can be applied to produce highly efficient agricultural, pharmaceutical and forestry crops to counter problems associated with employment and population growth in Nigeria.

Seed production is the primary event in the value chain of agrarian production. Quality seed production has been achieved employing this technology. Nigeria can use biotechnology to the best advantage, providing the world better quality food and produce, and ramping-up its industrial production of agro-allied products; managing its waste converting them into useful items and finally becoming a nonoil dependent economy. In order to achieve this, government must increase the level of awareness of biotechnology and genetically modified crops using Agricultural Education and Extension Programme and National Orientation Agency (NOA) with the support of mass media to create awareness about the development in biotechnology. Also, the NBDA needs to be proactive in releasing crops that have been certified and encourage research in other crops such as cocoa, sugar, palm oil, plantain, yam etc. that are of economic importance to the country. Finally, the use of agricultural biotechnology will not only ensure food security but in addition, will ensure that local farmers utilize the appropriate technology needed for large scale production leading to the prosperity of the farmers and national economic growth.

1. Technological advocacy and wide enlightenment on agricultural biotechnology, its products and implications are urgently needed to address the challenges highlighted.
2. The government, academia, industry and other stakeholders need to double down on efforts to develop and implement safe agricultural biotechnologies for various applications. In general, the authors envisage that the finding will add credence to the quest for effective R &D and the implementation of agricultural biotechnology in Nigeria.

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