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Problems and Prospects of Agricultural Biotechnology in Nigeria's Developing Economy

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***Abstract*—**Science offers opportunities for revolutionizing human activities, enriched by input from scientific research and technology. 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 review identified the problems of agricultural biotechnology in Nigeria. On the part of rural farmers, there is a lack of adequate knowledge or awareness of biotechnology despite the fact that they constitute the bulk of Nigerian farmers. On part of the 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 problems include: 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 diseases resistant crops and livestock are another viable area of contribution of biotechnology to agricultural production. In conclusion, agricultural biotechnology will not only ensure food 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, provided government plays its role of adequate funding and good policy implementation.

Keywords—Biosafety, biotechnology, food security, genetic engineering, genetic modification.

I. 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 [1]. Since the beginning of creation, man has been using agriculture as the most importance means of meeting the three basic needs of life which are food, shelter and clothing [2]. 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 [1]. 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 contribute immensely to food production, while maintaining a healthy environment which reduces the amount of fertilizer, herbicide and pesticide used in farming [3].

Agricultural biotechnology holds enormous promise 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 so that it can withstand climatic changes and environmental stresses, and increase in production and nutritional 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 [4], recent scientific advances in genetics have opened up a range of potential new applications 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 developments in agricultural biotechnology include genomics (mapping of complete organisms) and bioinformatics (computer processing of masses of genetic data) [5].

In many developing countries, and inclusive of those in Islamic world, 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 [6]. 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 [7]. 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 impedes

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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.

II. Concept of Agricultural Biotechnology

The need to feed the ever increasing world population of 1.7 billion in 1900, and now about 7.2 billion and expected to climb to 9.6 billion in 2050, and with over 2 billion currently malnourished, has sprung up researches in science and agriculture looking for ways to curb the imminent food shortage in the world [8]. One of the major objectives of this research is to assess whether in Nigeria, biotechnology will lead to an increase in the country's agriculture yield with minimum impact on the environment, addressing the needs of small farmers as well as larger commercial producers. For many developed countries, biotechnology holds this promise and it is termed the "doubly green revolution".

Biotechnology is referred to as the application of DNA or gene technologies for the agronomic improvement of crop plants [9]. Genetics is the best known as the most powerful of these techniques, holding great promise for improving crop yields, quality and value of agricultural products. Biotechnology allows the genetic code imparting specific traits, for example, resistance to a disease infection, or drought resistant, to be identified and isolated from a given organism. Once reduced to a few micro liters of sticky fluid, this genetic material can be adjusted as required and introduced into cells of a given plant to become an integral component of the crop's native generic make up [9].

The power of genetic modification technology has the ability to take genes from one organism and insert them into another plant in order to impact novel characteristic. This capability is rooted in the biological reality that the genetic code (genes) for all living organisms are organized in the same manner with minimal changes can be made to operate in a non-native genetic background. It is therefore possible to transfer genetic code from algae, bacteria, and viruses in animal to plants or to move genes between sexually incompatible species, that is, a crop plant can be modified to produce their own pesticide, or to have improved nutritional qualities. Recent advances over the last five years have demonstrated the ability to transfer more than one gene into a plant genome [10].

These attributes increase the potential to engineer complex disease and pest resistance pathways to produce high quality plants. Also, a biosynthesis pathway can also be engineered to produce high value pharmaceuticals and other polymers within the plants tissues. Therefore, the ability to transfer beneficial agronomic traits from one organism to the other across species boundaries, within and out of the kingdom, allows a multitude of possibilities which can only be limited at the time by our imaginations. However, if handled in a responsible manner, biotechnology represents a revolution with immense potential for the wellbeing of mankind [11].

III. Genetically Modified Crops

Genetically modified crops (GMCs, GM crops or biotech crops), are plants or crops whose DNA has been modified using genetic engineering techniques in order to introduce new traits to the plants which do not occur naturally in the specie. These traits may include resistance to a certain pest, disease or environmental condition, reduction in spoilage, or resistance to chemical treatments or improving the nutrient composition of the crop [12].

The first genetically modified crop was an antibiotic-resistant tobacco plant produced in 1982 [13]. The first field trials occurred in France and the USA in 1986, when tobacco plants were engineered for herbicide resistance [14].

GMC has been widely adopted by farmers between 1996 and 2015, the total surface area of land cultivated with GM crops increased by a factor of 100, from 17000 km^2 (4.2 million acres) to 1,797,000 km^2 (444 million acres) [15]. As at 2010, 10% of the world's arable land was cultivated with GM plants [16], and in 2014, meta-analysis concluded that GM technology adoption had reduced chemical pesticide use by 27%, increase crop yield by 22% and increased farmers product profit by 68% [17]. There is a scientific consensus that currently available food derived from GM crops poses no greater risk to human health than conventional food [18], but that each GM food needs to be tested on a case-by-case basis before introduction.

The legal and regulatory status of GM foods varies by countries, with some banning or restricting them and others permitting them with widely differing degrees of regulation [19].However, some opponents have objected to GM crops on several grounds, including environmental concerns, whether food produced from GM crops is safe, whether these crops are needed to address the world food needs, whether the foods are readily accessible to poor farmers in developing countries and whether the crop can be propagated or replanted. No significant reports of the ill effects from GM food have been documented in the human population [20]. While the labeling of GM crops is required in many countries, the United States Food and Drug Administration does not require labeling, nor does it recognize any distrust between approved GM and non-GM foods [21].

Tables I and II show some genetically modified crops and their country of first approved.

Tables I and II show some genetically modified crops, approved countries and usage. These crops have been propagated successfully with improved traits in Europe, Asia and America, with only South Africa in the African sub region.

TABLE I
HERBICIDE TOLERANCE CROPS [22]-[25]

Crop	Use	Countries approved in	First approve	Notes
Alfalfa	Animal feed	US	2005	Approval withdrawn in 2007 and then re-approved in 2011
Canola	Cooking oil Margarine Emulsifiers in packaged food	Australia Canada US	2003 1995 1995	
Cotton	Fiber Cotton seed oil Animal feed	Argentina Australia Brazil Columbia Coats Rice Mexico Paraguay South Africa US	2001 2002 2008 2004 2008 2000 2013 2000 1994	
Maize	Animal feed High-fructose corn syrup Corn starch	Argentina Brazil Canada Colombia Cuba European Union Honduras Paraguay Philippines South Africa US	1998 2007 1996 2007 2011 1998 2001 2012 2002 2002 1995	Grown in Portugal, Spain, Czech Republic, Slovakia and Romania
Soybean	Animal feed Soybean oil	Uruguay Argentina Bolivia Brazil Canada Chile Costa Rice Mexico Paraguay South Africa US Uruguay Canada	2003 1996 2005 1998 1995 2007 2001 1996 2004 2001 1993 1996 2001	
Sugar Beet	Food	US	1998	Commercialized 2007, production blocked 2010, resumed 2011.

TABLE II
INSECT RESISTANCE CROP [8], [26]-[29]

Crop	Use	Countries approved in	First approve	Notes
Cotton	Fiber Cottonseed oil Animal feed	Argentina Australia Brazil Burkina Faso China Colombia Costa Rica India Mexico Myanmar Pakistan Paraguay South Africa Sudan US	1998 2003 2005 2009 1997 2003 2008 2002 1996 2006 2010 2007 1997 2012 1995	Largest producer of Bt cotton
Egg plant	Food	Bangladesh	2013	12 ha planted on 120 farms in 2014
Maize	Animal feed High-fructose corn syrup Corn starch	Argentina Brazil Columbia Mexico Paraguay Philippines South Africa Uruguay US	1998 2005 2003 1996 2007 2002 1997 2003 1995	Centre of origin for maize
Poplar	Tree	China	1998	543 ha of Bt poplar planted in 2014

The number of USDA approved fields released for testing grew from four in 1985 to 1,194 in 2002 and average around 800 per year thereafter. As of September 2013, about 7,800 releases had been approved for corn, more than 2,200 for soybeans more than 1,100 for cotton and about 900 for potatoes. Releases were approved for herbicide tolerance (6,772 releases), insect resistance (5,190) and virus/fugal resistance (2,616). As of September 2013, the USDA has received proposals for the release of GM squash, plum, rose, tobacco, flax and chicory [30].

IV. Challenges Facing Agricultural Biotechnology in Nigeria

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 [5].

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 Agriculture and Biotechnology Project (NABP). The survey results suggest that the Nigerian public is only marginally aware of biotechnology [5].
- Lack of funds and inadequate budgetary provision. Research and development requires a lot of funding to acquire modern equipment and training of personnel in key biotechnology techniques [5], [2].
- Poor institutional capacity building; most of Nigeria's higher institutions and research institutes lack capacity in scientific DNA manipulation and laboratory management [7]. 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 [5].
- 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, due partly to lack of funds and the drifts to university with higher wages [31]. 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 [2].
- 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 [5].

The rules governing the trade of biotech-derived products and indeed all products must be based on scientific risk assessment and risk management.

V. 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, 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 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 [32]. Recent activities on agricultural biotechnology have also witnessed massive enlightenment and awareness workshops that engaged Nigeria on a personal and corporate level. The high print of the recent development was the endorsement of the genetically modified organism (GMO) by Nigeria's reputable science-based professional body, the Nigeria Academy of Science (NAS). The institution declares that GMOs are beneficial for crop improvement and for the overall improvement of the 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 mass. 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 [32]. 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 the African bio-fortified sorghum (ABS) [33].

Field trial of the bio-cassava plus or vitamin of cassava (developed in the United State by the Plant Danforth Center, Missouri) was formally launched in Nigeria on July 31, 2013 under the agricultural transformation of the Federal Government. Biotech cowpea was also developed in Australia

with significant participation of Nigerian scientists. Nigerian 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 [7].

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 Bio-safety 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 cowpea [32].

Stakeholders in the biotechnology sector are also committed to continue their efforts to engage policy makers, government institution, 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 [33].

The Nigerian government, over the last five 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 [32], [33].

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 the 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 [32].

VI. Conclusion

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 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 non-oil dependent economy. In order to achieve this, government must increase the level of awareness of biotechnology and genetically modified crops, using agricultural extension officers and National Orientation Agency (NOA) with the support of mass media to create awareness about the developments 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, provided government plays its role of providing adequate funding and good policy implementation.

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