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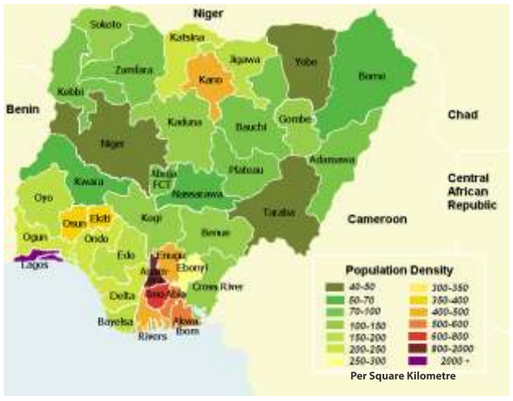
The Status of Crop Biotechnology in Nigeria: Issues and Challenges

1.0 Introduction

Food crop production in Nigeria has not kept pace with its population growth, because the population is growing at about 3.2 per cent per annum while food crop production is at about 2.0 per cent (NBS, 2011). The declining agricultural productivity in Nigeria is worrisome and a real challenge for Government with a population of approximately 170 million people to feed. The declining trend is as a result of many factors including abiotic and biotic stresses. Farmers face challenges of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Zoellick, 2009). The challenge is to develop technologies that can overcome these limiting factors, and can be utilized by small-scale farmers who use minimal external inputs. Such technologies can include use of biotechnology products.

Crop biotechnology has been recognized as a technology that can help farmers to produce more from improved crop cultivars that are pest resistant, drought tolerant, water use efficient and efficient in nitrogen fixation. The edible plant parts can also be genetically modified to provide consumers with more micronutrients to correct for malnutrition and diseases, especially in children and vulnerable group. Genetically Modified (GM) crops have helped to improve farming techniques and crop production around the world by increasing plants' resistance to diseases and pests and reducing pesticide applications, as well as maintaining and improving crop yields.

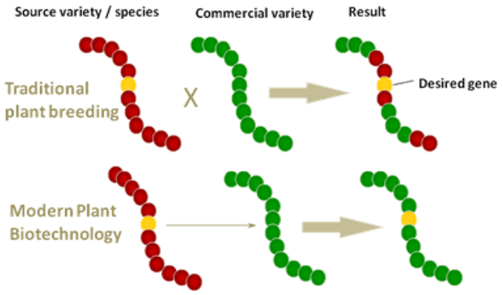


Map of Nigeria showing Population Density

Nigeria's commitment in realizing food security, agricultural productivity is in the domestication of biotechnology, especially crop biotechnology. This policy brief will focus only on the status of crop biotechnology in Nigeria.

2.0 Crop Biotechnology

Biotechnology is defined as a set of tools that uses living organisms (or parts of organisms) to make or modify a product, improve plants, trees or animals, or develop microorganisms for specific uses. Biotechnology has the potential to increase agricultural productivity, enhance food security, and move agriculture away from a dependence on chemical inputs helping to reduce environmental problems. It encompasses a number of tools and elements of conventional breeding techniques, bioinformatics, microbiology, molecular genetics, biochemistry, plant physiology, and molecular biology.



Agricultural biotechnology is the term used in crop and livestock improvement through biotechnology tools. The biotechnology tools that are important for crop biotechnology include: conventional plant breeding, tissue culture and micro-propagation, molecular breeding or marker assisted selection, genetic engineering and GM crops and molecular diagnostic tools. Crop biotechnology, while merely one of the many possible scientific options to improve agricultural productivity, has triggered increased interest in its consistent and substantial benefits.

3.0 Crop Biotechnology Development in Nigeria

Crop biotechnology allows scientists to maintain and improve crop and pasture productivity by modifying plants in ways not always possible using conventional breeding techniques. Crop biotechnology has the potential to produce novel products from plants, improve their nutritional quality, increase productivity and adapt crops to environmental stresses resulting from a changing climate.

Over many thousands of years, farmers have engaged in what plant breeders now call selective breeding, by selecting and saving seed from those plants with the most desirable features. Over time, plant breeding has become more sophisticated, and now involves the deliberate crossing of different varieties or even species, including close wild relatives.

Crop biotechnology has allowed the speeding up of traditional breeding approaches, and made it possible to transfer desirable characteristics from almost any kind of organism into plants. Of the many and diverse applications of crop biotechnology, genetically modified (GM) crops have been adopted by farmers worldwide at rates never before seen by any other advances in the history of agriculture.

Nigeria through the National Biotechnology Development Agency (NABDA) and other research institutes and international partners has made series of efforts in making sure that Nigeria is not left behind in tapping from the benefits of biotechnology, especially crop biotechnology. Modern biotechnology has been adopted by Nigeria in realizing certain objectives in developing crops with certain traits under confined field trials e.g. Bio-cassava plus (BC+), Bt. cowpea, Africa Biofortified Sorghum (ABS), and recently Nitrogen-Use Efficient, Water-Use Efficient and Salt-Tolerant (NEWEST) Rice.

4.0 Status of Genetically Modified (GM) Crops trials

Crop biotechnology in Nigeria is increasingly being taken advantage of both at the research and application levels. In the last few years, many institutions have initiated active research and development programmes in arable crops and root and tubers. Some examples include the development and micro-propagation of plantain and banana improvement at the Sheda Science and Technology Complex (SHETSCO) and the National Biotechnology Development Agency (NABDA), Abuja, cassava biotechnology research at the National Root Crops Research Institute, Umudike, cowpea and sorghum biotechnology at the Institute of Agricultural Research, Zaria, and recently rice biotechnology at the National Cereals Research Institute, Badeggi, Many training activities on biotechnology go on regularly at the University of Agriculture, Abeokuta.

Generally, confined field trials (CFTs) are conducted under the responsibility of scientists from public or private research institutions. These trials are usually carried out on a small scale, often on not more than one-hectare area of land, at experimental stations such as those under the control of national agricultural research systems (NARS), local universities, or private sector research units. Such institutions are staffed by competent scientists with sound experience in the safe conduct of field trials and have capacity to evaluate the performance of new varieties for farmers.

Since CFTs are conducted in an open field, scientists design them to prevent the escape of the new genes and other plant material outside the experimental sites. While CFTs allow scientists to collect data on the performance of a particular GM crop, they can also be used to demonstrate a new technology to farmers and other stakeholders.

4.1 Bio-cassava Plus (BC+)

Confined Field Trial of Bio-Cassava Plus (BC+) by National Root Crop Research Institute (NRCRI), Umudike, Abia State, Nigeria

Bio-Cassava Plus (BC+) programme has an important objective to develop genetically modified (GM) biofortified cassava containing

increased quantities of important nutrients such as iron, zinc, protein and the vitamin A precursor, â-carotene for improved health and quality of life among poor farmers, including women, and young children in Africa. The first confined field trial (CFT) of GM cassava in Nigeria was successfully conducted in 2010 at National Root Crops Research Institute (NRCRI), Umudike, Nigeria (Sayre et al., 2011).

GM technology is much more effective and efficient than conventional approaches in terms of improving â -carotene in cassava and also has great potential in improving the quality of root and tuber crop production, and creating disease resistant cassava in the light of prevalent cassava mosaic disease (CMD) in Africa (Adenle et al., 2012).

4.2 Nitrogen-use efficient, Water-use efficient and Salt-tolerant (NEWEST) Rice

The recognition of the importance of rice in national food security and the need to reduce the amount of foreign exchange spent on rice importation has made increased rice production a major priority of Nigerian government, especially in the Agricultural Transformation Agenda (ATA) of the present administration. A disturbing situation about the issue of self-sufficiency in rice is the increasing rate of consumers' preference for imported rice (Erenstein, et al., 2004). There is therefore a need to increase its production and productivity. To improve productivity, African farmers will need to shift from low yielding, extensive land practices to more intensive, higher-yielding practices, with increased use of improved seeds, fertilizers and irrigation. Abiotic stresses represent significant constraints to rice production in Nigeria, both in quantity and quality.

traits have resulted in the release of several varieties with at least one of these traits, but no known developed variety has been staked with the three traits of nitrogen-use efficiency, water-use efficiency and salt-tolerance, which are the major abiotic stresses in the rice agro-ecologies in Nigeria. The African Agricultural Technology (AATF), Kenya is working with partners (National Cereals Research Institute, Badeggi and others) to develop and disseminate farmer-preferred and locally adapted rice varieties with enhanced nitrogen-use efficiency, water-use efficiency and salt-tolerance (NEWEST). Confined field trials (CFT) for the NEWEST rice containing the combination of genes for the three traits commenced in Nigeria in 2014.

4.3 Africa Biofortified Sorghum (ABS)

Nigeria is a largest producer of sorghum (or guinea corn) in the world with an annual production of about eleven million (11,000,000) tons of grains and the fifth exporter of sorghum in the world. It has been recognized as a potentially valuable industrial crop by the brewing industries and confectioners. It is usually used as a weaning meal for children but it lacks protein and essential amino acids, which can lead to malnutrition in children. Bio-fortifying sorghum with macro- and micronutrients, therefore, is considered a major step at resolving the nutritional challenge. ABS project commenced in Nigeria in 2009. The project goal is to produce a highly fortified grain with:

- Higher levels of vitamin A accomplished by introducing the pro-vitamin A biosynthetic pathway in sorghum seed.
- Better digestibility of protein.
- 50 percent more iron (Fe) and zinc (Zn) bio-availability, brought about by silencing expression of a gene involved in phytate biosynthesis, which reduces the availability of those minerals in sorghum seed.

The first Confined Field Trial (CFT) commenced in July 2011 for the introgression of ABS traits into 3 adapted Nigerian varieties. NABDA is one of the three participating institutions (Africa Harvest Biotechnology International, Kenya; Institute for Agricultural Research (IAR), Samaru, Zaria, and NABDA) working on ABS under a Confined Field Trial. This will help in the production of sorghum both in quantity and quality.

4.4 Bt Cowpea

Confined Field Trial of Pod Borer Resistant Cowpea. Source AATF

Farmers in West Africa have identified Maruca insect as a major problem in cowpea production. The damage caused by Maruca to cowpea plants reduces the size and quality of the cowpea. Conventional insecticide can be used to control this pest, but they are expensive, not always available to farmers, and due to inadequate training in their use, often lead to unintended human and environmental safety impacts. This results in some farmers using unapproved chemicals to protect cowpea crops, and other farmers having to tolerate the damage because they do not have any effective way to control Maruca. The deployment of a transgenic cowpea product that is capable of protecting itself from attack by Maruca will make it easier and cheaper for farmers to produce cowpea in areas where this pest is a problem.

The Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria has completed first multi-location trial of the Genetically modified (GM) cowpea variety with yield showing resistant to Maruca and having up to seventy percent yield improvement over the conventional cowpea varieties. Confined field trials was done to verify what is discovered in the laboratory that this new cowpea can protect itself from Maruca infestation and after multi location testing was conducted to know if the crop can withstand Maruca infestation, the testing was conducted in three areas of Minjibir in Kano State and Samaru in Kaduna State. Work has started on crossing the GM cowpea variety with local varieties most preferred by farmers. The project began in 2009 as a measure to make available and preferred local varieties that have natural resistance to insect and pest especially Maruca since the use of chemical has become more harmful to human, livestock and the environment.

5.0 Micro-propagation

Tissue culture at the University of Missouri, Kansas City, USA. Source OFAB Biotechnology Study Tour Group to the US in August 2012.

This is a tissue culture method developed for the production of disease-free, high quality planting material and for rapid production of many uniform plants. Actively dividing young cells (meristem) are placed in a special medium and treated with plant

hormones to produce many similar sister plantlets. Since the meristem divides faster than disease-causing virus, clean materials are propagated and hundreds of uniform plantlets are produced in a short time.

Through micro propagation, it is now possible to provide clean and uniform planting materials in plantations – oil palm, plantain, pine, banana, date palm, rubber tree; field crops – eggplant, pineapple, tomato; root crops – cassava, yam, sweet potato; and many ornamental plants such as orchids and anthuriums. Micro propagated plants were found to establish more quickly, grow more vigorously and taller, have a shorter and more uniform production cycle, and produce higher yields than conventional propagules. This tissue culture method has been used seriously in Nigeria by the National Biotechnology Development Agency (NABDA), Abuja; National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan; Sheda Science and Technology Complex (SHETSCO) and International Institute of Tropical Agriculture (IITA), Ibadan to produce disease-free and uniform planting materials of banana, plantain, date palm, pineapple, etc.

5.1 Challenges of Crop Biotechnology in Nigeria

Despite the first demonstration of CFT of GM crops in Nigeria and excitement among scientists about the potential of biotechnology, future release of GM crops to the farmers and consumers in Nigeria still poses a significant challenge given environmental and health risk concerns among the public. The challenges include:

1. Lack of scientific expertise and limited capacity for risk analysis and safe evaluation of GM crops.

2. High cost of regulation of GM crops, for example, the review of application for field-testing CMD-resistant cassava in Nigeria by the Eidgenossische Technische Hochschule (ETH) would have far exceeded the actual cost of the field test itself.

3. Inadequate consultation with local farmers or perhaps failure among participating scientists to arrive at important decisions. For example, GM cassava that must carry important two traits including a disease resistance trait, which has not yet been created, but is already undergoing transformation in the laboratory (Adenle et al. 2012).

4. Lack of substantive national biosafety law in Nigeria is still hindering full fledge domestication and commercialization of GM crops. Although, there exist biosafety guidelines that have helped in conducting confined field trials in IAR, Zaria and NRCRI, Umudike.

5. Insufficient funding for and financing of crop biotechnology research in Nigeria both from the public and private sectors.

6. Lack of modern infrastructure for crop biotechnology research and development impedes the speed of biotechnology research in Nigeria.

6.0 Building and Strengthening Capacity for Crop Biotechnology Research and Development in Nigeria

1. Realigning with the emerging linkages in national agricultural research systems

The current national agricultural research system depends on basic research, applied research, technology development, and technology transfer (which includes extension). Basic and applied research overlap in biotechnology to perhaps a greater extent than in traditional areas of agricultural science. In realigning the system to promote biotechnology, communication is essential among basic researchers, applied researchers, and farmers and private companies, the end users of technology. For the agricultural research system to be most effective, links among the disciplines of science that support agriculture as well as links between basic and applied research and technology development and transfer must be strengthened.

Crop biotechnology projects in Nigeria are designed to build and strengthen the capacity of scientists, technicians, and extension officers, farming NGOs on the benefits of the projects. But, more is still needed to be done in strengthening the new capacity in the National Biotechnology Development Agency and then retraining existing capacity especially in the national agricultural research system (NARS) for agricultural biotechnology research and development to be more beneficial for the socio-economic wellbeing of Nigerians as envisaged especially after the commercialization of GM crops as it is in other parts of the world. Projects on GM crops are expected to be supported by a holistic consortium of international scientists including Nigerian scientists.

2. Funding for crop biotechnology research and development

Current expenditures for agricultural research in the agricultural research system is grossly inadequate to fund conventional agricultural research and cannot accommodate crop biotechnology. The potential benefits of biotechnology will not be realized without a continued commitment to basic research. Funding and institutions provide the foundation for progress in biotechnology in general, and crop biotechnology in particular. A long-term commitment of adequate support is critical because biotechnology requires a substantial initial investment to acquire and build upon basic knowledge. Applying biotechnology to agriculture will put new demands on existing relationships among research institutions, will influence patterns of funding, and will alter established pathways between discoveries and commercial developments.

3. Training and Education

To initiate and implement advances in crop biotechnology will require more than appropriate institutional structures and funds. Crop biotechnology also requires a work force of agricultural research scientists trained to apply molecular biology techniques critical to solving crop problems.

For benefits in agricultural biotechnology in general and crop biotechnology in particular, to be more reaped, there should be major increase in public support for training programmes, which are needed to provide a high-quality research capability that ensures the future of Nigeria agriculture and meets the growing need of scientists trained for agricultural biotechnology. Programmes like career development awards especially for postgraduate studies, training grants, pre and postdoctoral fellowships, and retraining opportunities should be supported more in the areas of agricultural biotechnology.

4. Infrastructural development for crop biotechnology

The current infrastructure for agricultural research is not sufficient and cannot support modern crop biotechnology research. Laboratories for biotechnology research should be equipped with modern facilities.

7.0 Conclusion

Crop biotechnology research and development in Nigeria has started on a good note but new strategy that will deliver envisaged benefits as it is in other parts of the world must be developed and carefully followed. This strategy must ensure that scientists are better trained, infrastructure are provided, institutional linkages are enhanced for biotechnology development will improve agricultural productivity, enhance nutritional quality, adapt to crops to environmental stresses, enhance farmers' income, generate more employment opportunities especially among youths and improve health status of Nigerians especially children and women.

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