Challenges in application of biotechnology in crop and aquaculture production in Nigeria

Ugbe, Lawrence A., Ada, Fidelis B. and Agim, Marcel U.

2Dept. of Fisheries and Aquatic Sciences, Faculty of Agriculture and Forestry, Cross River University of Technology, Obubra Campus, Nigeria.

Corresponding author E-mail:fbekehada@yahoo.com.

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In this paper, challenges in application of biotechnology in crop and aquaculture production in Nigeria seeks to explore the benefits of applying biotechnological research in crop and fishery production as part of giant strides toward the attainment of a hunger free Nigeria. Biotechnology is a tool for solving many problems affecting crops, livestock and fishery production in developing countries. Genetic modification, is extremely important in developing new ways to increase food production, improve nutrient content, and provides better processing and storage characteristics of agricultural products. Apart from enhancing the production of aquatic species and offer environmental benefits, biotechnology also offer help in the use of synthetic hormones in induced breeding, transgenic fish, gene banking, uniparental and fish production and health management. Recommendations are also presented here on ways of encouraging the adoption of biotechnological research, such as allaying public perception and fear about the suspected dangers of consuming genetically modified products (GMP). Agricultural transformation programme, which should integrate biotechnological research, must benefits all sectors, including resource-poor populations especially where increase productivity is more difficult to achieve.

Key words: Biotechnology, crop production, aquaculture production, challenge, Nigeria.

INTRODUCTION

The word transformation means a holistic change from the old way to a new way. Economic transformation agenda of any administration usually refers to a programme of complete change or turn around that will bring economic futures to the nation, by projecting the economy from what it is at present, to a higher level of growth and development. Therefore agricultural transformation will be a programme of complete change or turn around in the agricultural sector policy of the economy to ensure a national steady growth in food and raw material production, as part of the nation's National transformation agenda.

Agriculture remains the main stay of Nigeria's economy. Nevertheless, a nation that cannot feed itself at best is set for doom. Agricultural transformation plan which is a component of the Nations' entire national economic transformation is an 'action plan' fashioned by the Federal Ministry of Agriculture and Rural Development on behalf of the Federal Government of Nigeria. The action plan appears to be the road map for transforming Agriculture in Nigeria for self sufficiency in food production. The haul mark of the action plan is to enable the country attain her vision of achieving a hunger-free society through an agricultural sector that drive income growth, accelerates achievement of food and nutritional security, generates employment and transforms Nigeria into a leading player in global food markets to growth wealth for millions of farmers (FMARD, 2011).

This vision can be achieved if the Nigerian Government through the Federal Ministry of Agriculture and Rural Development and all other stakeholders in agricultural development such as the research institutes, individual farmers and co-operative societies fully integrate modern biotechnology into the agricultural research and production process.
Scope of biotechnology

Biotechnology is the application of biological knowledge base, in crop, animal and fish production, food and nutrition, (processing and packaging) and in the pharmaceutical industries for the production of drugs. Hoban and Kendall (1993) and (Agbeda, 2012) explained that it is called biotechnology because it deals with living cells and their molecules to improve lives. It uses organisms or their products for commercial purposes. Parsley (1990); and Matthews-Njoku and Adesope (2008) pointed out that it requires a wide range of procedures for modifying living organisms according to human purposes-going back to the history of the domestication of animals, cultivation of plants, and the improvements of these two through breeding programmes that employ artificial selection and hybridization. As such, traditional oriented biotechnology has been in practice since the beginning of record history. It has been in use to: bake bread, brew alcoholic beverages, and breed food crops or domestic animals.

Biotechnology is any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific use. Biotechnology is any technique that uses living organisms, or substances from those organisms, to make or modify a product, to improve plants uses (Ota, 1989; Sherwood et al., 1999).

However, recent developments in molecular biology have given biotechnology new meaning, new prominence and new potentials. This is the modern biotechnology that has captured the attention of the public, because it can have a dramatic effect on the world economy and society.

The key component of modern biotechnology is genetic engineering. Genetic engineering itself is not a biotechnology, but rather a technique in biotechnology which has developed through decades of basic research in cell and molecular biology. Today, a gene can be identified, isolated, cut off, inserted and transformed. This genetic manipulation is what is known as genetic engineering.

Genetic engineering has made it possible to improve our understanding of the living organism and to apply the knowledge to the life and activities of man which include; food, agricultural production, forestry, fish production, animal rearing, horticulture (Opabode and Adebooye, 2005; Ezeonu et al., 2012).

BIOTECHNOLOGY IN CROP PRODUCTION

The role of modern biotechnology in crop production cannot be overemphasized. In fact, biotechnology will through the production of genetically modified plants, impact the agricultural and plant science in three major areas; (1) Growth and development control (vegetative, generative and reproductive/propagation) (2) Protecting plants against the ever-increasing threats of abiotic and biotic stress. (3) Expanding the horizons by producing specialty foods, biochemicals and pharmaceuticals (Altman, 1998). But Alhassan (2003) and Abdi and David, (2009) pointed that there is no biotechnology crop under development in Nigeria that will be on the market in the near future.

All organisms are made up of cells that are programmed by the same basic genetic material, called DNA (deoxyribonucleic acid). However, each unit of DNA is made up of a combination of Nucleotides, sugar and phosphate. Segments of the DNA are responsible for instructing individual cells how to produce specific proteins. These segments are referred to as genes. It is the presence or absence of the specific protein that give an organism a trait or characteristic. There are over 10,000 different genes found in most plants and animal species. The total set of genes for an organism is organized into chromosomes within the nucleus. The process by which a multi-cellular organism develops from a single cell through an embryo stage into an adult is controlled by the genetic information of the cell as well as interaction of the genes and gene products with environmental factors.

Therefore genetic engineering is the technique of removing, modifying or adding genes to a DNA molecule in order to change the information it contains. By changing this information, genetic engineering changes the type or amount of proteins an organism is capable of producing.

Genetic engineering is used in the production of drugs, human gene therapy, and the development of improved plants. Emphasis here is on its application in aquaculture and crop production. For example an insect produces a gene referred to as “Bt” has been inserted into several crops such as corn, cotton and potatoes in order to give the farmers new tools for integrated pest management. “Bt corn” is resistant to corn borer. This inherent resistance thus reduces a farmer’s pesticide use for controlling corn borer, and in turn requires less quantity of chemicals and potentially provides higher yielding agricultural biotechnology crops.

Although major genetic improvements have been made in crops, progress in conventional breeding programmes has been slow. In fact, most crops grown have less than their full genetic potential. These short falls in yield are due to the inability of crops to tolerate or adapt to environmental stresses, pests and diseases.

Genetic engineering has enabled scientists to develop the ability to insert genes that give biological defense against disease and insects thus reducing the need for chemical pesticides, and research is on to convey genetic traits that enable crops to better withstand harsh conditions, such as drought. Research is also going on to develop transformation techniques and applications for control of diseases caused by plant viruses in tropical
plants such as rice, cassava and tomato.

For instance, in 1995, the International Laboratory for Tropical Agricultural Biotechnology (ILTAB) reported the first transfer through biotechnology of a resistant gene from a wild species of rice to a susceptible cultivated rice variety (FAO, 1998). The transferred gene, according to the report, expressed resistance to Xanthomonas oryzae, a bacterium which can destroy the crop through disease.

Benefits can also be seen in the environment, where insect-protected biotech crops reduce the need for chemical pesticides use. Insect protected crops allow for less potential exposure of farmers and ground water to chemical residues, while providing farmers with season long control. Also by reducing the need for pest control, impacts and resources spent on the land are less, therefore preserving the top soil.

Modern biotechnology has offered opportunities to produce more nutritious and better tasting foods, higher crop yields and plants that are naturally protected from diseases and insect pests. Modern biotechnology allows for the transfer of only one or a few desirable genes, thereby permitting scientists to develop crops with specific beneficial traits and reduce undesirable traits (IMPB, 2012).

Traditional biotechnology such as crops pollination in corn produces numerous, non selective changes. Genetic modifications have produced fruits that can ripen on the vine for better taste, yet have longer half lives through delayed pectin degradation.

The report further stated that tomatoes and other produce containing increased levels of certain nutrients, such as vitamin C, vitamin E, and or beta carotene, help to protect against the risk of chronic diseases, such as some cancer and heart diseases (Jones, 1998).

Similarly, introducing genes that increase available iron levels in rice is three fold potential remedy for iron deficiency, a condition that affects more than two billion people and causes anemia in about half the population. Lots of today’s cheese products are made with a biotech enzyme called Chymosin.

This is produced by genetically engineered bacteria which are considered more pure and plentiful than its naturally occurring counterpart, rennet, which is derived from calf stomach tissue.

Tissue culture was developed in the 1950s and became popular in the 1960s. Today, micro propagation and in vitro conservation are standard techniques in most important crops, especially those dealing with vegetative propagation.

Tissue culture includes micro propagation, embryo rescue, plant regeneration from callus and cell suspension, protoplast anther and microspore culture. The techniques that are being used for large scale plant multiplication. Micro propagation has proved especially useful in producing high quality disease-free planting materials of a wide range of crops.

Biotechnological applications in crop production focus on the following; as highlighted by Parsley (1990):

- adopting agricultural microbiology in producing microorganisms that are beneficial to crop cultivation, cell and tissue culture, inducing the rapid propagation of useful microorganisms and plant species, applying new techniques, based on the use of monoclonal antibodies and nucleic acid probes, for diagnosing plants pests and diseases and to detect foreign chemicals in food, genetic engineering of plant species to introduce new traits with resistance to pests and diseases, new genetic mapping techniques, based on the use of restriction fragment length poly-morphising (RFLP), as an aid to conventional plant breeding programmes and new bio-control agents for pest control, to reduce pesticide use.

### BIOTECHNOLOGY IN FISHERIES AND AQUACULTURE

Fisheries and Aquaculture form important sector of food production in Nigeria, providing the nutritional security, contributing to the agricultural exports and engaging about 10% of the nation’s population in different income earning activities (Offem et al., 2010). With diverse resources ranging from deep seas to lakes, and more than 10% of the global biodiversity in terms of fish and shellfish species, Nigeria has shown continuous and sustained increment in fish production since independence in 1960, celebrating fish festivals among different tribes, especially the Ijaw people.

The use of modern biotechnology in enhancing the production of aquatic species holds great potential not only to meet demand but also to improve aquaculture. Genetic modification and biotechnology holds great potentials to improve the quality of fish reared in culture. Biotech aquaculture also offers environmental benefits (Barolli et al., 1999).

When biotechnology is appropriately integrated with other technologies for the production of food, agricultural products and services, it can be of significant assistance in meeting the needs of an expanding and increasingly urbanized population in Nigeria.

According to Billington and Hebert (1991), the increase public demand for sea food and decreasing natural habitats have encouraged researchers to study ways that biotechnology can increase the production of marine food products, and making aquaculture as a growing field of animal research.

Biotechnology in fisheries allows scientists to identify and combine traits in fish and shellfish to increase productivity and improve quality. Scientists are investigating genes that will increase production of natural fish growth factors as well as the natural defense compounds marine organizations use to fight microbial infections.

Modern biotechnology is already marking important contributions and poses significant challenges to aquaculture and fisheries development (Ballacharya et al., 2002).
BIOTECHNOLOGY IN FISH BREEDING

Gonadotrophin hormone (GnRH) is now the best available biotech tool for the induced breeding of fish. Gonadotrophine (GnRH) is the key regular and central initiator of reproduction cascade in all vertebrates. Depending on the structural variant and their biological activities, a number of chemicals have been prepared from GnRH, example Salmon GnRH analogue, and are profusely used in fish breeding. The induced breeding of fish is now successfully achieved by the development of GnRH technology (Halder et al., 1991).

Transgenosis (Transgenics)

This is the introduction of exogenous gene/DNA into host genome resulting in its stable maintenance, transmission and expression. Technology of transgenics offers an excellent opportunity for modifying or improving the genetic traits of commercially important fishes, mollusks and crustaceans for aquaculture. The technique has now been successfully applied to a number of fish species. Dramatic growth enhancement has been shown using this technique especially in Salmonid (Sherwood et al., 1993 and Diwan et al., 1997).

Chromosome engineering

Chromosome sex manipulation techniques, used to induce polyplody (i.e. triploidy and tetraploidy) and uniparent chromosome inheritance (gynogenesis and androgenesis) have been applied extensively in culture fish species (Baroiller et al., 1999). These techniques are important in the improvement of fish breeding as they provide a rapid approach for gonadal sterilization, sex, control, improvement of hybrid viability and clonation. Induced triploidy is widely accepted as the most effective method for producing sterile fish for aquaculture and fisheries management (Bonger et al., 1994).

Fish health management

Disease problems are major constraints for the development of aquaculture. Biotechnological tools such as molecule diagnostic methods, use of vaccines and immuno stimulants are gaining popularity for improving disease resistance in fish and shellfish species worldwide for viral disease (Sherwood et al., 1993; Bonger et al., 1994).Biotechnological tools such as gene probes and polymerase chain reaction (PCR) are showing great potential in this area. Gene probes and PCR based diagnostic methods have developed for a number of pathogens affecting fish and shrimp. In case of finfish aquaculture, numbers of vaccines against bacteria and viruses have been developed (Grace, 1997).

PROBLEMS OF BIOTECHNOLOGY

The major problem confronting the application of biotechnology in agriculture is the public perception and risk assessment of transgenic crops. This controversy has attracted the attention of non-scientific partisans to each side. Both those for and against may not have the technical knowledge to assess the potentials dangers and benefits of biotechnology in crop improvement. Irrespective of this ideological dispute, biotechnology products will be accepted by people who support scientific-based progress, in a similar way that new cultures or innovative crop husbandry techniques have previously become integral parts of farming systems.

The main concern is the biosafety – the safe and environmentally sustainable use of all biological products and applications for human health, biodiversity and environmental sustainability in support of improved global food security. However, just as with any new means of food production, there are potential human health risks that must be considered when foods are developed using biotechnology (FAO, 1998). It is important to encourage people world wide to develop and apply appropriate strategies and safety assessment criteria for food biotechnology research and to ensure the wholesomeness and safety of the food supply.

Adequate bio-safety regulations, risk assessment of biotechnology products, mechanism and instruments for monitoring use and compliance are needed to ensure that there will be no harmful effects on the environment or for people (Grace, 1997). Potential environmental hazards from new products of biotechnology, mainly involving GMOs, have raised concerns that in the absence of adequate legislation, foreign companies in developed nations may use developing countries as test site for their products.

Some of the potential environmental risks concern plant pests (Altman, 1998). Gene escape from GMOs may result in increased weediness in sexually compatible wild species. The inclusion of novel genes for herbicide resistance in plants may increase the occurrence of weeds with resistance to certain agrochemicals. The inclusion of pest resistance in plants should be carefully evaluated for potential development of resistance in pests and possible side-effects on beneficial organisms.

Consumer concern about transgenic crops also focuses on their safety as food, especially if modifications could influence their metabolism or health (Baroiller et al., 1999), transgenic plants without selectable markers, such as antibiotic resistance genes, are needed to convince GMP-sceptics of the advantages of genetic engineering for crop improvement. In this way, their criticism concerning the potential risks of transgenic crops could be overcome. For example, molecular or metabolic markers may provide a means to identify transgenic plants with desire trait(s), these alternative markers should be safe from environmental and health perspective.
BIOTECHNOLOGY AND AGRICULTURAL TRANSFORMATION

The growing human population and the concomitant increase in the use of natural resources are generating a series of negative effects on ecosystems, such as pollution, loss of genetic diversity, soil fertility decline, climate change, deforestation and desertification. Yet agriculture is expected to play two major roles; to become more productive and at the same time more sustainable; that is, to supply the food needed without depleting renewable resources. Therefore, breeding plants that produce higher yields of better quality but do not adversely affect the ecosystem can be achieved only through a very broad scientific input (Ota, 1989). New technologies, such as DNA recombinant biotechnologies, if properly focused, offer a responsible way to enhance agricultural productivity for new and the future. Agricultural transformation agenda in Nigeria should evolve a policy programme that will lead to a sustainable food production through developing low-cost applications. This is an important complementary element in increasing food production and stability for especially the rural poor.

Biotechnology coupled with other techniques is a powerful tool in agricultural development with great potentials, and offers a potential solution for many problems affecting crops, livestock, fisheries food and nutrition etc.

National agricultural transformation programmes of the Federal Ministry of Agriculture should ensure that biotechnology benefits all sectors, including resource-poor rural populations. Parts of the transformation programmed should be to extensively harness biotechnological research since it offers unique opportunities to solve environmental problems, some of which are derive from unsustainable agricultural practices. Biotechnology if brought to focus in the agricultural transformation, presence solutions to the problems of low productivity, biotic and abiotic stresses as well as improved nutritional or medicinal content built into the genotype of plants. This will reduce the use of agrochemicals and water, thus promoting sustainable yields, food security and added value integration (FAO, 1998).

Part of the action plan of the transformation programme should be to encourage farmers to adopt the use of products of biotechnology as planting materials especially seeds. Agricultural research institutions in Nigeria should extensively integrate biotechnology into agricultural research including research in fishery technology.

CONCLUSION

Agriculture is expected to feed an increasing human population, which is forecast to reach, 8 billion people by 2020, of which 6.3 billion will be in the developing countries including Nigeria. The present administration in Nigeria has come up with an action plan on agricultural transformation, which seeks to achieve a hunger-free Nigeria through an agricultural sector that accelerates achievement of food and nutritional security, generates employment and transform Nigeria into a leading player in global food market. This vision is achievable if new biotechnology is integrated to serve as complement to agricultural technology leading to better and available seeds and improved sustainable production technology. New techniques, based on the use of monoclonal antibodies and nucleic acid probes for diagnosing plant pests and diseases and detecting foreign chemicals in traits among others.

Recent report from the Federal Ministry of Agriculture quoted the Hon. Minister as saying that a situation where Nigeria spent N356 billion in 2011 on importation of rice alone was unacceptable. The Ministry’s action plan is to produce 2.5 million metric tons of rice by 2015 and generate one million jobs. Cassava production is to increase from 34 million metric tons to 51 million metric tons. Other crop earmarked for increase production include; cocoa, beans, sorghum, etc. The government’s vision will be achieved if biotechnology is integrated in the agricultural research and development process of the country and is embraced by all major stakeholders in the agricultural business.

In fisheries, research on the use of synthetic hormones in induced breeding, transgenic fish, gene banking, uniparental, polyloidy population and fish health management is ongoing while greater part of this research has started yielding positive results in the fish industry.

RECOMMENDATIONS

Biotechnology provides resistance to crop and improve production and reduce chemical pesticide usage, thereby making major improvements in both food quality and nutrition. So Nigeria should focus more on biotechnological research. He can provide some forms of assistance including finances to research institutions that promote development of crops that will meet the standards and challenges of our time including climate change.

A lot of money is required in biotechnological research as it involves skilled staff backed up by well equipped laboratories with proper working conditions, a constant supply of good quality water, a reliable electricity supply, and organized institutional support including timely delivery of reagents and access to internet and other international networks.

Biotechnology is more expensive than conventional research, so it should be used only to solve specific problems where it has comparative advantage.
Biotechnology research should not be privatized in Nigeria as the consequence will be the risk that it could be aimed mainly at resource rich farmers at the expense of the resource poor. Biotechnology research and policy should also address the needs of the poor farmers in rural communities in Nigeria who depend on agriculture for their livelihoods.

Banning transgenic crops and fishery products is not desirable because the potential benefits are so great. To allay public worries about genetically modified product (GMP) possibility of inadvertent production of toxins and allergens, food safety assessment techniques, based on toxicological testing as used for food additives can be carried out in foods or components produced by biotechnology.

Plants and fish seeds and other planting materials developed from biotechnology should be made available and sold to farmers in Nigeria at cheaper rates through government support.

REFERENCES


