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Agricultural Biotechnology in Developing Countries: Status in Nigeria

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Abstract: This study discusses the status of agricultural biotechnology of some developing countries including Nigeria. Agricultural biotechnology has the potential to solve local agricultural needs andto greatly increase food production.Some advances in agricultural biotechnology with emphasis on crop production are treated. The issue of genetically modified organisms and crops, together with their associated concerns have also been discussed.Various factors promoting and inhibiting the application of agricultural biotechnology in developing countries, with particular reference to Nigeria are enumerated and discussed. Solutions to the identified problems have been proffered, which would make agricultural biotechnology worthwhile in Nigeria.

Key words: Agricultural biotechnology, food production, genetic engineering, transgenic crops, Nigeria

INTRODUCTION

It is estimated that by the year 2050, the world population would be about 11.6 billion, with 90% of this, residing in developing countries of southern hemisphere (James, 1997). The crucial question is whether food production will increase sufficiently to mirror this growth in population. Will the conventional agricultural practices, supply such quantity as to take care of such population. With growth in population, there is reduction in Land-Man ratio as a result of pressures for competing socio-economic demand for land over time, hence the already limited cultivable land is being drawn from its traditional agricultural uses (Irefin *et al*., 2005). Also there is a gradual decline in agricultural activity many people are picking up white collar jobs. Those that are involved in agriculture are yet to optimize the application of various advances to boost agricultural sector, especially in developing countries.

Although the advent of mechanization farming andthe application of chemical fertilizers brought about improvements in agricultural productivity.

These 2 advances could not solve many agricultural needs, because they could not modify the traits of crops. Crop producers are looking for strong breeds and high yielding types. These qualities are achievable by the use of biotechnology. A special aspect of this is called genetic engineering.

Biotechnology according to Persley (1992) is defined as any technique that uses living organisms or substances from these organisms, to make or modify a product, to improve plant or animal or develop microorganism for specific uses.

Many developing countries including Nigeria are in Africa. According to Brink *et al*. (1998) to meet Africa's food requirement, it is necessary to increase the efficiency of food production. They noted that Africa has been lagging behind in reaping the benefit of Green Revolution of 1970 and 1980s in the sense that they have been limited in the use of high-yielding varieties of maize, wheat and rice in the continent. It is clear from all indications that the direct use of genetic improvement and biotechnology offer a tremendous potential for increasing agricultural productivity (Villalabos, 1995).

Most developing countries (including Nigeria) still rely on importation to meet their food requirements. Agricultural production is also insufficient to sustain the process industry in these countries. The application of appropriate biotechnology in these countries would ensure sufficient food production and agro based raw materials. A review of the types, extents and methods of application of biotechnology is therefore desirable, if the local agricultural needs are to be addressed. This work discusses developments in agricultural biotechnology in developing countries with special focus on Nigeria.

ADVANCES IN AGRICUTURAL BIOTECHNOLOGY

Biotechnology can be classified as either conventional or modern. Conventional biotechnology will include such traditional practices as crossbreeding,

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stem-cutting, grafting e.t.c. While modern biotechnology would include the techniques involving tissue culture, cell fission, bioprocess and genetic engineering or recombinant DNA techniques (Irefin *et al*., 2005).

Genetic engineering can modify crops for a range of characteristics conferring improved agronomic performance, herbicide tolerance, pest and disease resistance, handling and storage properties as well as other traits. Hence, obtaining combinations of agricultural valuable traits otherwise impossible by the traditional breeding methods are made possible by genetic engineering. The effect is the increase in per hectare yields as well as the varieties of such crops.

In Latin America, Brazil is the leading Country in developing biotechnology. In agriculture, the Country is focusing on Nitrogen fixation, crop resistance to adverse ecological conditions, increased photosynthetic efficiency of forage crops andimprovement of biological pest control. A remarkable achievement is the Brazil's miracle alcohol programme, in which tissue-culture is used to produce sugar cane with high yield and tolerance to herbicides, while enzyme technology is employed to improve the fermentation of the sugar into alcohol (Hobbelink, 1991). Mexico's agricultural related biotechnology efforts center on tissue-culture of fruits and flowers for export andsophisticated genetic engineering work, using recombinant DNA technology targeted at four projects: Human insulin, human interferon, DNA polymorphism for racial history, production of xanthenes gum in micro organisms.

China and India are the lead Countries in agricultural biotechnology in Asia. China is reported to have been especially successful with the development of high yielding hybrid rice andtissue cultured potatoes, sugar cane, grapes, Chinese fir, red banana, orange and pineapple (Hobbelink, 1991). In Thailand, work on animals focuses on embryo transfer in dairy cattle to increase milk production and hormone technology on buffaloes to increase fertility.

Brink *et al*. (1998) in their research reported on the status of Nigeria and other African countries in plant biotechnology. Nigeria was credited to be involved in the following biotechnology programmes:

- Micropropagation of cassava, yam, banana and ginger.
- Long-term conservation of cassava, yam andbanana and medicinal plants.
- Embryo rescue for yam.
- Transformation and regeneration of cowpea, yam, cassava and banana.
- Genetic engineering of cowpea for virus and insect resistance.
- Marker assisted selection of maize and cassava.
- DNA finger printing of cassava, yam andbanana pest and microbial pathogens.
- Genome linkage maps for cowpea, cassava, yam and banana
- Human resource development through group training, degree-related training, fellowships and networking.

A resent study has shown that a number of improved crop varieties have been developed in Nigeria. These include high-yielding wheat, cotton, sorghum, maize, cocoa, cashew, coffee andtea. Disease tolerant oil palm, coconut, late and raphia-seed, as well as cowpea which are resistant to biotic and abiotic factors, late maturing groundnut andimproved variety of rice from crosses of *O. sativa* and *O. glaberrima* were reported to have been developed (Irefin *et al*., 2005). The study also revealed that about 74.28% of the biotechnology researches undertaken in Nigeria were in response to local agricultural needs rather than technology driven, with only about 14.29% of these researches employing recombinant DNA technology. The inability of Nigeria and many developing countries to apply modern biotechnology techniques is attributable to the paucity of scientist specializing in these areas. Even though biotechnology efforts in Nigeria appear to be focused on areas with concrete application for small farmers, their usefulness for majority of farmers have been limited by several factors.

Estimate indicates that the global area planted with transgenic Genetically Modified Crops (GMCs) increased from 2-68 million hectares from 1996-2003, respectively (James, 2003).

Although few developing countries have released GMCs varieties so far, a preliminary analysis (Dhlamini *et al*., 2005) from FAO-Bio Dec, an FAO database providing information on crop biotechnology products/techniques in use or in the pipeline in developing and transition countries, reveals that more than 20 countries are involved in GM crop research and application activities (covering experimentation (including laboratory or glasshouse research), field testing or commercialization), including over 200 experimentation activities (where research on one trait in one crop in a single country is counted as one activity). It is expected that more GM product will be produced in a greater number of developing countries in the future.

PROMOTERS /INHIBITORS OF AGRICULTURAL BIOTECHNOLOGY

Researches and surveys on application, acceptability and benefits, as well as undesirable effects of biotechnology on agricultural sector and society have

attracted many workers, including public and private bodies in recent time. Many of these surveys focus on developing countries while the developed countries often stand as reference point of analysis and comparison. Factors such as physical, environmental, political, economic, demographic, literacy rate, information technology as well as others, have been seen to promote or inhibit the suitability and sustainability of biotechnology application in agriculture. The following factors among others are determinants of agricultural biotechnology in Nigeria and other developing countries.

Inadequate resources: Human, scientific infrastructure andfunding: A serious deficit of skilled human resources in the plant sciences and biotechnology is evident in Africa (Brink *et al*.,1998). From one of the references cited by Irefin *et al.* (2005) it is reported that by 1994, Africa had only about a 106 trained modern biotechnologist, out of which Nigeria had about 10 scientists trained in gene cloning. Because of brain drain, many of these scientists would be practicing in developed countries where work environment is friendlier, eg better equipped laboratory andremuneration. In effect, much fewer than this number of skilled scientists would be available to man research laboratories in Africa. Irefin *et al.* (2005) also reported that of the nine institutes surveyed in Nigeria, only 48 researchers where engaged in various aspects of agricultural biotechnology, with only about 40% possessing PhD in biotechnology andrelated fields. Nigeria and other African countries must increase their capacity to train and retain skilled scientists in order to optimize the opportunities that biotechnology offer for adding value to agriculture.

Another major problem with developing countries biotechnology programmes is the lack of financial resources and scientific infrastructure. Laboratory that are fully equipped and well staffed are required to produce transgenic plants. Only very few of such laboratories are available in Nigeria.

From the background document to electronic conference 8 organized by Food and Agricultural Organization (FAO, 2002) the following in respect of funding and investment in agricultural biotechnology are gathered: that annually, private sector probably invests more than 1.5 billion dollars, mostly in developed countries, the public research organization and universities in developed countries invest up to 1.5billion dollars, the public sector National Agricultural Research System (NARS) in developing countries invest 100-150 milion dollars (excluding donor funding), the 16 International Agricultural Research Centers (IARC) of the Consultative Group in International Agricultural Research (CGIAR) together invest roughly 25 million dollars (about 8% of their total budget) and finally donors such as Rockefeller foundation or non-profit technology transfer organizations invest $40-50 million in developing countries. It is clear from the report that biggest investment is from private sector and majority of biotechnology researches are carried out in developed countries.

Unlike in some developing countries like Brazil and Republic of Korea, private organizations have not been deeply involved in funding R and D activities in agricultural biotechnology in Nigeria (Irefin *et al*., 2005). It would appear that Nigerian entrepreneurs are not interested in experimental development, but prefer to invest in already proven innovations. This has placed the burden of funding biotechnology programmes solely on public research organizations, which do not receive adequate funding from government.

Information and Communication Technology (ICT): The rate at which information is disseminated is dependent on the type of ICT available. According to the report by Brink *et al.* (1998) in many areas of Africa (consisting of many developing countries), modern communication systems were lacking. In Nigeria, mobile phones became readily available only 5 years ago. Although Internet access is spreading, the cost is still relatively high. Interestingly, the rural areas, in which majority of the farmers are located are mostly affected, due to severe lack of infrastructure. Hence, treasure of information on agricultural biotechnology from developed countries may well be lying untapped at various websites.

Providing Internet facilities in universities and research institutes in Nigeria, will enhance the abilities of researchers to access information and to network. With the recent launch of Nigeria's satellite (NigComSat-1) , It is hoped that some of these problems may now be overcome to further improve access to ICT andreduce cost.

Irregular power supply: Brink *et al.* (1998) identified irregular power supply as a major hindrance to efficient application of even basic tissue-culture technologies. This is still very true in Nigeria and many developing countries.

Many of the equipment employed in biotechnology require continuous non-stop running for days. Also some of the products, as well as the reagents and enzymes needed, may require refrigeration. The option of powering research laboratories by alternative sources other than the public power supply system can greatly increase the cost of both research and application of biotechnology

techniques in many developing countries, thereby limiting the ability of farmers to benefit from these efforts.

Regulation/legislation: A lack of national or regional priority setting in agricultural research is evident in many African countries; which is reflected in a lack of awareness and commitment by national governments (Brink *et al*., 1998). As a result of this, many African countries do not have specific bio-safety regulations and legislation andthis hinders the use, evaluation and release of Genetically Modified Organism and Genetically Modified Crops (GMOs and GMCs).

Unlike ordinary research materials used in laboratory, greenhouse and field studies, transgenic organisms are subject to special rules intended to ensure that they are used in a way that does not pose an unacceptable risk to humans, animals or the environment (Adair *et al*., 2001).

In Nigeria, there has not been any regulatory legislation regarding GMOs and GMCs. Most research works on the various mandate crops are in the area of conventional biotechnology (Irefin *et al*., 2005) which may not require much regulation. The low level of public awareness on GMOs and GMCs may also have contributed to this situation.

Another aspect, in which legislation is important, is in determining the nature and extent of patenting of biotechnology inventions. There is a need to strike a balance between protection of intellectual property rights and making biotechnology inventions available and affordable to majority of farmers in developing countries.

Training, retraining and networking: According to Brink *et al*. (1998) between 1992, 1998 and 82 short term fellowships were awarded to researchers from African countries (including Nigeria) for studies in areas of industrial and desert biotechnologies, within the framework of UNESCO global network of microbial resources.

Irefin *et al*., (2005) advocated for the establishment of formal departments of biotechnology, in some Nigerian universities, as well as promoting postgraduate studies in areas related to agricultural biotechnology, by award of scholarships and fellowships. They also suggested the need for retraining of experts in conventional biotechnology, in order to acquire the necessary skills required in modern biotechnology.

In Nigeria, about nine agricultural research institutions, including a national center for genetic resources and biotechnology are involved in training and research in biotechnology techniques. There is a need to build the capacity of these institutions to train, retrain and attract researchers.

To enhance scientific cooperation and maximize information exchange at national, regional and continental levels, networking is needed. Some of the major networks dealing with plant biotechnology in Africa include, Africa Association For Biological Nitrogen Fixation (AABNF), African Plant Biotechnology Network APBnet), International Institute of Tropical Agriculture (IITA) etc. The establishment of these associations and other initiatives encourage dialogue among farmers, scientists and decision makers, thereby enhancing the benefits of biotechnology in addressing national and regional agricultural needs. Greater collaboration between research institutions within and outside the continent, having similar mandates is desirable in this regard. This will eliminate duplication of research efforts, as well as enhance the quality of research outputs.

Motivation for biotechnology research: The appropriateness of the type of biotechnology pursued by developing countries has been called to question. A major concern is that a substantial part of developing countries biotechnology research is directed towards the major cash crops, which are normally controlled by large estate owners. For example, while Brazils fuel alcohol programme was estimated to have saved the country $1billion in energy expenses in 10 years (between 1980 and 1990) the attendant expansion in the land area devoted to sugarcane occurred at the cost of fertile land traditionally dedicated to food production by small farmers (Hobbelinks, 1991).

Research priorities should emphasize needs-driven solutions to local agricultural problems, which may differ from country to country andbetween regions. Focusing on techniques with clear application possibilities for the majority of the farmers should be the preferred choice, rather than joining the high-tech biotechnology race taking place among the industrialized countries.

Poverty: The seeds from tissue cultured plants are expensive, so also are genetically engineered seeds. Modified seeds and planting materials usually require adequate water, fertilizer, pesticide and herbicide application, which cost a lot of money. Some of these factors combine to make biotechnology innovations, unaffordable to the vast majority of farmers in developing countries, most of whom are peasants.

In Nigeria most farmers could not adopt the biotechnologically improved crops and varieties because they could not afford the seeds and maintain them (Irefin *et al*., 2005). Various initiatives of government to make loans available to farmers through financial institutions have not been successful, either because

small farmers lack the collateral to access such funds or they do not fully appreciate the cumbersome procedures usually adopted in disbursing such funds.

ATTITUDES AND CONCERNS REGARDING GMOs AND GMCs

A GMO is an organism into which one or more genes (called transgene) have been introduced into its genetic material from another organism. The gene may be from a different kingdom (eg. A bacterial gene introduced into plant genetic material), a different species within the same kingdom or even from the same species.

Very few issues have raised as much public discussion and controversy recently as the use of genetic modification in Food and Agriculture (FAO, 2005). According to Stone (2002) it is rather remarkable that a process as esoteric as the genetic modifications of crops would become the subject of a global war of rhetoric. There have been claims and counter claims portraying the wonders-or horrors of the new technology. In some cases, individual African countries have refused to accept food aid derived from GM crops, whereas there is little or no public concern about other biotechnologies used in food and agriculture, such as fermentation, use of molecular DNA markers, vegetative reproduction of crops andforest trees, embryo transfer and embryo/semen freezing in livestock or triploidization and sex-reversal in fish.

Recent evidence has shown that, there are potential risks in eating food derived from genetically engineered crops as opposed to naturally occurring ones. For instance, the new proteins produced in GM foods could act themselves as allergens or toxins, alter the metabolism of the food plant or animal, causing it to produce new allergens or toxins or reduce its nutritional qualities or values (Irefin *et al*., 2005). The potential of GMCs and GMOs to cause unacceptable effect on the environment has also been of concern. For example, the ecological issues associated with transgenic pest resistant crops, such as their potential to become problem weeds, or to enhance the weediness of nearby sexually compatible relatives (Traynor and Westwood, 1999) are topical. The issue of widespread replacement of small farms and varied agriculture by vast seas of monoculture agriculture andthe associated social and environmental consequences for developing countries is yet another concern (Altier, Rosset and Thriepp, 1998; Hobbelink, 1991).

Also ecological theory predicts that large-scale landscape homogenization with transgenic crops will exacerbate the ecological problems already associated with monoculture agriculture.

The use of GMOs is most substantial in the crop sector, where the GM crop species involved are ones that are extensively traded internationally. Although most developing countries are currently not developing GMOs, their government may nevertheless be required to regulate and develop policies about them, because of the possibility of releasing imported GM varieties or importing GM food (food from GMOs (eg. GM corn) or food that contains ingredients from GMOs (e.g., chocolate containing GM soy bean)).

Agricultural activities take place, by and large, in rural areas. Production of GMOs therefore directly impacts the people living in rural areas and their environment. In addition, people in the rural areas have often more limited access to information than their counterparts in urban areas, due to eg. remoteness, lower literacy rates and poorer infrastructure. These factors similarly limit the ability of rural people to access and influence policy makers and the decision-making process. Awareness about GMOs and involvement in decision-making regarding GMOs may therefore differ for rural and urban people. In Nigeria issues concerning GMOs and GMCs have not featured much in the public domain, because of the low level of awareness regarding them.

Marris (2004) concluded that one of the lessons to be learnt from studies of public attitudes to GM crops and food was that "public concerns needs to be taken into account by all the operators of the industry, including R and D, marketing, commerce and distribution. Government and international bodies also need to take in to account these concerns, when elaborating risk-related regulations and dealing with trade disputes.

CONCLUSION

The application of modern biotechnology methods, if targeted at solving local agricultural problems, has the potential to greatly increase food production in Nigeria and other developing countries of Africa. However, African countries would need to build their capacity to train and retain skilled agricultural biotechnologists, in order to optimize biotechnology application in agriculture. The provision of infrastructure and adequate funding for agriculture related biotechnology R and D is also required. In the case of Nigeria, greater participation by private sector in the funding of biotechnology R and D is desired, as done in developed countries. For this to be effective, the interaction between the research institution and private sector should commence from the initial stages of the projects rather than at the pilot stages of development.

Delivering biotechnology innovations at rates that are affordable to majority of farmers must also be addressed, if these efforts are to translate into the desired increase in food production in Nigeria.

The lack of awareness and regulations have adversely affected the capacity of Nigeria to apply modern biotechnology techniques in agriculture. Nigerian government needs to urgently develop policies and provide specific bio-safety regulations on the use and handling of GM products in the country.

Awareness campaigns on agricultural biotechnology, especially on GMOs and GMCs, if undertaken, would ensure that the general public is guided in having the right perspective about these products, thereby eliminating some of the concerns regarding biotechnology products.

REFERENCES

Adair, D., R. Irwin and P.L. Traynor, 2001. A practical guide to containment: Greenhouse Research with Transgenic Plants and Microbes. Inform. Sys. Biotechnol. Virginia Tech., USA., pp: 1.

Altieri, M.A., P. Rosset and L.A. Thriepp, 1998. The potential of Agro ecology to combat Hunger in developing world. 2020 Brief 55, International Food Policy Research Institute, Washington DC.

Brink, J.A., R.W. Barbara and E.J. Dasilva, 1998. Plant biotechnology: A tool for development in Africa. Elec. J. Biotechnol., pp: 1-3.

Dhalamini, Z., C. Spillane, J.P. Moss, J. Ruane, N. Urquia and A. Sonnimo, 2005. Status of research and application of crop biotechnologies in developing countries. A preliminary assessment. In preparation.

FAO., 2002. What should be the role of biotechnology in the agricultural research agenda of developing countries? Background document to Conference 8 of the FAO Biotechnology Forum, pp: 13.

FAO., 2005. Public participation in decision-making regarding GMOs in developing countries: How to effectively involve rural people. Background document to conference 12 of the FAO Biotechnology Forum.

Hobbelink, H., 1991. Biotechnology and the future of world Agriculture. Zed Books Ltd. London.

Irefin, I.A., M.O. Ilori and B.O. Solomon, 2005. Agricultural biotechnology RandD and innovations in Nigeria, 1: 64-80.

James, C., 1996. Chairman's commentary. The first decade of crop biotechnology. In: Advancing altruism in Africa. ISAAA Annual Report 1996.

James, C., 1997. Progressing public-private sector partnership in International Agricultural Research and Development. In: ISAAA Breifs No 4: 1-32.

James, C., 2003. Preview: Global status of commercialized transgenic crops. ISAAA Breifs No. 30.

Marris, C., 2004. Issues concerning public awareness and attitude towards genetically modified banana and tropical fruits. Third session of the intergovernmental Group on Banana and Tropical Fruits, Puerto de la Cruz, Spain, pp: 22-26 .

Persley, G.J., 1992. Beyond Mendel's Garden: Biotechnology in agriculture. In: Biotechnology enhancing research on tropical crops in Africa. CTA/IITA co-publication, pp: 11-19.

Stone, G.D., 2002. Both sides now: Fallacies in the genetic modification wars, implication for developing countries andanthropological perspectives. Curr. Anthropol., 43: 611-630.

Traynor, P.L. and J.H. Westwood, 1999. In: Ecological effects of pest resistance genes in managed ecosystem Proceedings of a workshop by information system for Biotechnology. Bethesda, Maryland, USA., pp: 5-11.

Villalabos, V.M., 1995. Biotechnology in agriculture: How to obtain its benefits while limiting risks. Induced mutations and molecular techniques for crop improvement. IAEA. Publication, Austria, pp: 477-486.