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Noval Biotechnological Advancements and its Implementation Strategies in Achieving Food Security in Nigeria.

Nchedo Josephine Oguine[1]
Department of Political Science, Nasarawa State University, Keffi, Nigeria

Ozioma Collins Oguine[2]
Department of Computer Science, University of Abuja, Abuja, Nigeria

Kanyifeechukwu Jane Oguine[3]
Department of Computer Science, University of Abuja, Abuja, Nigeria

Abstract:*As society evolves, emerging problems arise, and most importantly, rapid population growth has necessitated the increase in food production to match the growing population in Nigeria; this has propelled a clarion call to improve the agricultural system which will, in turn, boost productivity. The societal evolution has disarticulated the crude farming that was not adequate to enhance required food production and security in Nigeria. Therefore, to curb the emerging challenge in the sector, biotechnologies could be introduced to fasten production and leverage efficiency in the farming, reduce the cost of production and food loss or damage caused by biotic factors (pathogens) and abiotic factors such as drought, wind, and flood; to mention but a few. The paper intends to examine holistically the conceptualization and impact of biotechnology in agriculture in enhancing food production and attain sustainability in LDC like Nigeria. The paper will rely on secondary sources for information to evaluate the impact of advanced technologies in farming which was brought about by agricultural revolution in several historical epoch.*

Keywords: *Biotechnology, Food Security, Genetic Engineering, Agriculture, Innovation*

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I. Introduction

Statistics data from 1995 to 2008 show that there has been an increasing trend in chronic hunger throughout the world (FAO, 2009). FAO (2011) estimates that almost 1 billion people throughout the world are undernourished, with 239 million in Sub-Saharan Africa and 578 million in Asia. And as such, less developed countries (LDC) due to hunger, poverty, and expectation of increased expenditure, food, and other basic needs would be more intense.

Hence, to curb the illeffects of an increased and bloated population, more drastic programmes/policies must be developed and adopted in the form of agricultural reforms to prevent poverty and hunger. This also includes the development of more efficient technologies, effective utilization of available land without destroying the ecosystem, expanding agricultural production areas in a bid to make a huge leap within the shortest time possible. Undoubtedly, the above-listed solutions will directly improve the income of the farmers also increasing the GDP of Nigeria.

Biotechnology has provided scientists with new approaches to develop crop varieties' resistance to diseases and reduce the need for expensive agricultural chemicals. continue to face in the future. Competition from abroad impels us to devise and use new technologies that can improve the efficiency and quality of Indian agricultural production. Securing a better life for our citizens where each one of us, can lead lives of dignity and fulfillment, therefore, merits undivided attention in our development strategy. A natural corollary to this is the attainment of the goal of food security for all. The per capita availability of land has also been shrinking due to population increase and this has been compounded by an increase in wasteland. There is also the spread of urbanization and the growing demand for more land. We are left with a situation where we have to produce more from the limited land available to ensure food security.

II. Review of Literature

2.1 Concept of Biotechnology

Biotechnology in one form or another has been part of human development since the dawn of agriculture. Human Ingenuity has led to increased production and greater diversity and quality of livestock and varieties of crops. Today's food crops and domestic animals embody the benefits of many generations of selection and breeding.

Modern biotechnology is mainly based **on recombinant DNA (rDNA) and hybridoma technology** in addition to bioprocess technology. rDNA technology is the main tool used to not only produce geneticallymodified organisms, including plants, animals, and microbes but also to address the fundamental questions in life sciences (Nair, 2008). In agriculture, rDNA technology can be used to produce new varieties of crop plants with improved agricultural and nutritive qualities. Transgenic plants, which are resistant to biotic and abiotic stresses such as salinity, drought, and disease, have been produced.

A large number of recombinant proteins have been produced in plants over the last twenty years, demonstrating the ability of plants to compete with existing industrial production systems. The use of plants for producing recombinant proteins has been termed "Molecular Farming" and its rapid progress is driven by the several advantages provided by the plant expression systems. Since then, other important vaccine candidates and therapeutic proteins have been produced in transgenic plants and are in different stages of clinical trials **(Badri et al 2006)**. Some important recombinant (Transgenic plant-based) products produced in plant systems available in markets are represented in Table 1.1 below:

Product Plant	**System**	**Company name**	**Commercial name**
Aprotinin	Corn, tobacco	Prodigene	AproliZean
β-glucuronidase	Corn	Prodigene	GUS
Trypsin	Corn	Prodigene	TrypZean™
Recombinant human lactoferrin	Corn, rice		Lacromin™
Recombinant human lysozyme	Rice	Ventrica Biosciences	Lysobac™
Recombinant lipase	Corn	Meristem Therapeutics	Merispase™
Avidin	Corn	Prodigene	Avidin
Recombinant Human intrinsic factor	Arabidopsis	Cobento Biotech AS	Coban
Collagen	Corn	Prodigene, Medicago	

Table 2.1: Recombinant (Transgenic plant-based) products

Plant-made nutritional compounds (PMNs) Plants can provide most of the nutrients required in the human diet. However, major crops are deficient in one or the other nutrients. The advances in genetic modifications have made it possible to enhance the nutritional quality of the plants (Aspelund & Glatz, 2010). Several technical advances have been made from earlier attempts to simultaneously manipulating multiple steps in plant metabolic pathways and in constructing a novel, multi-enzyme pathways in plant tissues (Bohmert, 2000, Wu et al., 2005). In the last few years, a lot of progress has been made in the field of biofortification, specifically plants with higher βcarotene, lycopene, vitamins, flavonoids, resveratrol, polyamines, nutraceuticals, amino acids, nutritional proteins, minerals, fatty acids, and carbohydrates are being produced.

2.2 History of Biotechnology

The Industrial Revolution, which spanned from 1800 to 1850, enabled an accelerated economic development that became strategic for the growth of countries (FAO, 2012), which in turn triggered the migration of people from rural areas to industrialized cities. To increase agricultural production and meet consumer and producer needs, the use of machinery on farms was imperative, progressing through remarkable improvements. The introduction of chemical fertilizers around the same period enabled crop protection against disease and the attainment of higher yields. One of the first chemicals employed was nitrogen-based, although its use was restricted due to high costs.

In England, agriculture became a science by performing novel experiments aimed at improving agricultural methods. which eventually led to important innovations such as crop rotation and discoveries such as the ability of some legumes to convert atmospheric nitrogen to nitrates (Overton, 1996). One of the earliest records of plant hybrids was the report by Cotton Mather in 1716.

The next important documentation regarding the development of plant hybridization was provided by a quarter in 1776. Gregor Mendel's postulates related to how different traits were passed from one generation to the next, and his paper "Experiments on plant hybridization", published in 1866 (Persley, 1991), marked the beginning of new technologies designed to improve vegetable species. However, plant hybridization occurred long before Mendel's experiments; most likely it was unintentional at first and could have occurred at any stage in the crop domestication process **(Vasey, 1992)**. In fact, crosses for both floral morphology and hybrid vigor were greatly expanded by many researchers during the next 100 years. In 1970, plants genetics allowed obtaining plant species that were more productive and exhibited resistance to some pests.

In 1960, a new movement changed the farming system; The Green Revolution, which is a term used for the rapid increase in food production, especially in underdeveloped and developing nations, via the introduction of high-yield crop varieties and the application of modern agricultural techniques (FAO, 2004). The Green Revolution arose as the technological response to a worldwide food shortage, which became threatening in the period after World War II. The technologies developed during this period, which usually involve bioengineered seeds that worked in conjunction with chemical fertilizers and heavy irrigation, had a huge impact on three main kinds of cereal (maize, wheat, and rice). A particularly important finding was the discovery of how the biological molecule of DNA was responsible for inheritance. In the 1960s, the genetic code was cracked, and subsequent studies began the transfer of genetic material from one organism to another by genetic engineering techniques **(Dash et al., 2016)**. The intersection between genetic engineering and biotechnology was the main factor in the creation of genetically modified organisms (GMOs) as shown in Fig 1.1 below.

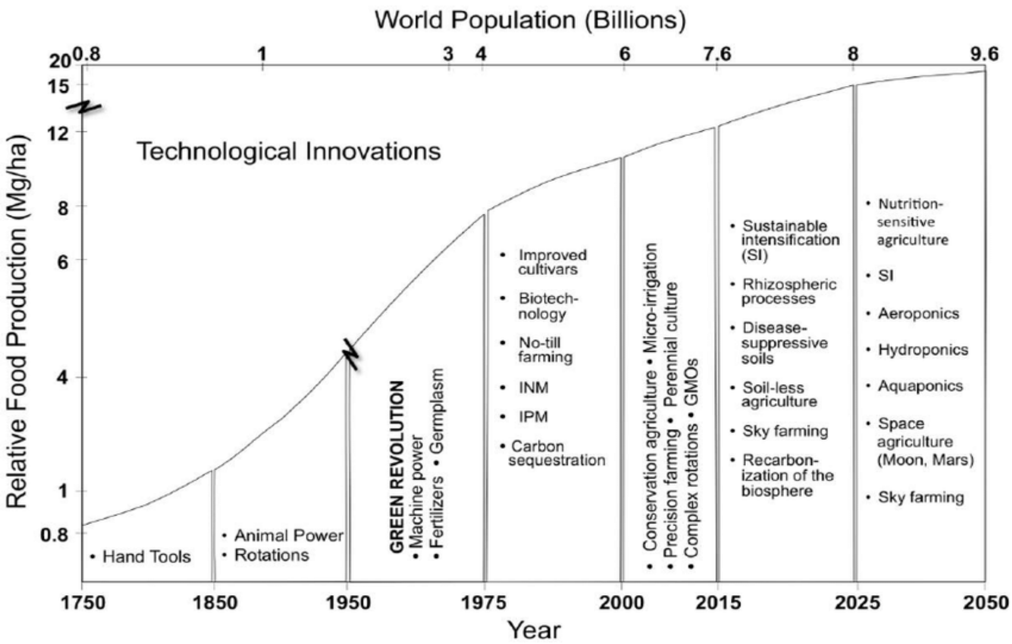

Fig. 2.1:Technological evolution and future innovative and emerging technologies.

One of the first agricultural research centers was the International Maize and Wheat Improvement Center (CIMMYT), which was created in Mexico in the 1960s, with the help of the Rockefeller Foundation (FAO, 2000; Ceccon, 2008). At this institute, Mexicans and foreign researchers worked together for the genetic improvement of crops and produced exceptional results: in just two decades, wheat productivity increased from 750 kg ha-1 in 1950 to 3200 kg ha-1in 1970 **(Ceccon, 2008)**. Today, wheat and maize produced from research at CIMMYT are planted on millions of hectares around the world. However, one limitation regarding basic and applied agrarian research is that it usually is carried out in developed countries with specified climate conditions, and innovations and improvements in crop yield can only be obtained in similar conditions. Several innovative changes took

place until 1996 when full-fledged commercialization of GM crops. For this reason, it was necessary to adopt the new technologies and discoveries to warmer or more arid climates that prevail in underdeveloped countries.

There are different types of biotechnology such as Bioinformatics, Blue biotechnology for the production of bio-oils, Red Biotechnology is for medical and pharmaceutical purposes (vaccines and antibiotics). Green biotechnology is basically for agricultural processes, it is used for the domestication of plants via micropropagation and the transgenic plants to grow under specific environments in the presence or absence of chemicals (**Boehm, 2007)**. Green technology has also explored skills involving the use of microorganisms to clean and reduce waste **(Wardlaw et al, 2004).**

Table 2.2: Summary of the main events in the development of biotechnology Period Events:

1664	Beginning of the Golden Rice project
1854	Discovery of bacteria
1857	Microbiology of lactic fermentation
1860	End of the spontaneous generation theory
1866	Mendel's postulates of classical genetics.
1875	Beginning of the use of machinery in farming
1941	One gene-one enzyme hypothesis
1946	Bacterial conjugation.
1953	DNA structure
1959	Gene regulation
1960	Green Revolution
1966	Genetic code decoding
1970	High specificity of restriction enzymes Rise of Phyto genetics CIMMYT foundation
1973	Recombinant DNA
1978	Human proinsulin gene isolation
1985	Polymerase chain reaction
1992	Beginning of the Golden Rice project
1996	Full-fledged commercialization of GM crops

2.3 The Challenge of Food Security in Nigeria Today

Despite the rich agricultural resource and technical endowments as well as several interventions by successiveadministrations,the Nigerian agricultural sector has been operating far below its potentials, consequently, primaryindices of food security at the national and the household levels are still unsatisfactory. Access to adequate and well-balanced nutrition is limited, as nutritious foods areat times expensive. Food supply is very unstable, as post-harvest losses put at between 15-40% percent tempers with the food supply chain, giving rise to loss of seventy percent (70%) of perishable food that is scarce offseason and thirty percent (30%) of durable foods (Adesida, 2009).

Due to the low economic statuses of most of the citizens with 70.8% living below the poverty line, the food intake and the general nutritional well-being of the populace are of low quality. Consequently, sixty-five percent (65%) of Nigerians are reported to be malnourished (Ohakim, 2008; Agbaegbu, 2009).

Demand for food alone is not the only cause of agriculture's growing footprint. Many countries, even those experiencing famine, rely on the export of food to generate income (Vandermeer and Pefecto, 2007). In recent decades, large-scale conversions of the agroecosystem in some countries have been correlated with an increase in food insecurity, motivated by the push to produce more export commodities at the expense of foods of higher nutritional value for domestic consumption (Pengue, 2005).

New or improved technologies could help feed the world (Heinemann, 2009; IAASTD, 2009a). Before considering which, technological approaches are best for reducing the effects of alcaic technology and inefficient reform strategies on agriculture, it will be essential to determine which problems are best solved by technological tools and which can be solved by changes in the socio-economic and socio-political status quo. Critical questions about the causes of these problems will also be asked. Conspicuously, quite a great number of them are evaluated to have been caused by a lack of technology.

Underscoring this fact (FAO, 2004), pointed out that loss of human productivity over time has been identified among persons whose physical and intellectual capacities have been impaired by low birth weight, protein-energy malnutrition, and the shortages of essential vitamins. This makes an individual's self-actualization impossible to attain and limits the level of contributions such persons could make to national development.

Elaborating on the negative implication of food insecurity on the livelihood of humans, Lawal and Asala (2008), posited that where there is a lack of calories in the body the physical composition of man suffers such that he may not reach his full potentialities in life. Pointing out the intellectual drawback of poor nutrition on individual development, Ohakim, (2008) said that individuals particularly children that are not secured in terms of food will have their growths stunted and k their ability to learn mathematics also stunted. Thus, nutrient deficiencies lead to subnormal development of intellectual abilities which renders an individual more of a liability than an asset for national development.

Such loss of human productivity arising from poor nutrition deducts from the national economy and is not food for a country like Nigeria that is striving towards technological growth and development, whose basis is adequate and efficient human capital.

2.4 Public Perception of Biotechnology, Science, and Society

Our perceptions or attitudes toward things are not always rational and are often culturally influenced. They are a combination of thoughts or the cognitive dimension, feelings, or the affective dimension, and the way we react to the behavioral dimension. The cognitive dimension consists of things we know, the affective dimension comprises of things we feel and the behavioral dimension is how we will act on the attitudes we build. Attitudes help us to become socially acceptable; belonging to a group is very important, and it gives meaning to things we experience.

Advancements in science and technology have made our life very simple and fast. At the same time, some of this advancement has caused great concern regarding the long-term impacts on the environment and life. In 1985, the World Commission on Environment and Development (WCED), also known as Brundtland Commission appointed by United Nations (UN), recommended sustainable development preserving the environment without any degradation. The Commission defined sustainable development as 'the development that meets the needs of the present without compromising the ability of future generations to meet their own needs'**(Mahanty et al, 2016)**. There are lots of definitions and views regarding sustainable development for different nations. In all these views the common point on which all nations agree is that science and technology are portrayed as a double-edged sword. There are two opposing ideologies regarding the use of science and technology: The Holistic Ideology Reductionistic Ideology.

Holistic Ideology recommends the use of traditional methods on all fronts of life from agriculture to industry. This ideology argues that modern society gives more importance to formal knowledge and neglects informal and traditional types of knowledge. According to this ideology, there is no problem in the agriculture sector (**(Mahanty et al, 2016)**). Earth can produce sufficient food materials for the entire population if we would return to consume some of the old or traditional grains, which can be easily grown. It also recommends the use of chemical manures, pesticides, herbicides, and the use of minimum tillage to conserve the land and to produce a crop. Whatever problem persists in the world is mainly due to the unequal distribution of food that is produced.

Reductionistic Ideology argues for the use of new knowledge to improve the quality of agriculture and crop plants. It recommends continuous research and development studies to find out new solutions to problems. Both these groups and their variant types have given different views regarding sustainable development with minimum impact on the environment.

The application of biotechnology in society raises many social, ethical, and legal questions. To date, many countries have not developed any system or mechanism to manage the social and ethical issues raised by biotechnology. More so, no organized investigation has been undertaken to explore the social and ethical guidelines with which the public would like to manage the development of biotechnology. But without public understanding, acceptance, and support, the role that biotechnology could play in solving environmental and food production problems could be hindered.

2.5 The Power of Biotechnology

Biotechnology simply implies the use of technologies based on living systems to develop commercial processes and products now includes the techniques of recombinant. DNA, gene transfer, plant regeneration, microbes, tissueculture, monoclonal antibodies, and bioprocess engineering. Using these techniques, we have begun to transform ideas into practical applications. For instance, scientists have learned to genetically alter certain crops to increase their tolerance to certain bacteria, viruses, fungi, etc. Various Applications of Biotechnology includes:

Microbes

Aside from the total overhauling of the farming implements and techniques from the use of primitive tools in farming; biotechnology is a vital area of scientific discovery that should be explored, handled with the keenest interest to make headway in agricultural output by the use of microbes to improve crop yields. The plants in all environments depend on Microbes and therefore potentially all crops no matter where they are grown, could benefit from the optimization of their microbial partners in a symbiotic relationship. Microbes and plants are intimate partners in the everyday process, these microbes have the capabilities to help solve the pressing human problem of food assurance thereby improving economic gain **(Reid& Greene 2002)**.

"Microbes can be tapped to increase Agricultural productivity and help feed the World" (Reid and Greene, 2002). Microbes support plants by increasing the availability of nutrients, enhancing plant root growth, neutralization of toxic compounds in the soil, making plants more resistant to diseases, heat, flood, and drought, and deterring pathogens and predators. Agricultural productivity, the output-to-input ratio in agricultural systems can further be improved. Microbes can be efficiently used to improve agricultural production and reduce the use of chemical inputs (Reid and Greene, 2002). By 2050, the United Nations estimates that the world population will be about 9.3 billion from 6.9 billion in 2010.

This technology will help to solve problems of how well plants grow in the scalding soil around sandy, stone hot springs, how do plants survive in deserts, in an environment where they spend a timeline underwater due to seasonal flooding or in salty or acidic soil or malnourished soils. The microbial technology had helped plants overcome these environmental challenges in most communities or regions (Wardlaw et al. 2004).

2.5.1 Tissue-Culture Based Techniques

Biofertilizers

Soils are dynamic living systems that contain a variety of micro-organisms such as bacteria, fungi, and algae. Maintaining a favorable population of useful microflora is important from a fertility standpoint. The most commonly exploited micro-organisms are those that help in fixing atmospheric nitrogen for plant uptake or insolubilizing/mobilizing soil nutrients such as unavailable phosphorus into plant-available forms, in addition to secreting growth-promoting substances for enhancing crop yield; such microbes are called biofertilizers or microbial inoculants (FAO, 2015a).

They can be generally defined as preparations containing live or latent cells of efficient strains of nitrogen-fixing, phosphate-solubilizing, or cellulolytic micro-organisms that are applied to seed or soil with the objective of increasing the numbers of such micro-organisms and accelerating certain microbial processes to augment the availability of nutrients in a form that plants can assimilate readily (FAO, 2010).

Biofertilizers are used in several developing countries such as Kenya and Thailand, often involving nitrogen-fixing *Rhizobia* bacteria (FAO, 2006). This category includes the production and use of bio-fertilizers and the use of nitrogen-fixing bacteria and/or mycorrhizal fungi to improve plant performance. Recent studies have shown that there are numerous plant growth-promoting rhizobacteria that not only enhance nutrient uptake by crops but also induce systemic tolerance to other abiotic stresses such as drought and salinity (Yang et al, 2009).

As with biofertilizers, the use of bio-nutrition strategies carries the double benefit of reducing input costs for farmers and preventing nitrate and phosphate accumulation within soils and run-off into sensitive watercourses. There are numerous examples of the use of these strategies in developing countries both to augment the nutritional status of crops and as alternatives to chemical supplements. For example, it was shown in Thailand that rhizobial inoculants can effectively replace chemical fertilizers for the production of soybean, groundnut, and mung bean crops (Boonkerd, 2002). The substitution of chemicals with organic fertilizer has a positive effect on soil nutrient content as well as on soil tilts and texture, making organic fertilizer superior to chemical fertilizers (Cuevas, 1997).

Micro-propagation

Micro-propagation is the laboratory practice of rapidly multiplying stock plant material to produce a large number of progeny plants using plant tissue culture methods. For instance, the shoot tips of banana or potato are excised from healthy plants and cultivated on gelatinized nutrient media in sterile conditions (in test tubes, plastic flasks, or baby food jars), so that contamination with pests and pathogens is avoided.

The plantlets obtained can be multiplied an unlimited number of times by cutting them into single node pieces and cultivating the cuttings in similar aseptic conditions. Millions of plantlets can be produced in this manner in a very short time. The plantlets are then transplanted in the field or nurseries where they grow and yield low-cost, disease-free propagation materials ready to be distributed to farmers (FAO, 2009a).

Today, micro-propagation is widely used for a range of developing country subsistence crops including banana, cassava, potato, and sweet potato; for commercial plantation crops, such as oil palm, coffee, cocoa, sugarcane, and tea; for niche crops such as cardamom and vanilla; and for fruit trees such as almond, citrus, coconut, mango, and pineapple. Some of the many countries with significant crop micropropagation programmes include Argentina, Cuba, Gabon, India, Indonesia, Kenya, Nigeria, Philippines, South Africa, Uganda, and Vietnam (FAO, 2009c).

Mutagenesis in crop

This involves the use of mutagenic agents such as chemicals or radiation to modify DNA and hence create novel phenotypes. Induced mutagenesis has been used in crop breeding programmes in developing countries since the 1930s. It involves changes in DNA induced during *in vitro* culture. Somaclonal variation is normally regarded as an undesirable by-product of the stresses imposed on a plant by subjecting it to tissue culture. However, provided they are carefully controlled, Somaclonal changes in cultured plant cells can generate variation that is useful to crop breeders.

Almost 3 000 new crop varieties have been developed and released by countries using mutation-assisted plant breeding strategies and an estimated 100 countries currently use induced mutation technology (FAO/IAEA, 2008). Case studies from Kenya (wheat), Peru (barley), sub-Saharan Africa (cassava), and Vietnam (rice).

In the livestock sector, mutagenesis has also been used in developing countries**. The Sterile Insect Technique (SIT)** for control of insects (for example, screwworm and tsetse flies) relies on the introduction of sterility in the females of the wild population. This method is usually applied as part of an Area-Wide Integrated Pest Management (AW-IPM) approach and has been applied in developing countries in the livestock sector as well as for the control of crop pests. An estimated number of 30 countries use the SIT against insect pests (FAO/IAEA, 2008).

2.6 The role of Genetic Engineering in Agriculture Optimization

Biotic Stress: They may aim to improve crop performance in the field by conferring pest and disease resistance, herbicide resistance, or tolerance to environmental stresses (such as drought or flooding). They may also aim to develop products with enhanced value, such as improved post-harvest life, nutritional value, or other health benefits.There is an increasing demand by consumers for fruits and vegetables free of pesticide and other residues, but cultivation without their use is only partially possible by using suitable resistant genotypes in a suitable environment. Plants have developed several natural defense strategies to protect themselves against the attack of pathogen and pest diseases. The resistance normally depends on the early response of the plant to pathogen attack, which leads to a rapid accumulation of reactive oxygen species (ROS) namely oxidative burst (Lamb and Dixon, 1997).

Bacteria Resistance: In the last few years, several crops have been genetically engineered to produce their own Bt proteins, making them resistant to specific groups of insects. “Bt” is short for Bacillus thuringiensis, a soil bacterium that contains a protein that is toxic to a narrow range of insects, but not harmful to animals or humans. Applications of Bt bacteria have been used to control insect pests for many years before the advent of the current Bt crops made using biotechnology. Varieties of Bt insect-resistant corn and cotton are now in commercial production(Hammond-Kosack and Jones, 1996). Other crops being investigated include cowpeas, sunflower, soybeans, tomatoes, tobacco, walnut, sugar cane, and rice

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Fungal Resistance: Among diseases, fungi are the main cause of yield loss in fruit crops. They are controlled by several traditional techniques including quarantine, sanitation, breeding, and clonal selection of resistant varieties and application of fungicides. However, resistant cultivars, with the onset of new strains of virulent pathogens, tend to become susceptible over time. In addition, the unrestrained use of fungicides, as well as increasing production costs and degrading the environment, induce new forms of resistance within pathogens, forcing the development of new pesticides. These problems have encouraged the search for biotechnological solutions to combating fungal disease.

Virus Resistance: There is an increasing demand by consumers for fruits and vegetables free of pesticide and other residues, but cultivation without their use is only partially possible by using suitable resistant genotypes in a suitable environment. Many plants are susceptible to diseases caused by viruses, which are often spread by insects such as aphids from plant to plant across a field. The spread of viral diseases can be very difficult to control and crop damage can be severe. Insecticides are sometimes applied to control populations of transmitting insects, but often have little impact on the spread of the disease. Often the most effective methods against viral diseases are cultural controls such as removing diseased plants or plant varieties bred to be resistant or tolerant to the virus, but such strategies may not always be practical or available. Scientists have discovered new genetic engineering methods that provide resistance to viral disease where options were limited before.

Herbicide Tolerance: Chemical herbicides are frequently used to control weeds. Weeds growing in the same field as crop plants can significantly reduce crop yields because the weeds compete for soil nutrients, water, and sunlight. Many farmers now control weeds by spraying herbicides directly onto the crop plants. Because these herbicides generally kill only a narrow spectrum of plants (if they didn't, they would kill the crop plants, too), farmers apply mixtures of multiple herbicides to control weeds after the crop has started to grow. Researchers realized that if a crop plant is genetically engineered to be resistant to a broad-spectrum herbicide, weed management could be simplified and safer chemicals could be used. It is often argued that such GE varieties reduce soil erosion because they make the adoption of soil-conserving practices such as "no-till" easier. Resistance to synthetic herbicides has been genetically engineered into corn, soybeans, cotton, canola, sugar beets, rice, and flax. Some of these varieties are commercialized in several countries. Research is ongoing on many other crops. One application of this technology is that herbicide could be coated on seed from an herbicide-resistant variety; for example, maize. While the maize would germinate and thrive, weeds and parasites such as Striga would be killed.

Delayed Fruit Ripening: Delaying the ripening process in fruit is of interest to producers because it allows more time for the shipment of fruit from the farmer's fields to the grocer's shelf, and increases the shelf life of the fruit for consumers. Fruit that is genetically engineered to delay ripening can be left to mature on the plant longer, will have a longer shelf-life in shipping and may last longer for consumers. Foods with improved nutritional value Researchers are using biotechnology for the development of foods with improved nutritional value. Genetic modification can be used to produce crops that contain higher amounts of vitamins to improve their nutritional quality. Genetically altered "golden rice," for example, contains three transplanted genes that allow plants to produce beta-carotene, a compound that is converted to vitamin A within the human body. Vitamin A deficiency is the world's leading cause of blindness that has affected as many as 250 million children (FAO & IAEA. 2008).
Biotechnology has also been used to alter the content of many oil crops, either to increase the amount of oil or to alter the types of oils they produce. Biotechnology could also be used to upgrade some plant proteins now considered incomplete or of low biological value because they lack one or more of the essential amino acids. Examples include maize with improved protein balance and sweet potatoes with increased total protein content.
Reducing the toxicity of certain foods is also a goal of biotechnology. For example, reduction of the toxic cyanogen in cassava is possible and could be produced in the future.

Fig. 2.2:Genetic Engineers carrying out Genetic Modification of Plants

III. Implication of Adopting Biotechnology

3.1 Merits of Biotechnology in Agriculture

What are the benefits of genetic engineering in agriculture? Everything in life has its benefits and risks, and genetic engineering is no exception. Much has been said about the potential risks of genetic engineering technology, but so far there is little evidence from scientific studies that these risks are real. Transgenic organisms can offer a range of benefits above and beyond those that emerged from innovations in traditional agricultural biotechnology. Following are a few examples of benefits resulting from applying currently available genetic engineering techniques to agricultural biotechnology.

Increased Crop Productivity

Biotechnology has helped to increase crop productivityby introducing such qualities as disease resistance and increased drought tolerance to the crops. Now, researchers can select genes for disease resistance from other species and transfer them to important crops. For example, researchers from the University of Hawaii and Cornell University developed two varieties of papaya resistant to the papaya ringspot virus by transferring one of the virus' genes to papaya to create resistance in the plants. Seeds of the two varieties, named 'SunUp' and 'Rainbow', have been distributed under licensing agreements to papaya growers since 1998. Further examples come from dry climates, where crops must use water as efficiently as possible. Genes from naturally drought-resistant plants can be used to increase drought tolerance in many crop varieties. In the words of Norman Borlaug, the father of Green Revolution (GR) a renowned scientist: "Agriculture science and innovation have an enormous potential to increase yields of small farmers and lift them out of hunger and poverty" (Norman Borlaug, 1996).

Enhanced Crop Protection

Farmers use crop-protection technologies because they provide cost-effective solutions to pest problems which, if left uncontrolled, would severely lower yields. As mentioned above, crops such as corn, cotton, and potato have been successfully transformed through genetic engineering to make a protein that kills certain insects when they feed on the plants. The protein is from the soil bacterium Bacillus thuringiensis, which has been used for decades as the active ingredient of some "natural" insecticides. In some cases, an effective transgenic crop-protection technology can control pests better and more cheaply than existing technologies. For example, with Bt engineered into a corn crop, the entire crop is resistant tocertain pests, not just the part of the plant to which Bt insecticide has been applied. In these cases, yields increase as the new technology provides more effective control. In other cases, new technology is adopted because it is less expensive than a current technology with equivalent control. There are cases in which new technology is not adopted because for one reason or another it is not competitive with the existing technology. For example, organic farmers apply Bt as an insecticide to control insect pests in their crops, yet they may consider transgenic Bt crops to be unacceptable.

Improvements In Food Processing

The first food product resulting from genetic engineering technology to receive regulatory approval, in 1990, was chymosin, an enzyme produced by genetically engineered bacteria. It replaces calf rennet in cheese-making and is now used in 60 percent of all cheese manufactured. Its benefits include increased purity, a reliable supply, a 50 percent cost reduction, and high cheese yield efficiency. Improved nutritional value Genetic engineering has allowed new options for improving the nutritional value, flavor, and texture of foods. Transgenic crops in development include soybeans with higher protein content, potatoes with more nutritionally available starch and an improved amino acid content, beans with more essential amino acids, and rice with the ability to produce beta-carotene, a precursor of vitamin A, to help prevent blindness in people who have nutritionally inadequate diets.

Better Flavor

Flavor can be altered by enhancing the activity of plant enzymes that transform aroma precursors into flavoring compounds. Transgenic peppers and melons with improved flavor are currently in field trials.

Fresher Produce

Genetic engineering can result in improved keeping properties to make transport of fresh produce easier, giving consumers access to nutritionally valuable whole foods and preventing decay, damage, and loss of nutrients. Transgenic tomatoes with delayed softening can be vine-ripened and still be shipped without bruising. Research is underway to make similar modifications to broccoli, celery, carrots, melons, and raspberry. The shelf life of some processed foods such as peanuts has also been improved by using ingredients that have had their fatty acid profile modified.

Environmental Benefits

When genetic engineering results in reduced pesticide dependence, we have fewer pesticide residues on foods, we reduce pesticide leaching into groundwater, and we minimize farmworker exposure to hazardous products. With Bt cotton's resistance to three major pests, the transgenic variety now represents half of the U.S. cotton crop and has thereby reduced total world insecticide use by 15 percent (Nair, 2008). Also, according to the U.S. Food and Drug Administration (FDA), "increases in adoption of herbicide-tolerant soybeans were associated with small increases in yields and variable profits but significant decreases in herbicide use".

Benefits for Developing Countries

Genetic engineering technologies can help to improve health conditions in less developed countries. Researchers from the Swiss Federal Institute of Technology's Institute for Plant Sciences inserted genes from a daffodil and a bacterium into rice plants to produce "golden rice," which has sufficient beta-carotene to meet total vitamin A requirements in developing countries with rice-based diets. This crop has the potential to significantly improve vitamin uptake in poverty-stricken areas where vitamin supplements are costly and difficult to distribute and vitamin A deficiency leads to blindness in children.

3.2 Challenges of Biotechnology in Developing Countries

Nigeria as a developing country in relatively backward in terms of biotechnologies when some of her par third world countries have attained an applaudable level of development in the use of biotechnologies to improveagricultural production. These are some of the challenges hindering the LDC nation from attaining the desired result of adopting modern farming techniques. These challenges can also be traced down to Nigeria's agricultural sector.

Investments in Biotechnological R&D

Investment patterns in biotechnology R&D are highly uneven in developing countries. For example, China recently invested US$500 million in biotechnologies and is now an acknowledged global leader in agriculturally applied plant genomics (USDA, 2008). Indeed, much of the spectacular economic growth of modern China has been underpinned by huge gains in agricultural productivity that enabled the country to remain self-sufficient in many major crops despite steady increases both in population and in per capita food consumption (IAASTD, 2008). Brazil and India each spend less than one-tenth of the Chinese agricultural biotechnology budget, but vastly out-spend the whole of sub-Saharan Africa (Sharma et al, 2003).

China, India, and Brazil are now recognized as significant global centers of emerging excellence in biotechnology that will soon be on a par with the United States and the European Union. A note of concern here comes from a recent downward revision in estimates of global agriculture R&D spending, especially in developing countries. The lack of adequate and sustained investments remains a major limiting factor in most developing countries (IAASTD, 2009). This situation may be exacerbated by the consequences of the current economic downturn.

Biotechnology Capacities

Aside from attitude polarization on genetically modified crops; insufficient and unstable investments in R&D is also a key problem. A further constraint in developing countries is the limitation of capacity to generate, adapt or utilize potentially beneficial biotechnologies due to limitations in agricultural research systems. Such limitations include absent or inadequate policies for agricultural R&D at the government and institutional level (Spielman et al, 2007); Deficiencies in economic and physical infrastructures (including trade markets) impede farmer ability to capitalize on new biotechnologies (Diaoet al., 2008); the weaknesses of research institutions that do not allow efficient implementation of research projects; insufficiently educated/trained human resources and the lack of appropriate incentive schemes for capacity building, the retention and motivation of staff through competitive career development opportunities.

Poor Awareness/Sensitization

Poor scientific, political, and public awareness of the opportunities and risks of different crop biotechnologies (Gresselet al., 2004); inconsistent policy and regulatory regimes regarding issues such as IPR enforcement, the protection of plant and animal health, biosafety, food safety, and bioethics (Diaoet al., 2008).The rollout of GM crops has been inhibited by high transaction costs and complex, inconsistent regulatory requirements, sometimes leading to IPR avoidance and piracy of traits that could be regarded as a qualified market failure.

Technology Uptake

Crop varieties and management systems developed by even the most sophisticated new technologies will have little impact on improving food security in developing countries unless they are effectively taken up by farmers on a sustained, long-term basis (Tripp, 2001).

Indeed, while modern breeding and crop management technologies can easily take a decade or more to make improved materials available to farmers, it is a telling but often overlooked fact that the widespread on-farm adoption of such technologies can take much longer (FAO, 2007f).

Technology uptake, or lack thereof, is an abiding concern for the improvement of food security at the small farmer level. For example, it is estimated that simply by applying existing recommended practices of crop management, Ghanaian farmers could double or treble the average yields of most staple crops (Al-Hassan and Diao, 2007).

Seed Systems

One of the major hurdles to the wide-scale use of improved varieties obtained through biotechnological approaches in developing countries is the weakness of the local seed systems. In many developing countries, the vast majority of seeds used in agriculture are supplied by informal seed systems which include farm-saved seeds, seed exchanges between farmers, and seeds purchased from local markets. The informal seed system can, in some instances, play a significant role in the conservation of local landraces and other precious genetic resources, and satisfies the demand for low-cost inputs, but the seed supplies oftendo not meet acceptable standards.Also, the seeds offered by the formal production and distribution systems are frequently more expensive and cannot be accessed by farmers with low purchasing power. In addition to infrastructure, government support within developing countries may consider providing financial incentives to farmers to plant higher-yielding varieties that will ultimately bring increased revenue back to the farmer.

Extension Services

In a recent report on seed delivery systems in Africa,Guei, Somado, and Larinde (2008) stated that: “Most extension services are characterized by a lack of information, technical capacity, and logistics for timely delivery of advice to farmers. They have the inadequate capacity in terms of personnel and are unable to formulate and implement good and sound technology transfer approaches”. Even in comparatively well-developed and resourced cropping systems such as oil palm in Malaysia, the effectiveness of extension services to smallholders have come in for criticism (Jalaniet al., 2002).

Extension services are fundamental to the success of agricultural development, including advice to farmers and local seed production and distribution. Because they are an end-of-pipeline function, extension services are frequently overlooked by researchers, policymakers, and government budget allocations.

Importantly, the linkages between agriculture researchers, extension personnel’s and producers are quite weak, resulting in the poor uptake of innovations, research that fails to reflect smallholder needs, and the delivery of the wrong type of extension education programmes (FAO, 2001). And yet, without a good extension service the introduction of even the best new crop varieties may be delayed or prevented (World Bank, 2007). Some of the problems with extension services include poor human resources, inadequate operational and transportation support, and inappropriate orientation and methodological approaches. Extension agents also have a particularly difficult and often isolated role that may be hampered by poor or inappropriate training, insufficient technical support, lack of motivational incentives, unrealized expectations of farmers, and external pressures from third parties such as private seed merchants or NGO representatives.

To buttress the above statement of government intervention and extension services, Nigeria in 2017, has made history and it has made the output of 18 million metric tons of rice (FMARD, 2016) but more needed to be done.

IV. Status- Quo on The Adoption of GMO Crops in Nigeria

Genetically modified crops ("GM crops", or "biotech crops") are plants used in agriculture; the DNA of which has been modified with genetic engineering techniques. In most cases, the main aim is to introduce a new trait that does not occur naturally in the species. Transgenic food crops are meant to be resistant to certain pests, diseases, stressful environmental conditions, resistance to chemical treatments (such as resistance to herbicide), reduction of spoilage, or improving the nutrient profile of the crop (National Academy of Sciences, 2001, Paarlburg, 2011). These techniques have allowed for the introduction of new crop traits as well as far greater control over a food's genetic structure than previously afforded by methods such as selective breeding and mutation breeding.

Farmers have widely adopted GM technology; ten percent (10%) of the world's croplands were planted with GM crops in 2010. As of 2011, eleven (11) different transgenic crops were grown commercially on 395 million acres (160 million hectares) in 29 countries such as the US, Brazil, Argentina, India, Canada, China, Paraguay, Pakistan, South Africa, Uruguay, Bolivia, Australia, Philippines, Myanmar, Burkina Faso, Mexico and Spain (Paarlburg R, 2011).Commercial sale of genetically modified foods began in 1994 when Calgene first marketed its Flavr Savr delayed ripening tomato (James, 1996).

To date, most genetic modification of foods has primarily focused on crops in high demand by farmers such as soya bean, corn, canola, and cottonseed oil. These have been engineered for resistance to pathogens and herbicides and better nutrient profiles. In recent years, to be precise 2015, GM livestock has also been experimentally developed; none were available on the market; but in 2015 the FDA approved the first GM salmon for commercial production and consumption (Nicolia et al, 2014).

Over time now there has been an attitude polarization on the impact of GMO crops on humans whether they are fit for consumption or not. There is a scientific consensus that currently available food derived from GM crops poses no greater risk to human health than conventional food (Haslberger, 2003). Each GM food must be tested on a case-by-case basis before introduction. Nonetheless, members of the public are much less likely than scientists to perceive GM foods as safe (Marris, 2001).

A major and polarized debate about GMOs has been underway since the 1990s; the debate revolves around their potential impacts on food security, the environment, biodiversity, human and animal health, and the control of circumstances to increase production which will, in turn, improve the earnings of the farmers.

GM seeds have helped Nigerian farmers to improve yield, quality of food and boost sales and profit. The GM seeds are advantageous because they cannot be attacked by worms or other soil pests and so prevents infestation and attacks from pests and diseases leading to the growth of durable and healthy agricultural produce. This will ensure a bountiful harvest and the farmer's profit and income will be improved (National Biotechnology Development Agency (NABDA), 2005). Although there are lots of controversies as to "whether the organic food is better than GMO crops in terms of investment" The evolution in agricultural processes has called for innovation in the sector. However, this does not mean total eradication of the traditional processed. It's a matter of choice and it is a win-win situation.

Though, the Open Forum for Agricultural Biotechnology (OFAB) in Africa, the Nigerian chapter (NABDA), has contributed to promoting access to biotechnology crops through the dissemination of information and increasing awareness on agricultural biotechnology for farmers, Policymakers, the media, and other stakeholders.This is achieved through its sensitization of people on the benefits and potentials of GM crops for increased productivity, economic development, nutrition enhancement, job, and wealth creation (Daily Trust, 2009).Actually "there is no difference between GMO's and organic seeds except through special techniques".

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The legal and regulatory status of GM foods varies by country, with some nations banning or restricting them, and others permitting them with widely differing degrees of the regulation (Pollack A, 2010; Lynch D, Vogel D, 2001). Regulation varies in a given country depending on the intended use of the products of genetic engineering. For example, a crop not intended for food use is generally not reviewed by authorities responsible for food safety. The European Union differentiates between approval for cultivation within the EU and approval for import and processing. While only a few GMOs have been approved for cultivation in the EU several GMOs have been approved for import and processing; the cultivation of GMOs has triggered a debate about the coexistence of GMOs and non-GM crops. Depending on the coexistence regulations, incentives for the cultivation of GM crops differ (Beckmann et al 2011). In Nigeria, the NABDA controls and regulates the type and quantity of transgenic crop varieties in circulation to ensure the safety of the producers, consumers, and larger markets that are involved in the food value chain.

V. Conclusion and Recommendation

Agriculture occupies a significant place in our growth matrix in terms of food security and gross domestic product. The Nigeria nation that is oil resource endowed could seek to diversify her economy; therefore, agriculture is a sure sector that calls for key attention towards sustainable growth and economic development. Technology reform in agriculture will propel farmers to think smarter, work more efficiently and be capable of utilizing these novel methods of farming to double productivity. Biotechnology in farming will reduce the government's annual budget and spending on the procurement of farm inputs such as fertilizer, pesticides, and herbicides. Biotechnologies amongst others are one of the scientific innovations with such enormous potential to create a push-up in agricultural production. Its current impact on agriculture arises from the recent introduction of improved crop seeds which appears to be a revolution that will bring about substantial change to the agricultural sector in Nigeria.

The knowledge gained from basic plant research will buttress future crop improvements but effective and robust mechanisms for the rapid and effective translation of research discoveries into public good agriculture remain to be developed. Maximum benefit will be derived if robust plant breeding and crop management programmes have ready access to all the modern agricultural production techniques, both transgenic and non-transgenic; to address food security issues. This will require additional investments in capacity building for Research and Development in most developing countries.

The big puzzle, is how well will the Nigerian agricultural sector and farmers benefit from modern technologies in production? In an attempt to answer this question, Nigeria as an oil resource nation must evaluate how it has effectively utilized the proceeds from the sale of crude oil to feed other sectors of the economy to support economic development and the livelihood of its citizens. The income from this rent should be channeled towards the implementation of the Malabo declaration of all African countries investing 10% of their annual budget to the agricultural sector to enhance their production capacity to ensure food security and maintain a hunger-free nation. Nigeria and other developing countries must develop expertise to ensure sovereign decisions are made on adopting biotechnologies to carry out their own independent, broad-based risk/benefit analyses in the agricultural sector to curb the emerging challenges in the sector.

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