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POTENTIALS OF BIOTECHNOLOGY IN CROP PRODUCTION AND ENVIRONMENTAL MANAGEMENT IN NIGERIA AND BIOSAFETY IMPLICATIONS

By

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Abstract: In many industrialized countries, biotechnology has contributed to progress in agriculture. It is of particular relevance to developing countries that are confronted with an ever-increasing population, food shortage, and scarcity of economic resources. However, large-scale use of biotechnology has its own constraints, which the paper enumerated. When biotechnology results in crop cultivars with improved yield, economic benefit to farmers and women who trade in these crops and hence quality of life improves, new industries also emerge due to emergence of new products and needs. Hence, unemployment rate would drop. Production of biogas is an important industrial application that is relevant to Nigeria because of its implication in waste management. In many industrialized countries, genetically modified organisms (GMOs) were previously perceived by the public as environmental threats and resisted greatly. The controversy about GMOs is leading to new ways in which potential risks are perceived and in ways in which potential risk issues are dealt with. This paper harnesses opportunities presented by biotechnology that could be beneficial for national food crop production, environmental management and also discussed biosafety issues arising from transgenic products.

Keywords: biotechnology, bioremediation, economy, crops, safety.

INTRODUCTION

Biotechnology is an area of multidisciplinary science, involving a variety of distinct subjects, where living organisms or their useful parts are put into effective use to cater for the welfare of humanity. It is a powerful tool that can, in a quick and thorough manner, bring what is most lacking in agriculture. Biotechnology may be grouped as conventional (or traditional) biotechnology and modern biotechnology (or genetic engineering). The emergence of modern biotechnology over the last few decades has opened new doors for increased productivity not only for agriculture but also in medicine and industry. Biotechnology is of particular relevance to developing countries that are confronted with an ever-increasing population, food shortage, and scarcity of economic resources. Harnessing of solar energy to improve photosynthetic bacteria as well as utilization of agriculture and organic wastes to produce methane using biogas plants are also aspects of biotechnology in vogue. The same is true of biological nitrogen fixation, a prerogative of certain free living or symbiotic anaerobic and photosynthetic bacteria and algae. Biotechnology tools are employed in biofuel production and in biological clean up of contaminated soils. The age

long fermentation, a biotechnology tool is a process facilitated by bacteria and has been used in food and beverage industry from time immemorial to produce products like yoghurt, cheese and beer.

In most developing countries of West and Central Africa where food is produced, famine, poverty, and malnutrition remain huge constraints in rural as well as urban areas. Interestingly, though, agriculture, which makes up forty percent of export revenue and thirty-five percent of the gross domestic products of West and Central African revenue, employs seventy percent of the labour force and covers endless agro ecological lands (Nwalozie, 2006).

Significantly, in many industrialized countries, biotechnology has contributed to progress in agriculture, while, in developing countries, it comes to add itself to the many technological tools to achieve crucial productivity and sustainability targets, to increase food production on the same land surface areas or less, with added nutritional value and projected lesser negative impact on environment. However, large-scale use of biotechnology has its own constraint: skilled human resources are limited; material and financial resources are lacking; the controversies about some agricultural biotechnologies, such as the genetic engineering and products from this new technology, remain widespread and time consuming (Roy-Macauley, 2007). In any case, given to the skyrocketing rural population growth, its dependency on agricultural production systems highly vulnerable to climatic changes, the scarcity of fertile lands per head, need to increase and improve agricultural production biotechnology has become definitely very important (Nwalozie, 2006).

SIGNIFICANCE OF BIOTECHNOLOGY IN CROP PRODUCTION

Improvement of yield and quality of landraces of desired crops is an important factor. Many of the land races are disease resistant, having evolved over time through natural selection pressure. However, a major constraint to their production is low yield. Conventional breeding has been used to improve some of these crop species with the inherent problem of increased susceptibility to diseases and pests. Some hybrids produced through conventional breeding do not quite represent the landraces and often resulted in a shift in crop use, which is often not desirable. With biotechnology, specific gene can be introduced to improve yield of the desired landraces. An example is Bt-Cotton, which was engineered to produce Bt-protein (i.e. *Baccilus thuringiensis* protein) developed and grown in China for years and in 2001, insecticide use dropped on cotton fields 78% (Pray *et al.,* 2002). Insect-resistant corn has been developed and is grown in Argentina, Australia, Canada, China, EU, Japan, Korea, Mexico, Philippines, Russia, South Africa, Switzerland, Taiwan, UK, US and Uruguay.

Another aspect of relevance of biotechnology is in the production of **herbicide tolerant and pest resistant crops**, such as Round-up ® ready maize that is tolerant of the herbicide Round-up ® (Verschwele, 2012). Weed like *Striga* (witchweed) is parasitic on maize, grows toward the crop roots, attach and suck nutrients from the crop, poisons it and cannot be controlled conventionally. Biotechnology intervention through the use of herbicide tolerant maize would be helpful in such instance. Insect-tolerant transgenic rice is grown already in Iran and herbicide-tolerant transgenic rice is also grown in Canada, Russia and USA. India is an example of a developing nation where biotechnology has been put to great use and they have success story with Bt Cotton. The literacy level in Nigerian is average (UNESCO) and it is expected that the literacy level of the farmers will be lower and as such, farming practices like herbicide application, insecticide application and fungicide application (to name a few) require some levels of skill. This has made the use of such chemicals difficult and where possible, the high cost of the chemicals has not made them attractive to farmers. The increasing cost of labour has made manual weeding, which had been a cheaper alternative for farmers, become increasingly expensive with resulting high weed incidence. On the long run, herbicide tolerant crops and pest resistant crops may be cheaper for the farmers and less hazardous to use.

Drought and Flood Tolerance: The importance of climate change and environmental degradation to sustainable food production makes it imperative for a faster and more effective tool than conventional breeding be applied in crop improvement. Although biotechnology would not replace classical breeding, it would greatly enhance efficiency and selection. It is common for areas not previously prone to flood to experience flash floods in response to global warming and resultant change in climate. Climate change has resulted in longer periods of drought that earlier experienced. Over time, new cultivars adapted to the emerging climate would emerge. However, population pressure and the high demand on food would not withstand the natural process of natural selection and evolution. Genetic engineering tools could be employed to hasten the natural process through the identification of specific genes that encode the desired trait in a plant, isolating or synthesising it and inserting it into the crop of interest.

Biofortification and Quality Improvement

Biofortification for increased protein content is an attraction for grain crops. In Nigeria and many parts of Africa, carbohydrate-rich tuber crops and cereal grains form largely the staple. In rural areas, malnutrition is a major challenge because of the heavy consumption of these food crops. These crops can be engineered to express protein rich in essential amino acids. For instance ASP1, an artificial storage protein that is rich in essential amino acids has been introduced and successfully expressed in rice and cassava. Cassava and yam have been modified to lower the amylopectin content of starch, which has been associated with diet-related condition such as type 2 diabetes (Niba, 2003).

Transgenic maize with modified amino acid content has been developed and would be useful in improving protein intake with consumption of maize in Nigeria. Soybean with modified fatty acid (Oleic acid) content has been developed through biotechnology and is grown in Australia, Canada, Japan and the USA. Efforts are still underway to optimize expression and increase the level of protein accumulation in transgenic plants. Crops have also been fortified for for increased micronutrients: golden rice is vitamin A fortified rice that was developed to cater for the large vitamin A deficiency among the Asian children population (Potrykus, 2001; Barry, 2005). According to UNICEF the estimated annual number of children deaths precipitated worldwide by Vitamin A deficiency lies at 1.15 million. Tomatoes have also been engineered to express higher levels of folic acid.

Storage and Processing

Poor storage facilities have often resulted in loss of perishable crops soon after harvest especially at the peak of harvest. Using biotechnology to increase shelf life of crops would be of benefit in Nigeria. Genetically modified tomato Flavr Savr (also known as CGN-89564-2) was the first commercially grown genetically engineered food to be granted a licence for human consumption produced by the Calofornia company, Calgene in 1992. Flavr Savr was engineered for slow ripening and softening while the fruits still retained its natural colour and flavour product of genetically modified tomato with longer shelf-life/delayed ripening (Weasel, 2009). In poor storage conditions, mycotoxin contamination has been a major problem. Biotechnology has been used to develop grain crops that are less susceptible to mycotoxin contamination. This would greatly improve the health of farming populations whose diet is largely contaminated by the toxin.

Improving processing quality of food crops is also needed and biotechnology would be able to address this need.

Drought and Poor soil quality

In areas of drought and poor soil quality, where high quality proteins are scarce, genetic modification has been undertaken on some legumes and in soybean to increase the levels of high quality proteins. Drought tolerant crops are also being engineered.

Biofertilizer and Biofuels

A biofuel is a type of fuel whose energy is derived from biological carbon fixation. Biofuels include fuels derived from biomass conversion, as well as solid biomass, liquid fuels and various biogases (Demibars, 2009). Biogas is methane produced by the process of anaerobic digestion of organic material by anaerobes (Redman, 2008). It can be produced either from biodegradable waste materials or by the use of energy crops fed into anaerobic digesters to supplement gas yields. The solid by-product can be used as biofuels or a digestate can be used as a biofuel or a fertilizer. Biogas can be recovered from mechanical biological treatment processing systems. Huge wastes generated in urban centres in Nigeria can be effectively put to economic use as biogas. Effluents of farming and agricultural production are all wastes that would find appropriate use with biotechnology tools. In fact, farmers can produce biogas from cow dung and other animal manure by using an anaerobic digester (Framers Guardian, 2009) while the digestate can be used as fertilizer.

Development of organic fertilizer (biofertilizers) falls within the purview of conventional biotechnology and ensures healthier environment. Agriculture being generally responsible for close to 15% greenhouse has emission. Use of chemical agricultural inputs is also responsible for considerable environmental pollution and underground water contamination. Application of bio-inputs would greatly reduce this adverse effect. Biofertilizers are biological organisms packaged as fertilizers. Several organisms including bacteria, fungi and algae have been employed as biofertilizers. This would reduce the pollution often associated with the use of agricultural inputs like agrochemicals, inorganic fertilizers, etc.

Bioremediation

Environmental pollution and degradation could be handled by the production of GM trees for bioremediation. Managing industrial pollutants is a major problem in the nation. Plants can be genetically modified to take up pollutants in the soil, break it down into non-toxic compounds. Certain bacteria could also be modified to enhance their ability to breakdown petrochemicals. These organisms would then be introduced to water bodies and land to mop up oil spills. There is great potential in the use of genetic engineering to create organisms specifically designed for bioremediation (Lovely, 2003). The bacterium *Deinococcus radiodurans* (the most radioresistant organism known) has been modified to consume and digest toluene and ionic mercury from highly radioactive nuclear waste (Brim *et al*., 2000).

Relevance of biotechnology to national economy

Applied to the Nigerian economy, biotechnology offers additional technological opportunities capable to responding to the constant demand for food and to reducing vulnerability in the agricultural sector. It would also offer opportunities for technical skill development and emergence of new industries as equipment, consumables and facilities needed for biotechnology would be established. The production of biotechnology based plants, such as orchids, bamboos and a host of others has lead to export oriented industries in some developing countries like India.

Rapid production of disease free clones of crops like yam, cassava, banana and plantain has been possible through tissue culture technique. With less spoilage in storage, longer shelf life of crops, the optimum market price of the crop produce would be sustained for longer periods because of the improved quality. Increased economic benefit to farmers and women who trade in these crops is an important issue that should be considered.

The challenge of risk assessment would call for new fields of science and law (for legislation) to evolve. As a result, biotechnology contributes to income generation, technological advancement and national development, improving of nutrition and preservation of natural resources and ecosystem services. It is necessary to ascertain whether biotechnologies can supply rapid, safe, cost effective solutions to the intractable biotic and abiotic constraints. The institutional and infrastructure constraints to agriculture are amenable to positive human intervention, and could facilitate rapid adoption of the yield and quality enhancing biotechnologies(Nwalozie, 2006). Whether biotechnological solutions are employed is a matter of consumer demand and need, and the resolve of politicians and regulators to deal with these issues in a science and fact based manner with due resolve.

Biopharmaceuticals

Production of biopharmaceuticals is not left out. An Australian research team grew a genetically modified o*pium* poppy, which could be used to fight cancer and malaria. The GM poppy does not produce morphine and codeine, rather, it creates large amount of a compound, which scientists believe could be used to make new medicines (www.abc.net.au/news/newsitems/200411/). Recently, Brazil said it will breed large numbers of genetically modified mosquitoes to help stop the spred dengue fever, an illness that has already struck nearly 500,000 Brazilian people already in 2012 (http://www.google.com/hostednews/afp/article). These are prospects of biopharmaceuticals in managing diseases. Several plant-derived bio-pharmaceuticals for the treatment of human diseases that are in the pipeline for commercialization have been compiled by ISAAA, 2007.

Challenges of the use of genetically modified crops

Currently, commercialization of genetically-modified nutritionally-enhanced crop is very limited due to many factors that include the cost of introducing a new product to the market and the lack of suitable regulatory controls. The issue of risk perception is a major challenge that limits the application of modern biotechnology/genetic engineering. This gave rise to assessment of risks likely to be associated with the use of genetically modified organisms (GMOs).

GENERAL SAFETY ISSUES ARISING FROM TRANSGENIC PLANT PRODUCTS

Safety issues often hinge on food and feed safety. Environmental issues would centre on both direct and indirect effects considering the ecological impact of the direct cultivation of GMOs and the indirect impact. The proteins encoded by the genes in the GM plants should be compared with the non GM plants to assess the degree of equivalence. The toxicity and allergenicity of the protein would also be compared with known toxins and allergen computer aided comparison (The Royal Society, 2002; Bartsch and Schmitz, 2002).

Potential unintended effects on plant fitness due to genetic modification:

Many cereal crops are highly domesticated and generally unable to survive in the environment without cultivation and gene flow via pollen is largely restricted to neighbouring crops. There is fear that GM plants or their progenies

will differ from conventional varieties in their ability to survive and establish feral populations, especially maize and other cereals (Wolt, 2007).

Effects on target and non-target organisms:

Potential of developing resistance among the target organism is highly likely since the genes may be inherited and jointly segregated. Potential interactions of the GM plant with non-target organisms is unlikely and would be of no ecological relevance.

Indirect effect:

Indirect exposure to transgenic plants, especially cereals that are employed as animal feed, occur through manure and faeces from the gastrointestinal tracts of animals and accidental release into the environment of GM seed during transportation and processing. There are reports of development of insect resistance associated with the use of bt-cotton. However, there are conflicting reports as more natural enemies of insect pests have also been reported with the use of bt-cotton and other GMOs (Pray *et al.*, 2002). This has made risk assessment very necessary (National Research Council, 2002).

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