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AGRICULTURAL BIOTECHNOLOGY: A MEANS OF ACHIEVING FOOD SECURITY

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ABSTRACT

Food security and sustainable agriculture have become a burning issues in the national discuss at all levels of government as plans are being made for a changing global climate and increasing global population. One of the most important environmental challenges facing the developing world is how to meet current food needs without undermining the ability of future generations to meet theirs. Agricultural production must be sufficient to feed us now and in the future. Evidently, the current state of agricultural technology will not suffice to meet the production challenges ahead. Innovative technology (Agricultural biotechnology) has to be exploited in order to enable sufficient food availability in the future. Use of agricultural biotechnology and integrating same into the traditional smallholders farming system offer a bright prospect of meeting the growing demand for food by improving both yield and nutritional quality of crops and reducing the impact on the environment.

Keywords: food security, agricultural biotechnology, agriculture, genetic modifications, crops

INTRODUCTION

Food security and sustainable agriculture in the developing world and especially in sub-Saharan Africa has continued to dominate public debate and have remained an issue of global concern. Exacerbating these issues is the complex subject of population growth. According to Population Reference Bureau (PRB), the world population reached 6.6 billion people in 2006, up from 6 billion in 1999. It is projected that world population will beat the 8 billion mark in the year 2025; most of the increase is expected in the developing world (PRB, 2006). In order to meet these needs, FAO (1999) estimated that global food production must increase by 60% in developing countries to accommodate the estimated population growth, close nutrition gaps and meet dietary needs. In a similar report, FAO observed that more than 800 million people in the world do not have enough food to eat, causing 2400 people to die daily of hunger, three quarters of whom are children and under five. Additionally, the United Nation's subcommittee on nutrition (2000) estimated that 33% of children under five in the developing countries have experienced stunted height-for-age growth. This suggests chronic undernourishment throughout childhood, which can hinder overall health as well as intellectual development.

Population growth has direct implications on available land (and this is in the light of decrease in arable land worldwide). For Africa, where the rural population is close to 70% in most countries and where consequently the main economic and social activity is farming, these facts are issues of grave concern. It is estimated that population growth and income will lead to a further doubling of food demand over the next generation (McCalla, 1999). Yet, growth in farmers' crop yields has been slowing down since the 1980s, and in some regions of the world, grain yields have tended to level off (Pinstrup-Andersen Pandya-Lorch and Rosegrant, 1999). The challenge for developing countries therefore, is to ensure that their citizenry enjoys food security. Evidently, the current state of agricultural technology will not suffice to meet the production challenge ahead. This problem is further compounded by the fact that most of the agricultural research in the developing countries focuses on a narrow range of crops and many of the crops used by local communities have not benefited from modern research.

Developing an efficient sustainable agriculture in the current context of major global threats (climate change, soil degradation and erosion, water scarcity, biodiversity diminution) coupled with a continual population growth represents an imperative for conceiving a coherent strategy aimed to ensure food, feed, fiber and fuel security. Thus, innovative technologies have to be exploited in order to enable sufficient food availability in the future. In this context, agricultural biotechnology offers the best available options for diversifying agricultural production by speeding up the development of new varieties, including those of underutilized crops.

What is agricultural biotechnology?

All living organisms have the ability to improve themselves through natural means in order to adapt to changing environmental conditions. However, it takes hundreds of years before any detectable improvement is obtained. Man then learned how to domesticate and breed plants in order to develop crops to his own liking and needs using various means including biotechnology.

Biotechnology is defined as a set of tools that uses living organisms (or parts of organisms) to make or modify a product, improve plants, trees or animals, or develop microorganisms for specific uses. Agricultural biotechnology is the term used in crop and livestock improvement through biotechnology tools (Alfonso, 2007). This paper focused more on agricultural crop biotechnology because of its tremendous impact on crops.

How is agricultural biotechnology used?

Genetic engineering: Scientists have learned how to move genes from one organism to another. This has been called genetic modification (GM), genetic engineering (GE) or genetic improvement (GI). Regardless of the name, the process allows the transfer of useful characteristics (such as resistance to a disease) into a plant, animal or microorganism by inserting genes (DNA) from another organism. Virtually all crops improved with transferred DNA (often called GM crops or GMOs) to date have been developed to aid farmers to increase productivity by reducing crop damage from weeds, diseases or insects.

Molecular markers*:* Traditional breeding involves selection of individual plants or animals based on visible or measurable traits. By examining the DNA of an organism, scientists can use molecular markers to select plants or animals that possess a desirable gene, even in the absence of a visible trait. Thus, breeding is more precise and efficient. For example, the International Institute of Tropical Agriculture has used molecular markers to obtain cowpea resistant to bruchid (a beetle), disease-resistant white yam and cassava resistant to Cassava Mosaic Disease, among others. Another use of molecular markers is to identify undesirable genes that can be eliminated in future generations.

Molecular diagnostics*:* Molecular diagnostics are methods to detect genes or gene products that are very precise and specific. Molecular diagnostics are used in agriculture to more accurately diagnose crop/livestock diseases.

Vaccines: Biotechnology-derived vaccines are used in livestock and humans. They may be cheaper, better and/or safer than traditional vaccines. They are also stable at room temperature, and do not need refrigerated storage; this is an important advantage for smallholders in tropical countries. Some are new vaccines, which offer protection for the first time against some infectious illnesses. For example, in the Philippines, biotechnology has been used to develop an improved vaccine to protect cattle and water buffalo against hemorrhagic septicemia, a leading cause of death for both species.

Tissue culture*:* Tissue culture is the regeneration of plants in the laboratory from disease-free plant parts. This technique allows for the reproduction of disease-free planting material for crops. Examples of crops produced using tissue culture include citrus, pineapples, avocados, mangoes, bananas, coffee and papaya.

Agricultural biotechnology and the issue of food security

Agricultural biotechnology appears to be the most crucial for African countries and especially for resource-poor farmers whose sole livelihood depends on agriculture. The technique of agricultural biotechnology alone cannot solve all the problems associated with agricultural production but it has the potential to address specific problems such as increasing crop productivity, diversifying crops, enhancing nutritional value of food, reducing environmental impacts of agricultural production and promoting market competitiveness.

Crop yields have grown slowest in many parts of the developing world, especially in Africa. It is estimated that cereal yields in Africa have increased by nearly half of the rate in Latin America since 1970 (World Bank, 1993). Poor soils, low rainfall, high temperatures and the prevalence of pests continue to undermine food security in many parts of Africa. These challenges are compounded by the high costs of imported agricultural inputs. Improving the situation will require greater investment research and reliance on emerging technologies.

Enhancing the nutritional value of crops is another important aspect of food security. A good example in this area is the modification of rice to enhance its vitamin A content. United Nations projections show that while chronic malnutrition will decline in Asia and Latin America in the coming decades, the numbers for Africa will increase significantly. Agricultural biotechnology will make it easier to maintain traditional diets while improving their nutritional value.

Modern biotechnology could help in enhancing the competitiveness of agricultural products from the developing countries and thereby promoting their integration into the global economy. Efforts to diversify agricultural production in the developing world will not only promote food security in those regions, but it will also add new crops to world food market.

Contributions of agricultural biotechnology in achieving food security

Agricultural biotechnology should not be understood as a substitute for traditional tools of crop improvement. But integrating recombinant techniques into conventional breeding programs could substantially enhance the efficiency of agricultural research and development. On the one hand, breeding could be accelerated due to the more targeted transfer of desired genes into the crop. On the other hand, biotechnology could bring forth new crop traits that are not amenable to the conventional approach. Whereas traditional crossbreeding is confined to the exchange of genetic material within a certain crop species, recombinant techniques enable the transfer of valuable genes across species and even across kingdoms (Martin and Detlef, 2003).

However, a safe and sufficient food supply grown in an environmentally responsible fashion is essential for humanity. Like any technology, agricultural biotechnology has economic and social impacts. Since their introduction, crops improved using agricultural biotechnology has been used safely, with benefits such as the reduction of pesticide use. Agricultural biotechnology is only one factor among many influencing the health and welfare of farmers and other citizens in the developing world. As agricultural biotechnology continues to evolve, factual and open public discourse is vital to define the role it should play in society.

The new DNA manipulation techniques provide practicable means to overcome the limitations of plants breeders. Genes can be isolated from bacteria, viruses, fungi or animal and made to express in plants. Thus, the following areas of innovations seem of particular importance to future agricultural needs:

(1) those that breed resistance against specific diseases and common pests and insects,
(2) those that reduce environmental burden of fertilizers,
(3) those that reduce the demand for irrigation water and
(4) those that continue to improve crop production per hectare.

Transgenic breeding should therefore, be targeted at achieving the following major objectives:

Agronomic traits*:* The category of agronomic traits embraces all genetic modifications of plants that help to stabilize or increase the yields in farmers' fields. Since the immediate benefits of such traits accrue at the level of agricultural production, they are often referred to as 'input traits'. Prominent input traits are mechanisms of pest and disease resistance, which are often encoded by only a single gene (monogenic traits). Different transgenic pest and disease resistances have already been commercialized. In assessing the potential value of such traits it has to be considered that global crop losses induced by biotic stress factors reach a level of 25-30% (Oerke, Dehne, Schönbeck and Weber, 1994). Biotechnology could substantially reduce these losses without the need for increased pesticide applications. Other desirable agronomic crop traits include enhanced genetic yield potentials and tolerance mechanisms to abiotic stresses, such as drought, coldness and nutrient deficiencies in soils. Since these latter traits are usually determined by multiple genes (polygenic traits), the research is often more complicated. Recent advances in molecular mapping and functional genomics, however, demonstrate that related biotechnology products are also quite realistic in the near to medium-term future (Abelson and Hines, 1999). Thus, improved crop varieties could also be tailored to marginal agroecological regions, which have been largely neglected by the green revolution.

Quality traits: In contrast to the agronomic traits, which help increase the quantity of agricultural production, quality traits are related to the appearance or the chemical composition of the crop product. Hence, they are often referred to as 'output traits'. Quality traits can include enhanced densities of macro- and micronutrients essential for healthy human diets. If such traits are incorporated into staple food crops they could be beneficial especially for poor population segments that often lack purchasing power to buy sufficient amounts of higher-value and more nutritious foods. Researchers, for instance, managed to develop transgenic rice varieties with significantly enhanced vitamin A contents, now being used in rice breeding programs (Potrykus Lucca, Xudong, Al-Babilli, Hurrel and Beyer, 1999). It is estimated that worldwide more than 400 million people suffer from vitamin A deficiency which often leads to irreversible blindness and other deleterious health problems. Promising advances in biotechnological research to improve the micronutrient density in plants have also been reported for a number of other important vitamins and minerals. Although somewhat less related to food security, biotechnology also permits to modify plants in a way that they produce significant amounts of special chemicals, such as vaccines, other pharmaceuticals or biodegradable plastics.

Possible risks associated with using GM crops in agriculture

Some consumers and environmentalists feel that inadequate effort has been made to understand the dangers in the use of GM crops, including their potential long-term impacts. Some consumer-advocate and environmental groups have demanded the abandonment of genetic engineering research and development. Many individuals, when confronted with conflicting and confusing statements about the effect of genetic engineering on our environment and food supply, experience a "dread fear" that inspires great anxiety. This fear can be aroused by only a minimal amount of information or, in some cases, misinformation. With people thus concerned for their health and the well-being of our planetary ecology, the issues related to their concerns need to be addressed. These issues and fears can be divided into three groups: health, environmental, and social.

Health-related issues

Allergens and toxins

People with food allergies have an unusual immune reaction when they are exposed to specific proteins, called allergens, in food. About 2 percent of people across all age groups have a food allergy of some sort (Abah, Ishaq and Wada, 2010). The majority of foods do not cause any allergy in the majority of people. Food-allergic people usually react only to one or a few allergens in one or two specific foods. A major safety concern raised with regard to genetic engineering technology is the risk of introducing allergens and toxins into otherwise safe foods. The Food and Drug Administration (FDA) checks to ensure that the levels of naturally occurring allergens in foods made from transgenic organisms have not significantly increased above the natural range found in conventional foods. Transgenic technology is also being used to remove the allergens from peanuts, one of most serious causes of food allergy.

Antibiotic resistance

Antibiotic resistance genes are used to identify and trace a trait of interest that has been introduced into plant cells. This technique ensures that a gene transfer during the course of genetic modification was successful. Use of these markers has raised concerns that new antibiotic resistant strains of bacteria will emerge. The rise of diseases that are resistant to treatment with common antibiotics is a serious medical concern of some opponents of genetic engineering technology.

The potential risk of transfer from plants to bacteria is substantially less than the risk of normal transfer between bacteria, or between humans and the bacteria that naturally occur within human alimentary tracts. Nevertheless, to be on the safe side, FDA has advised food developers to avoid using marker genes that encode resistance to clinically important antibiotics.

Environmental and ecological issues

Potential gene escape and superweeds

There is a belief among some opponents of genetic engineering technology that GM crops might cross pollinate with related weeds, possibly resulting in "superweeds" that become more difficult to control. One concern is that pollen transfer from glyphosate-resistant crops to related weeds can confer resistance to glyphosate. While the chance of this happening, although extremely small, is not inconceivable, resistance to a specific herbicide does not mean that the plant is resistant to other herbicides, so affected weeds could still be controlled with other products.

Some people are worried that genetic engineering could conceivably improve a plant's ability to "escape" into the wild and produce ecological imbalances or disasters. Most crop plants have significant limitations in their growth and seed dispersal habits that prevent them from surviving long without constant nurture by humans, and they are thus unlikely to thrive in the wild as weeds.

Impacts on "nontarget" species

Some environmentalists maintain that once GM crops have been released into the environment, they could have unforeseen and undesirable effects. Although transgenic crops are rigorously tested before being made commercially available, not every potential impact can be foreseen. GM corn, for instance, produces a very specific pesticide intended to kill only pests that feed on the corn. In 1999, however, researchers at Cornell University found that pollen from GM corn could kill caterpillars of the harmless Monarch butterfly. When they fed Monarch caterpillar milkweed dusted with GM corn pollen in the laboratory, half of the larvae died. But follow-up field studies showed that under real-life conditions Monarch butterfly caterpillars are highly unlikely to come into contact with pollen from GM corn that has drifted onto milkweed leaves—or to eat enough of it to harm them.

Insecticide resistance

Another concern related to the potential impact of agricultural biotechnology on the environment involves the question of whether insect pests could develop resistance to crop-protection features of transgenic crops. There is fear that large-scale adoption of GM crops will result in rapid build-up of resistance in pest populations. Insects possess a remarkable capacity to adapt to selective pressures, but to date, despite widespread planting of GM crops, no GM tolerance in targeted insect pests has been detected.

Loss of biodiversity

Many environmentalists, including farmers, are very concerned about the loss of biodiversity in our natural environment. Increased adoption of conventionally bred crops raised similar concerns in the past century, which led to extensive efforts to collect and store seeds of as many varieties as possible of all major crops. These "heritage" collections in the USA and elsewhere are maintained and used by plant breeders. Modern biotechnology has dramatically increased our knowledge of how genes express themselves and highlighted the importance of preserving genetic material, and agricultural biotechnologists also want to make sure that we maintain the pool of genetic diversity of crop plants needed for the future. While GM crops help ensure a reliable supply of basic foodstuffs, U.S. markets for specialty crop varieties and locally grown produce appear to be expanding rather than diminishing (Abah, Ishaq and Wada, 2010). Thus the use of genetically modified crops is unlikely to negatively impact biodiversity.

Social issues

Labeling

Some consumer groups argue that foods derived from genetically engineered crops should carry a special label. In the USA, these foods currently must be labeled only if they are nutritionally different from a conventional food.

CHALLENGES FOR DEVELOPING COUNTRIES LIKE NIGERIA

(1) There is an urgent need for clear priorities to invest in biotechnology. This requires that developing countries like Nigeria should identify specific areas or technology trajectories in which to invest to meet specified goals and to utilize the available skills and resources optimally.

(2) Another crucial area of need is to ensure availability of finances for biotechnology research and development. Current investment in this area is not sufficient. This could be done by forging strategic alliances with the private sector, ensuring that the public good of availing food to all is not compromised by profit motivation.

(3) A responsible management of biotechnology should be established as a pre-requisite for sustainable agricultural development and it requires that effective regulation for bio-safety and food-safety are established wherever transgenic crops are to be developed and released.

(4) Developing countries should also consider the role of intellectual property rights and their impact on the acquisition, development and diffusion of biotechnology.

CONCLUSION

Modern agricultural biotechnology is one of the most promising developments in modern science. Used in collaboration with traditional or conventional breeding methods, it can raise crop productivity, increase resistance to pests and diseases, develop tolerance to adverse weather conditions, improve the nutritional value of some foods and enhance the durability of products during harvesting or shipping. With reasonable biosafety regulations and appropriate policies, this can be made accessible to small-scale farmers with little or no risk to human health and the environment. Therefore, in a world where the consequence of inaction is death of thousands of children, we must not ignore any part of a possible solution, including agricultural biotechnology.

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