Food Security and Biotechnology in Africa

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MODULE 3: PUBLIC RESPONSE TO THE RISE OF BIOTECHNOLOGY

UNIT 1; Introduction to Biotechnology (3 hrs)

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INTRODUCTION

According to Ruttam (2005), prior to the beginning of the twentieth century, almost all increases in crop and animal production was as a result of increases in the area cultivated or in the number of animals. Before the end of the century, almost all increases were due to increased land (and animal) productivity.

This was a period of transition from natural resource based to a science based system of agricultural production. The transition started in the developed countries in the latter part of nineteenth century, in most of the developing countries in the second half of the twentieth century. However, for some very poor countries, the transition has not yet begun. In this category belong almost all the countries of Sub Saharan Africa and some Caribbean and South East Asian countries.

By 1960s, when new perspectives informed by both agricultural science and economics were emerging, it was becoming imperative that much of the development in agriculture was becoming location specific. This trajectory has not changed, instead the productivity gap between science based agricultural economies and those apparently left out is widening. Techniques developed in developed countries were not directly transferable to less developed countries with dissimilar climate and resource endowment. Most of the producers in the developing countries are peasants with limited resources, both technical and economic, and thus very constrained in their efforts to improve agricultural outputs. The principal sources of high productivity in modern agriculture are reproducible resources consisting of particular material inputs and skills including other capabilities required to use such inputs successfully.

During the second half of the twentieth century, world population more than doubled. From 2.5 billion in 1950s, it went to 6.0 billion in the year 2000. The accompanying demands placed on global agricultural production arising out of the population and income growth almost tripled. By 2050, world population is projected to grow to between 9 to 10 billion with most of the growth expected to occur in poor countries where even moderate income growth combined with projected population growth could nearly double the demands placed on the worlds farmers by 2050 (United Nations, 2001). The leading resources and environmental constraints faced by the world's farms include soil loss and degradation, water logging and salinity, the co-evolution of pests, pathogens and hosts, and lately, the impact of climate change. The problems associated with pest control in farmlands have become increasingly serious in-spite of advances in pest control technology. Major agricultural pests include pathogens, insects and weeds. Earlier, much of the pest control efforts were in the application of chemicals. A fundamental problem in the efforts to develop methods of control for pests is that the control results in the evolutionary selection pressure for the emergence of organisms that are resistant to the control technology (Palumbi, 2001). It is estimated that the constraints posed by pest and pathogen control to sustainable agricultural growth is higher than those posed by both water and land.

Among the scientific breakthroughs in the twentieth century, advances in molecular biology and genetic engineering appear to be outstanding in addressing the constraints of global sustainable agricultural developments. Trans-genetically modified crops particularly maize, soybeans, and cotton, have diffused rapidly since they were first introduced in the mid-1990s. The applications of this technology currently available in the field are primarily in plant protection and animal health. Specific innovations include development of crop varieties that incorporate resistance to bollworm resulting in the reduction in the applications of chemical control from 8-10 to 1-2 spray applications per season (Nelson, 2000). These advances are enabling producers to raise crop and animal yields closer to their genetically endowed potentials though within the biological yields achieved by employing other methods of crop development based on Mendelian genetics. Armed with the gospel of reduced pesticide application that benefits both the farmers by reducing costs and reducing the risks of poisoning to people involved in pesticide sprays, improved crop yield and cash returns; and other environmental benefits, this would appear to be the innovation of the century.

Progress in the applications of genetic engineering in the overall development of agriculture especially in the developing world where the innovation appears to be much more needed is currently constrained by concerns about the potential health and environmental impacts of genetically modified plants and foods. Unfortunately, one of the outcomes of these concerns is the shift in the development of this innovation in favour of industrial and pharmaceutical applications. This will definitely delay the development of productivity enhancing biotechnology applications and agricultural developments in less developed economies. Two outstanding features of this innovation are the high precision of its application and overt involvement of private concerns in its development.

The scientific foundations for the Gene Revolution as the innovation in gene technology is called, were established roughly a century after the comparable foundation for the Green Revolution. Gene Revolution products use ‘genetic engineering’ techniques. This technology is characterized by considerable controversy over food safety and consumer and political resistance to genetically modified organisms (GMOs). The proposed benefits of agricultural biotechnology could dramatically increase crop yield and quality, eliminate dependence on costly chemical inputs and ease the present burden on the rural environment caused by high level of pesticides and fertilizer use. Conversely, biotechnology development may result in environmental catastrophe and irreversible damage to earth’s ecology. It is equally feared that once allowed to escape the laboratory, genetically engineered organisms could upset the fragile balance of the environment in ways unforeseeable and possibly unpreventable. Two sides of a coin, caution and balance are needed in harnessing the potential benefits the innovation has to offer in global agriculture.

Definitions and general characteristics of biotechnology

It is the aim of this unit to introduce biotechnology and its features and relationship with agricultural production system. What is the genesis and trajectory of public concerns and responses to adoption and utilization of the biotechnology in agriculture? How have the societal responses /concerns affected adoption and utilization of the technology for food production / agriculture in various cultures and societies?

Biotechnology is thousands of years old with its oldest forms shown in domestication of plants more than 8000 years ago, use of yeast in fermentation and production of wine and beer in the 11th century; other traditional and indigenous fermentation processes for which historical records do not exist, etc. However, the fore runner of modern biotechnology was the elucidation of the double helical structure of Deoxyribonucleic acid (DNA) in 1953 and subsequent understanding of how heredity works. This equipped researchers with knowledge of how genetic information could be inserted, changed, or deleted within a host organism in order to create a different organism with different characteristics (Committee on National strategy for biotechnology in agriculture, NRC, agricultural biotechnology, strategies for competitiveness at 23; 1987). Gene transfer technology allows researchers to achieve results with greater accuracy, speed, precision and reliability.

Biotechnology defined: This is defined as a set of tools that use living organisms (or parts) of living organisms to make or modify products for specific uses. Technically, the UN defines biotechnology as the use of living systems and organisms to develop or make products, or "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use" (UN Convention on Biological Diversity, Art. 2).

Biotechnology is the integrated use of biochemistry, microbiology, and engineering sciences in order to achieve technological (industrial) application of the capabilities of micro-organisms, cultured tissue cells." (*European Federation of Biotechnology*).

"Biotechnology is the controlled use of biological agents, such as microorganisms or cellular components."(*US National Science Foundation*)

Biotechnology in the broad sense is not a discrete technology. It is a collective term that refers to a wide range of useful, enabling agricultural, industrial and medical technologies that includes, but not limited to genetic modification and manipulation that have wide applications in research and commerce. Biotechnology has been practiced by human society since the beginning of recorded history in activities such as brewing, baking and the production of fermented foods such as yoghurt and cheese. These technologies that utilize living organisms such as microbes, plants or animals, or parts of living organisms, such as cells or proteins have, over the past several decades, become totally integrated into the practice of plant and animal breeding and microbiology. They encompass advances in biology, genetics and biochemistry to technical and industrial processes as diverse as fish farming, drug development, forestry, crop development and fermentation. Although the term biotechnology refers to a much older and broader range of technologies, the techniques of genetic engineering are of such importance that the two terms have become virtually synonymous.

Historically, people were using biotechnology techniques thousands years before but they did not named their working field as biotechnology. The name biotechnology was given by Hungarian engineer Karoly Ereky in 1919 to describe a technology based on converting raw materials into a more useful product.

The ancient Egyptians made wine using fermentation techniques based on an understanding of the microbiological processes that occur in the absence of oxygen.

Egyptians also applied fermentation technologies to make dough rise during bread-making. Due in part to this application, there were more than 50 varieties of bread in Egypt more than 4,000 years ago.

- In wetter parts of the Nile Valley, Egyptians also bred geese and cattle to meet their society's nutritional and dietary needs.
- Yogurt was made at homes but the reason of the conversion of milk into yogurt was unknown to old people. Later researches showed that yogurt is made due to the action of bacteria added to milk; which is also biotechnology as it uses beneficial micro-organism.
- People have used selective breeding to improve production of crops and livestock to use them for food. In selective breeding, organisms with desirable characteristics are mated to produce offspring with the same characteristics. For example, this technique was used with corn to produce the largest and sweetest crops.

Modern biotechnology

The Second World War became a major impediment in scientific discoveries. After the end of the second world war some, very crucial discoveries were reported, which paved the path for modern biotechnology and to its current status.

- In 1953, JD Watson and FHC Crick for the first time cleared the mysteries around the DNA as a genetic material, by giving a structural model of DNA, popularly known as, ‘Double Helix Model of DNA’. This model was able to explain various phenomena related to DNA replication, and its role in inheritance.

 Dr. Hargobind Khorana was able to synthesize the DNA in test tube, while Karl Mullis added value to Khorana's discovery by amplifying DNA in a test tube, thousand times more than the original amount of DNA.
 Using this technological advancement, other scientists were able to insert a foreign DNA into another host and were even able to monitor the transfer of a foreign DNA into the next generation.
 In 1997, Ian Wilmut an Irish scientist, was successful to clone a sheep and named the cloned sheep as ‘Dolly’.
 In 2003, the Human Genome Project completes sequencing of the human genome.
 In 1978, Boyer was able to isolate a gene for insulin(a hormone to regulate blood sugar levels) from human genome using biotechnology. He then inserted it into bacteria, which allowed the gene to reproduce a larger quantity of insulin for diabetics.

Modern biotechnology provides breakthrough products and technologies to combat rare diseases, reduce our environmental footprint, feed the hungry, use less and cleaner energy, and have safer, cleaner and more efficient industrial manufacturing processes.

Fields in biotechnology

Famous biotechnological fields are:

1) Genetic engineering

Genetic engineering, also called genetic modification, is the direct manipulation of an organism's genome using biotechnology. Genes are the chemical blueprints that determine an organism's traits. Moving genes from one organism to another transfers those traits. Through genetic engineering, organisms can be given targeted combinations of new genes, and therefore new combinations of traits that do not occur in nature and, indeed, cannot be developed by natural means. Such an approach is different from classical plant and animal breeding, which operates through selection across many generations for traits of interest.

2) Tissue culture

Tissue culture, a method of biological research in which fragments of tissue from an animal or plant are transferred to an artificial environment in which they can continue to survive and function. The cultured tissue may consist of a single cell, a population of cells, or a whole or part of an organ. Cells in culture may multiply; change size, form, or function; exhibit specialized activity (muscle cells, for example, may contract); or interact with other cells.

3) Cloning

Cloning describes the processes used to create an exact genetic replica of another cell, tissue or organism. The copied material, which has the same genetic makeup as the original, is referred to as a clone. The most famous clone was a Scottish sheep named Dolly.

There are three different types of cloning:

- Gene cloning, which creates copies of genes or segments of DNA
- Reproductive cloning, which creates copies of whole animals
- Therapeutic cloning, which creates embryonic stem cells. Researchers hope to use these cells to grow healthy tissue to replace injured or diseased tissues in the human body.

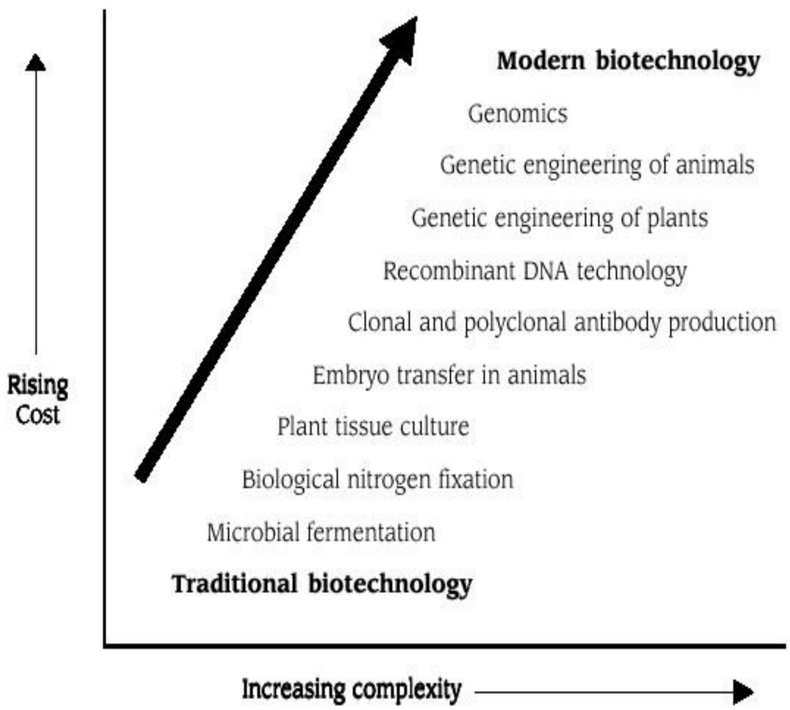
Impact of Biotechnology

Biotech is helping to heal the world by harnessing nature's own toolbox and using our own genetic makeup. Biotech improves crop insect resistance, enhances crop herbicide tolerance and facilitates the use of more environmentally sustainable farming practices. Essentially from an agricultural, food and environmental perspective, biotechnology is:

- Improving manufacturing process efficiency
- Reducing use of and reliance on petrochemicals;
- Using biofuels to cut greenhouse gas emissions
- Decreasing water usage and waste generation
- Generating higher crop yields with fewer inputs;
- Lowering volumes of agricultural chemicals required by crops-limiting the run-off of these products into the environment;
- Using biotech crops that need fewer applications of pesticides
- Developing crops with enhanced nutrition profiles that solve vitamin and nutrient deficiencies;
- Producing foods free of allergens and toxins

Developments in the trajectory of biotechnology are shown in figure 1 below.

Figure 1 Gradient of Biotechnologies



Source: Persley (1990) and Doyle and Persley (1996).

Agrochemicals, Types, Uses and Limitations

The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others. Among these, organochlorine (OC) insecticides, used successfully in controlling a number of diseases, such as malaria and typhus, were banned or restricted after the 1960s in most of the technologically advanced countries. The introduction of other synthetic insecticides – organophosphate (OP) insecticides in the 1960s, carbamates in 1970s and pyrethroids in 1980s and the introduction of herbicides and fungicides in the 1970s–1980s contributed greatly to pest control and agricultural output. Ideally a pesticide must be lethal to the targeted pests, but not to non-target species, including man. Unfortunately, this is not the case, so the controversy of use and abuse of pesticides has surfaced and has grown with introduction any new pesticides. The uncontrolled use of pesticides resulting in abuse has caused more problem than was initially envisaged. This has also led to public outcry and the banning of their use in many countries /regions of the world. The pattern of pesticide use varies among countries as dictated by the planned benefits. In some countries insecticides are more in use while in others especially for agricultural purposes, herbicides are utilized more. Generally, fungicides are used less than either herbicides or insecticides.

Tremendous benefits have been derived from the use of pesticides in forestry, public health and the domestic sphere and, of course, in agriculture, a sector upon which the economy of African countries depend. Pesticides have been an integral part of the processes involved in improving crop yields by reducing losses from the weeds, diseases and insect pests that can markedly reduce the amount of harvestable produce. Warren (1998) also drew attention to the spectacular increases in crop yields in the United States in the twentieth century. Webster *et al.* (1999) stated that "considerable economic losses" would be suffered without pesticide use and quantified the significant increases in yield and economic margin that result from pesticide use. Thus, for agricultural purposes, pesticides are utilized in the following ways;

i. **Protection of crop losses / yield reduction**

In medium land, rice even under puddle conditions during the critical period warranted an effective and economic weed control practice to prevent reduction in rice yield due to weeds. Severe infestation of weeds, particularly in the early stage of crop establishment, ultimately accounts for a yield reduction of 40%. Herbicides provided both an economic and labour benefit. With the appropriate use of herbicides, there is bigger harvest that translates to higher income and, easier weed control that translates to labour saving.

ii. Vector disease control

Vector-borne diseases are most effectively tackled by killing the vectors. Insecticides are often the only practical way to control the insects that spread deadly diseases such as malaria, resulting in an estimated 5000 deaths each day (Ross, 2005). Disease control strategies are crucially important also for livestock. Consequent upon weed control by the use of pesticides is the increased production of fruits and vegetables that have generally contributed to improved health of people by reducing incidences of cancer, high blood pressure, heart disease, diabetes, stroke, and other chronic diseases.

Limitations / hazards of Pesticides

The realization that persistent chemicals could be both uncontrollable and unexpectedly toxic is attributed to Rachel Carson (1962). From 1940s to 1960s, organochlorine pesticides, including DDT (Dichloro-Diphenyl trichloroethane) saw widespread use in the USA especially in agriculture and forestry. Its production and use has been banned since 1972 and similar policies against other organochlorine compounds have been enacted. Health risks associated with pesticide use include;

Pancreatic cancer; Exposure to technical grade DDT was associated with increased risk of pancreatic cancer with risk increasing with length of exposure.

Non –Hodgkin's Lymphoma; DDT is also associated with increased risk of this class of cancer. It is also associated with incidents of breast cancers.

The beneficial effects of pesticides in promoting yield increases and reduction of vector borne diseases appear in some cases to cancelled out by the health and environmental implications.

There is now overwhelming evidence that some of these chemicals do pose a potential risk to humans and other life forms and also present unwanted side effects to the environment (Forget, 1993). The annual world-wide deaths and chronic diseases rates due to pesticide poisoning number about 1 million per year (Environews Forum, 1999). The high risk groups exposed to pesticides include production workers, formulators, sprayers, mixers, loaders and agricultural farm workers. OC compounds could pollute the tissues of virtually every life form on the earth, the air, the lakes and the oceans, the fishes that live in them and the birds that feed on the fishes (Hurley *et al*., 1998). The US National Academy of Sciences stated that the DDT metabolite DDE causes eggshell thinning and that the bald eagle population in the United States declined primarily because of exposure to DDT and its metabolites (Liroff, 2000). Certain environmental chemicals, including pesticides termed as endocrine disruptors, are known to elicit their adverse effects by mimicking or antagonising natural hormones in the body and it has been postulated that their long-term, low-dose exposure is increasingly linked to human health effects such as immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer (Brouwer *et al*., 1999). Health surveillance of personnel engaged in the manufacture of these pesticides revealed a high occurrence of generalised symptoms (headache, nausea, vomiting, fatigue, irritation of skin and eyes) besides psychological, neurological, cardio-respiratory and gastrointestinal symptoms coupled with low plasma ChE activity (Gupta *et al*., 1984). These health risks of the once thought risk free means of improving food production led to their being either banned or reduction in usage. As a matter of fact, some of the innuendoes against biotechnology are fallout from the disappointment of pesticides with people thinking that same fate will meet the new innovation.

The early involvement of multinational corporations that were engaged in the manufacture of pesticides in the research and development on biotechnology did so with the hindsight of economic and politics of global food production.

Genetic Engineering

Within the past few decades, growth in the field of agricultural biotechnology was facilitated by the understanding that hereditary materials composed of the Deoxyribonucleic acid (DNA) situate in in the chromosomes in the nucleus. Genetic engineering is one of the biotechnological tools based on Recombinant DNA technology. The word genetic engineering can be interchanged with gene technology, genetic modification or gene manipulation. It refers to the process by which the genetic makeup of an organism can be altered using recombinant DNA technology. This technology involves using laboratory tools and specific enzymes to cut, insert, and alter pieces of DNA that contain one or more genes of interest. The capability to manipulate individual genes and to transfer genes between species that would not readily interbreed is what differentiates genetic engineering from conventional breeding. Transgenic (gene transfer between species) applications involve the modification of the genetic structure of one organism through the insertion of a gene from another organism and can be used to modify plants, animals and microorganisms. A gene is a biological unit that determines an organism's inherited traits. This process of modification is called genetic recombination because it adds traits that the original organism did not have. The resultant organisms are referred to as genetically modified or genetically engineered or living modified organisms (LMOs). These organisms have been genetically modified in a way that does not occur naturally. Genetic engineering allows gene transfer between un-related species. As a result, a genetically engineered organism contains additional or modified traits encoded by the introduced gene.

The first reported successful genetically engineered plant was when an antibiotic resistance gene was inserted into a tobacco plant (Horsch et al., 1984)). Also, the first genetically engineered (GE) food approved for human consumption was the so called Flavr-Savr tomato produced by the Californian Company, Calgene with an endowed rotting (senescence) resistance. The main traits introduced into commercialized food products from GE crops are herbicide resistance /tolerance and insect resistance. These have brought about many positive farm impacts. These have been found to be more environmentally benign than the weed management strategy it is replacing leading to substantial reduction in contamination of ground water, soil and air. It offers many more benefits to agriculture. However, it should be noted that the costs, risks and the controversies of the technology rage. Genetic engineering is a very recent technology.

GENETICALLY MODIFIED ORGANISMS

Genetic modification provides major benefits over traditional methods. First, the development of new varieties can be accelerated. Modification of genes can be more specific and controlled than is the case with conventional mutation and breeding methods. Also, genes from other species or varieties can be inserted to produce particular advantages. The resultant organisms from genetic recombination are called genetically modified organisms or living modified organisms. Modified non living products such as drugs, vaccines and food additives, may also be produced by genetic engineering. Genetic modification can be used to improve livestock, poultry and fish productivity in addition to their resistance to diseases. Crops can be genetically modified to improve appearance, taste, nutritional quality, drought resistance, and insect and disease resistance. Thus GM crops are usually held up as the solution to yield deficits.

FOOD SAFETY

Presently, there is no study that has shown that any of the available GM foods are any less safe than their non-modified counterparts. This does not however, mean that all products of biotechnology are entirely risk free making regulation mandatory. There are controversies surrounding GM foods on several levels including whether food produced with it is safe, whether and how it should be labelled etc. Health risks associated with GM foods are concerned with allergens, toxins, and genetic hazards. The mechanisms of genetic hazards fall into three categories; the expression of inserted genes and their expression products, secondary and pleiotrophic effects of gene expression and the insertional mutagenesis resulting from gene integration. Due attention should be taken for foods engineered with genes from foods that commonly cause allergies, such as milk, eggs, nuts, wheat, legumes, fish, molluscs, and crustacean (Maryanski, 1997). Also, any potential risk, immunological, allergenic, toxic or genetic, could be recognized and evaluated if health concerns occur. More concerns come with secondary and pleiotrophic effects. Many transgenes encode an enzyme that alters biochemical pathways. This could cause an increase or decrease in certain biochemicals. Insertional mutagenesis can disrupt or change the expression of existing genes in a new host organism. Random insertion can cause inactivation of endogenous genes, producing mutant plants. Of concern is the possible up regulation of naturally silent or low expressed genes. This is due to the fact that it is possible to activate genes that encode for enzymes in biochemical pathways towards the production of toxic secondary compounds (Conner and Jacobs, 1999). This becomes a big issue when the new protein or toxic compound is expressed in the edible portion of the plants, so that the food is no longer substantially equivalent to its traditional counterpart.

FOOD SECURITY

The spectre of food crisis raises important questions about future directions for agriculture including involvement of new innovations like biotechnology in global agriculture. As proposed by the proponents of this technology, it has the key to unchain certain constraints to crop output, crop quality and poverty alleviation.

Facts to consider: Currently, more than enough food to feed world population of about 7 billion people is produced. However, about one in six people in developing countries suffer from chronic hunger. The scenario is made more worrisome by some global demographic dynamics. For instance, the world population is projected to increase to over 9 billion people by the year 2050and nearly all of this increase will be in the developing countries. In addition, the on-going rural city migration is to continue such that by 2050 about 70% of the world population will be urban relative to 50% today. Moreover, income rise are also expected to continue with consequent changes in the dietary habits towards more protein, vegetable and animal product based diets instead of the current carbohydrate based one that predominated in the developing countries. With this larger, more urban and, on average richer population, it is expected that the global demand for food in 2050 may be 70% more than today (FAO, 2009a). Climate change is real and affects the frequency of extreme weather events, alters agricultural growing patterns as well as the distribution patterns of pest, weeds and diseases that threaten crops and animals. The overall impacts of climate change on agriculture and food security are expected to be increasingly negative.

Food Security Defined: According to Food and Agricultural organization (FAO) of the United Nations, food security exists when all people at all-times have physical or economic access to sufficient, safe and nutritious food that meet their dietary needs and food preferences for an active and healthy life (FAO, 1996).

There are four facets of food security from the above definition; **availability of food**, **access to food**, **utilization of food** and **food system stability**. The first focus area is availability of good quality and nutritious food from local, regional, international sources. Although the challenges are great, there are solutions and agriculture is the key. This is because agriculture accounts for about 30% of the GDP in agriculture based countries and for 50% of employment most developing countries. These countries which represent about 80% of the world's population are home to about 500 million small farms, supporting about two billion people. Moreover, three out of every four people live in rural areas, and most depend on agriculture for their subsistence. Promoting agriculture in developing countries is therefore the key to achieving food security. Following FAO (2009a), four areas are mapped out for executing this; Increasing investment in agriculture, broadening access to food, improved governance of global trade and increasing productivity and conservation of natural resource base.

Increasing the productivity of small holder farmers, fishers and foresters through appropriate application of good practices and improved technologies should be priority for developing countries intending to achieve food security. Increased productivity should be achieved while at the same time conserving the natural resource base upon which future productivity increases depend. To increase productivity, the suit of technological options for farmers should be as broad as possible, including those used to improve water management in irrigated and rain fed production systems, save labour, reduce post-harvest losses and improve natural resource management, increasing soil fertility and integrated pest management.

The suit of technological options should also include agricultural biotechnologies including conventional plant breeding, tissue culture and micro-propagation, marker assisted selection, genetic engineering and molecular diagnostic tools. Biotechnology also offers important tools for the diagnosis of plant diseases of both viral and bacterial origin, and immune-diagnostic techniques as well as DNA-based methods. In addition, biotechnology tools such as molecular markers, cryopreservation and in vitro slow growth storage are extensively used for the characterization and conservation of plant genetic resources (FAO, 2011b)

CAUSES OF THE CURRENT RISE IN BIOTECHNOLGY

The four thematic pillars of the recently launched Comprehensive Africa Agriculture Development Programme (CAADP) for investment and action in pursuing increased and sustainable productivity in agriculture, forestry, fisheries and livestock management, like the highlights of the world food summit, is aimed at addressing world food situation in the African continent. One of the key emphases in realizing the objectives of this programme among other issues is the application biotechnology for improved sustainable food production. It is aimed at reducing cases of food insecurity either in African sub region or globally.

The world population currently is about seven billion with its associated implication on natural resource. The African population of around one billion (15% of the world population) is growing at a faster rate than any other region of the world. A major global concern is how to feed this growing population while at the same time preserving the environment and promoting socio-economic development. Food insecurity prevails, even in developing countries with food surpluses. One proposed solution, redistribution of surpluses among and within countries poses serious practical and political challenges. Food aid programmes and efforts towards land reform have achieved much and should continue. However, improving the productivity of small farms is by far the best means of achieving a substantial reduction of food insecurity and poverty (Nuffield Council, 2011). In Africa south of the Sahara, more land is continually being brought into agricultural use. However, these increases threaten the natural rich biodiversity of the sub-region. This sustainability challenge demands that agricultural production per hectare should increase to meet the needs of the population, but at the same time this needs to be done in a way that preserves the environment for future generation. The current agricultural system in most of the developing countries is far from meeting the criteria for sustainability. The organic farming lobby suggests that the organic route is the best way to achieve sustainability with total disregard for biotechnology. However, yields from organic farming are low, indicating that more pristine land need to be brought into cultivation to feed the population with associated natural biodiversity loss. A study in UK showed a 55% drop in yield on organic farms compared with conventional farms, whereas there was only 12.5% increase in biodiversity. The increase in biodiversity would therefore be rapidly offset by the need to cultivate more land for the same production output.

The best aspects of agricultural technology need to be harnessed to address the challenges of increased productivity with sustainability. Modern biotechnology, including genetic modification technology represents one of the tools that can play a significant role in this endeavour with a little tinkering to meet the requirements and needs of the developing countries. Biotechnology appears to be attractive on basis of several promises including but not limited to agricultural sustainability, improved crop yield and income to the farmer, enhanced safety to the pesticide applicator, less expenses on pesticide purchases and promotion of biodiversity from reduced application of pesticides. Biotechnology also holds strong attraction in matters related to enhanced nutrient quality of foods as in bio-fortification with Vitamin A and iron, enhancement of amino acid and long chain fatty acids content among others.

Biotechnology as an advancement in food production technology is meant to address some of the shortcomings of green revolution of mid 1960s in addressing food security issues. The technology was capital intensive and therefore deemed unsustainable with high inputs in machineries, irrigation, fertilizers and good soil. Secondly green revolution was mostly about rice and wheat. Thirdly, the productivity gains using the traditional breeding techniques have apparently been exhausted even for rice and wheat. In addition, because of the strong link between agricultural growth and performance in the rest of the economy, overall economic growth has slowed down as well (Timmer C.P, 2003).

The current rise in biotechnology is attributed to the role potential and actual role that biotechnology is meant to play in food security. Food security does not depend only on the availability of food but also its nutritional quality. Unfortunately, poorest people in the world generally rely on a monotonous staple diet and since most plants are deficient in certain vitamins, minerals, and essential amino acids, a diet restricted to one major staple will tend to be nutritionally deficient. Biotechnology growth can be considered from the following perspectives.

General yield advances, especially for key food crops which can stimulate agricultural growth and lower food prices. Biotechnology can improve crop yields via insect protection, drought resistance.

Secondly, productivity gains for agricultural systems in degraded and hostile environment can be achieved through biotechnology due to the existence of genetic potential that thrive in these environments.

Productivity gains for non-grain crops and livestock are possible from biotechnology and these products have better demand opportunities as incomes increase.

Moreover, genetically modified crops offer the possibility of reduced input use especially pesticides with serious health and biodiversity implications. The potential for biotechnology to contribute to sustainable agricultural systems, through much more efficient utilization of water, nutrients and agrochemicals may be its most important promise in the long run.

The managers and stakeholders in the technology R&D and industry should however, be conscious of the constraints posed to the third world countries to adopt this technology; Scientific and economic developments, as well as politics.

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