Kenya: Biotechnology in Africa: Why the Controversy?

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This is a time of intensive discussions of Africa's agricultural and economic performance, and the potential impact of biotechnology on the economy and the welfare of the continent. The two issues that dominate the debate are the persistent poor performance of agriculture with associated widespread poverty, and the ability of biotechnology to resolve Africa's food crises taking into account its potential and perceived effects on the continent's enormous biological diversity.

Socioeconomic Situation

At a 3.1 percent growth rate, Africa's population was about 200 million 30 years ago; it is 520 million today and is projected to increase to 1.3 billion in the next 25 years. The continent has the highest population growth rate in the world.

Africa's present and growing population makes it difficult to maintain adequate food consumption levels. Although global food production has reached a stage where sufficient food is produced to meet the needs of every person on earth, the per capita food production and availability has, and still remains, lowest in Africa. Western Europe's per capita food availability stands at some 3500 kilocalories/day, those of North America at 3600 kilocalories/day. In sub-Saharan Africa, only 2100 kilocalories are available per person per day making this the lowest level of per capita food availability in the world.

Although Europe and America have large food surpluses, food availability in Africa is far from being adequate for all people to have access to food at all times. The notion that, at the global level, the problem is not one of inadequate food production but of distribution is correct in a statistical sense, but it is trivial and highly misleading. It suggests, for example, that redistribution of static food supplies is the solution to food deficiency, and further, it relegates the need to increase production in regions like Africa to a subsidiary role.

African people find themselves in a condition of inadequate food consumption levels because they do not earn sufficient income to obtain enough food to satisfy their needs. The situation may not necessarily be one of food scarcity but rather the scarcity of income or purchasing power. This in essence is poverty which prescribes undernutrition. Between 55 and 60 percent of the rural people in sub-Saharan Africa are absolutely poor, subsisting on less than US$1 per day. More than 200 million people (over one-third of the African population) suffer chronic undernutrition. Infant mortality in Africa is about 103 in every 1000 compared to 8 per 1000 in high-income countries. Most urban residents spend more than 80 percent of their earnings on food. This leaves very little for spending on human welfare including nutrition, education, and public health. About 32 out of the 48 low-income countries in the world are in sub-Saharan Africa.

Given that the notion of redistribution of the globally abundant food supplies to meet the needs of the poor countries is of more theoretical than practical significance, the proposition is to increase production in the African countries

themselves. A more productive agriculture in these countries should without exception be made an integral part of the process to increase food production. It is with this background that most governments in sub-Saharan Africa have the attainment of food-self sufficiency as their long-term national policy on food production and economic growth. Agricultural improvement to raise food production to "acceptable" levels is an urgent priority for these countries.

Agricultural Performance in Sub-Saharan Africa

Most of the African people earn their living by producing food, and employment and income earning opportunities are closely linked to productive agriculture. In sub-Saharan Africa 50-75 percent of the population and labor force are engaged in agriculture. In 1990, agriculture provided, on average, 32 percent of Africa's GDP, 66 percent employment (for 1987), and about 20 percent of its exports (World Bank 1989, 1992). In this context, agricultural development is critical to present and future economic growth and improvements in the welfare of Africa. Increases in incomes from a productive agriculture are needed to raise food purchasing power and to reduce poverty.

African agricultural growth has been slowing considerably during the last two decades. The annual growth rate fell from 2.3 percent in the 1970s to 2.0 percent in 1980-92. Of the major developing regions of the world, only in sub-Saharan Africa has the per capita food cereals output been declining over the last 30 years.

The stagnation of agriculture in sub-Saharan Africa is due to both internal and external factors. After independence, many African governments were committed to industrialization and to the political support of their urban residents (Lofchie 1987). Exports from agriculture have been heavily taxed to generate the capital for industrialization, thereby reducing incentives for agricultural production. Producer prices for agricultural exports in many countries in the 1980s were generally lower than 50 percent of world prices (World Bank 1986). In addition, a major indirect tax on agriculture has been imposed by overvalued exchange rates. This implicit tax on agricultural exports has been a disincentive to increased agricultural production and exports. With these low agricultural prices and other distortions unfavorable to agriculture such as importation of cheap competing foods, domestic food production has stagnated with farmers retreating from commercial activities to subsistence. There has been little incentive for farmers to invest in new technologies or in other agricultural enterprises. The low profitability has encouraged low productivity, risk avoidance measures including multiple cropping, minimum input use, and extensive agricultural activities based on human labor. The welfare of farmers has been reduced not only by these direct and indirect taxes on their exports, and distortion-reducing prices of competing imports, but also by poor rural marketing systems for industrial and food crops. Policy measures that remove such disincentives and promote productivity are needed.

The external considerations constraining African agricultural performance include a number of biotic and abiotic factors such as shortage of arable land, poor moisture availability, declining soil fertility, limited access to costly farm inputs, limited technological base, and pests and diseases.

Shortage of Arable Land

Past increases in agricultural productivity resulted from an expansion of land under cultivation. Because new arable land is no longer available, intensive techniques provide the best hope for increased production of the principal food crops in Africa.

Inadequate Rainfall

Comprehensive studies of African rainfall have shown a progressive drying trend, with drought a common occurrence over large parts of the continent. The frequent droughts in Africa have often been blamed on human agricultural activity, particularly overgrazing and deforestation. The fact remains that agricultural growth is severely constrained by extensive and severe rainfall shortages. We therefore need to develop crops and livestock breeds that are early maturing and adaptable to the harsh climatic conditions of Africa.

Soil Fertility

The problem of rainfall shortages in many parts of Africa is enormous, and is often compounded by low soil fertility such as in the semi-arid zones where soils tend to be sandy and prone to soil erosion and degradation. These soils lack important nutrients such as sulfur and phosphorus and have low organic matter content. Agricultural production in most parts of Africa therefore requires capital-intensive chemical fertilizer inputs. Fertilizers in Africa are expensive, so farmers use considerably less per hectare than in Europe and America. In 1993 a farmer could purchase 41 kilograms of DAP fertilizer for the price of 90 kilograms of maize. By late 1999 he/she can purchase only 25 kilograms of fertilizer for 90 kilograms of maize. Farmers in Africa therefore use suboptimal levels of fertilizer, averaging 11 kilograms/hectare compared to 90 kilograms/hectare in Asia.

The suboptimal application of fertilizer creates eutrophication of water sources, modified soil structure, and pH changes leaving the soil even more prone to erosion. Organic manure has low nutrient content, so frequent applications are needed. This leads to negative environmental consequences, and associated labor problems. We need to develop new and cheaper agricultural inputs to alleviate the current burden to farmers, and to enhance production.

Pests and Diseases

The devastating effects of plant pests and diseases in Africa is reflected in the amount of resources spent by farmers on their control. In Kenya in 1995, for example, farmers purchased the following agricultural chemicals: 1.36 million kilograms of insecticides, 3.4 million kilograms of fungicides, 113,000 kilograms of plant hormones, and 1.7 million kilograms of herbicides (Kenya 1996), plus large expenses incurred on livestock pest and disease control. Huge crop and livestock losses are incurred in Africa as a result of pre- and postharvest pest and disease damage. The issue of pest and disease resistance in crops and livestock is, therefore, of crucial significance to Africa.

Technological Base

Although area expansion and the use of conventional methods of breeding and agricultural R&D have served African agriculture well in increasing output in the past (for example, in Kenya the production of Katumani Mpya maize, Kenya Mtama sorghum, and rinderpest vaccines), these options can no longer sustain productivity. New intensive production techniques are now needed to augment yields and reduce losses, while conserving the natural resource base. Innovative technologies are urgently needed to transform agricultural growth and development in Africa. Biotechnology offers scope to resolve many of the problems affecting crops and livestock production in Africa.

Role of Biotechnology in Africa

The debate on biotechnology for Africa must be considered in the context of the continent's need for more food and the survival of its people. Biotechnology-derived solutions for biotic and abiotic stresses, if built into African genotypes of plants and animals, could reduce the need for, and the high costs of, agrochemicals and water. New solutions could also reduce the deleterious effects of diseases and weeds, thus promoting sustainable agricultural production in Africa. Several countries, especially South Africa, Kenya, Zimbabwe, and Egypt, are putting in place structures and capacities for R&D in biotechnology. Improvements in productivity are beginning to emerge from the applications of conventional and modern biotechnology.

For example, to address the problems of soil fertility and fertilizer application, for example, a number of countries have embarked on the use of *Rhizobium* inoculant in the production of grain legumes. The application of tissue culture to address constraints of availability to farmers of adequate disease-free planting materials and rapid improvement in crop production, is now commonplace in several countries. In Kenya, for example, the application of tissue culture technology has been initiated in different crops and has resulted in increased production of banana, pyrethrum, potato, cassava, sugarcane, and

flowers, most of which have become commercial enterprises. The demand for such materials is demonstrably high, and the changes at the household income levels of growers are becoming increasingly noticeable.

The use of DNA-based molecular markers is now applied in various forms to construct linkage maps of different species. This helps locate particular genes of relevance to the rapid improvement of crop and livestock breeding in Africa. Mapped markers are useful in speeding up selection of traits for use in conventional cross-breeding procedures. These techniques are applicable to many African crop improvement programs such as those seeking to enhance resistance to diseases (for example, maize streak virus) or to generate tolerance to insect pests and drought conditions. Specific programs and capacities in this field are rapidly emerging in Kenya and Zimbabwe, to address resistance to maize stem borer and drought tolerance.

The relevance of genetic modification to produce transgenic crop varieties with resistance to pesticides, insects, and diseases cannot be ignored, given the prohibitive costs to farmers of agricultural chemical inputs and yield losses. Improved food security, poverty alleviation, and environmental conservation in Africa will be enhanced using crops that have a high yield, and resistance to pesticides, insects, and diseases. Great strides are being made in the use of genetic engineering in Africa. Tangible examples include Kenya's virus-resistant transgenic sweet potato project, which is under development with Monsanto Company of the United States, Egypt's transgenic potato, maize, faba bean and tomato developments, and South Africa's new tobacco and cotton varieties with resistance to herbicides.

Recombinant animal vaccines have considerable application in Africa to combat rampant and devastating livestock diseases such as rinderpest and Rift Valley fever. Not only can such vaccines be produced inexpensively, but they also offer the advantages of multiple protection, low costs, as well as allowing the easy distinction between vaccinated and naturally infected animals. This feature is highly desirable in Africa with respect to livestock export to industrial countries, and in continental disease eradication efforts.

Although not exclusively DNA-based, plant and animal disease diagnostic kits, based on the products of biotechnology such as monoclonal antibodies and recombinant antigens, are important modern agricultural applications relevant to Africa. There are important economic implications for pathogen monitoring and disease control programs. Many laboratories in Africa are at present involved in the generation and application of these technologies in the study and control of human, animal, and plant diseases, including HIV/AIDS, theileriosis, trypanosomosis, rinderpest, and streak and mosaic viruses of different crops. Biotechnology therefore has tremendous potential in the improvement of agriculture and food production in Africa. There are numerous challenges, however, that need to be addressed if the people and the continent are to benefit in a sustainable way.

Challenges to Biotechnology Use in Africa

Although many initiatives have been taken to put in place structures and mechanisms for development of biotechnology in Africa, major differences exist between countries in relation to the level of application. Countries face a challenge in making decisions about their level of biotechnology. These include: (1) the development of a knowledge base appropriate to decisionmaking in the use of biotechnological approaches; (2) priority setting for biotechnology aimed at solving specific problems of national importance; (3) establishment of policy and regulatory structures for biosafety and intellectual property protection; (4) capacity development for enhancement of the above issues; and (5) establishment of linkage and cooperative mechanisms for biotechnology development, its transfer, and sustainable applications in Africa.

Why the Controversy?

There is overwhelming evidence and knowledge that the needs and drive for biotechnology in Africa are quite different from those of industrial countries. Africa's agenda is based on the urgent needs for technological change to enhance food production and to alter the course of widespread poverty, hunger, and starvation. Industrial coun-

tries are driven by market and profit. These distinctions must be understood and appreciated at the national, regional, and global levels.

The ongoing debate creates fear, mistrust, and general confusion to the public, and has failed to seek the views of African policymakers and stakeholders. The debate about biotechnology for Africa should not be whether or not the continent needs biotechnology, but how biotechnology can be promoted, supported, and applied in safe and sustainable ways that contribute to improved agriculture and to the social and economic welfare of the people of Africa. The need for biotechnology in Africa is very clear, and should not be confused with the marketing/food surplus-driven forces of the industrial countries.

Areas for Collective Consideration

Many countries in Africa face severe reductions in agricultural research funding. Because most biotechnology R&D is more expensive than conventional research, it should be focused on solving priority national or regional problems where it has a comparative advantage. This means that African countries must develop appropriate policies for biotechnology, and mount efforts to identify key national priorities for biotechnology, bearing in mind the needs of the resource-poor who depend on agriculture for their livelihood. This approach should take into account national development policies, private sector interests, market possibilities, technology diffusion mechanisms, and linkages. Diverse stakeholders should be involved in the formulation of national biotechnology policies, strategies, and plans.

The development and application of biotechnology in a safe and environmentally sustainable manner is the subject of considerable debate. Potential environmental hazards from new products of biotechnology, especially genetically improved organisms (GIOs), have raised concerns that, in the absence of adequate legislation and biosafety instruments, some companies may use African countries as test sites for their products, without prior informed agreement by the countries concerned. Appropriate regulatory arrangements need to be in place to help ensure that this does not occur (Doyle and Persley 1996).

The question today should not be whether or not Africa requires biotechnology, but rather how African countries can be assisted to harness and safely apply biotechnology to support development. Egypt, Kenya, South Africa, Zimbabwe, Botswana, Malawi, Mauritius, Cameroon, and Zambia either have or are in the process of adopting explicit biosafety regulations and guidelines, and some are involved in negotiations for an international biosafety protocol. Biosafety frameworks should be accommodative and promotional, rather than prohibitive, advocating the establishment of adequate and sound biosafety regulations, risk assessment and management regimes, and instruments for monitoring use and compliance. What Africa needs most at this time of intense European - American debate on developments and use of GIOs, is the creation of widespread public and policymaker awareness and education on all facets of biotechnology and biosafety. This will enable the countries to make judicious decisions on the path to biotechnology use.

Biotechnology R&D in Africa is presently focused on improving agriculture, with only very few initiatives targeting the ecological impact of GIO development. The greatest effort is still focused on tissue culture application. Over 85-90 percent of the biotechnology R&D in the region is within the public sector, with universities and agricultural research institutions taking on most of the responsibilities. Except for South Africa, local private sector engagement in biotechnology is limited. The private sector is dominant in biotechnology development in industrial countries.

African countries face a compelling need to develop long-term policies on biotechnology that (a) promote national biotechnology needs assessment and targeted research; (b) provide incentives for creation and financing of local private biotechnology enterprises; (c) promote local public R&D of foreign industry partnerships; (d) improve and enhance scientific capacities and technological infrastructure; and (e) integrate biotechnology risk management into existing environmental, health, and agricultural regimes.

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