

A BIOTECHNOLOGY STRATEGY FOR AFRICAN FOOD AND AGRICULTURE

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The present trends in Africa's perpetual food crisis, when viewed in the context of rapid population growth, cause concern as to the capacity of the African agricultural sector to meet present and future food production challenges in the region. Indeed, the food supply position is continuing to deteriorate at an alarming rate in several parts of Sub-Saharan Africa, where around 34 million people are threatened by severe food shortages and famine. All indications point to Sub-Saharan Africa's, already precarious food situation, deteriorating further in the future. Already, deaths from hunger, imminent massive starvation in the months ahead and acute malnutrition, are being increasingly reported in eastern Africa.

According to FAO data, Sub-Saharan Africa's population is predicted to increase, at 3.3 % per annum, to 675 million by the year 2000. The total demand for all food and agricultural products is projected to rise by 3.5 % annually, between 1985 and 2000. In particular, the total demand for cereals, the most widely consumed group of commodities in Africa, is forecast to increase to 100 million tonnes by 2000. This would increase the deficit between domestic supply and demand to 17 million tonnes. The problem of malnutrition is also expected to remain severe, with the number of people in Sub-Saharan Africa below the 1.2 basal metabolic rate increasing from 105 million in 1985, to 137 million in 2000.

These projections and forecasts clearly suggest the nature and magnitude of the food production challenges which African agriculture faces and substantiate the urgent need for determined efforts to combat the chronic food crisis which menaces millions of people. This can be achieved only by increasing agricultural productivity and the production of staple foods. In other words, there is a crucial need to introduce new and flexible systems and technologies to accelerate the environmental and sustainable development of agriculture in Africa.

Can the experiences gained from the technologies of the "green" revolution provide useful lessons for the researchers and policy-makers who are to launch agricultural development in Africa, in order to meet its food self-reliance challenges without prejudicing to the environment? Today, some of those technologies which depend on high-input use have reached their limits and, in many cases, are not sustainable. Environmental degradation, resulting from deforestation, soil erosion and soil and water pollution, which is the result, inter alia, of the excessive and inefficient use of agrochemicals, and the effluents of agroprocessing, is further exacerbating the problem. Despite significant growth in agricultural production during recent decades, millions of people are still suffering from chronic malnutrition and hunger.

This means that African countries should make their own decisions, with the improvement of their food production capabilities, by technologies and agricultural systems, as a primary goal, as to how to increase food production without damaging the environment. Such systems and technologies should take into account the fact that the efficient management and equitable use of Africa's diverse biological resources, with their variety of plants, micro-organisms and the ecological systems of which they are a part, provide the resource-base upon which any development, particularly agricultural development, is dependent.

Although modern biotechnology holds considerable promise to meet these challenges, much of the current biotechnological research and development will not be applied to this end, as it is largely in the hands of transnational corporations which develop products for which there is an assured market and high economic returns. Unfortunately, Africa, with its perpetual food crisis and its serious economic difficulties, lacks the capacity to harness the potential of modern biotechnology. However, the grave food shortages afflicting millions of Africans require an urgent and solemn commitment, on the part of the international financial community, to create this capacity, in order to introduce new and adaptable biotechnology for accelerated food and agricultural development. This report examines the objectives and strategies for the use and development of biotechnology in Africa, in order to improve and increase agricultural productivity and food production on an environmental and sustainable basis.

Objectives for an African Agricultural Biotechnology

Normally, as was done over the last 100 years, improvements in crop production, in the African context, would be by traditional plant-breeding procedures, based on manipulating of the genetic system of plants through sexual reproduction in whole plants. In recent years a technique for genetic manipulation at cellular levels, which has a unique potential for supplementing traditional plant-breeding procedures, has emerged. This technology has been developed from advances in the knowledge of cell culture and molecular biology. It includes a wide range of potentially useful techniques, all of which utilise in-vitro plant cell and tissue culture for the regeneration of functioning plants from tissue fragments, isolated cells, protoplasts or embryonic tissue. The term biotechnology has been applied to this new technology, receiving a great

deal of practical attention in the developed world, a world in which food production has already been made self-sufficient, with enough to eat and to export.

The subject of biotechnology, and its revolutionary capabilities, has captured the imagination of the developed countries. Indeed, governments and the academic, commercial and developmental communities of the developed world are investing large sums of money and human effort in pushing back the frontiers of knowledge, applying the new principles to make new products and developing programmes that utilise those products in projects to benefit the population without damaging the environment.

In the broadest sense, biotechnology is not new. Since numerous biological technologies have been used for hundreds of years, such as fermentation in the production of wine, the leavening of bread through the action of yeast and the improvement of plants or animals by selecting superior individuals and using them to propagate the next generation, or to crossbreed with existing individuals to produce improved offspring. The scientific understanding of biological constraints has been extended, and the potential for food production goes far beyond the Malthusian limits conceived by the preceding century's demographers.

Rather than biotechnology being defined within the narrow context of recombinant DNA and bio-processing techniques, it should be considered as any biological technique that uses living organisms, or substances from those organisms, to make or modify a product, to genetically improve plants or animals or to develop micro-organisms for specific uses. Within this definition a continuum of technologies is included in biotechnology, ranging from the long-established use of living organisms in brewing and biological control and the production of vaccines and cell growth regulators, to cell regeneration and recombinant DNA techniques for the genetic improvement of micro-organisms, plants and animals.

The main objective of Biotechnological application in African countries may well be to increase food production. But because of international economic influences, coupled with environmental and social constraints, these objectives must be pursued within the total context of a country's needs and resources. Three main objectives for biotechnology seem to encompass all the main reasons for engaging in agricultural research and development in Africa.

The first is to improve productivity. By improving the yield potential of a product or crop, it may be possible to raise production above the amount currently obtained, thus gaining a return on investment for research and development while still utilising the same levels of land, manpower and resources. In the scale of importance for African countries, increasing yield is the highest priority, especially in stressed environments where existing crop and animal yields are restricted by an unfavourable environment. Biotechnology is already being used to develop new and higher quality food, crops with greater stress-tolerance and new uses for agricultural commodities.

The second priority is to improve quality. By improving the quality of an existing product, it may be possible to increase production or improve its content and uniformity of constituents. Whatever the improvement strategy, the end result must be to increase consumer preference for improved products. Quality is essential if products from developing countries are to compete in world markets.

The third priority is to reduce the cost of production. This can be done by improving internal biological efficiency, increasing the ability of the organism to function in existing and marginal production environments, or improving the efficiency of response to cultural practices such as fertilisation, nutrition, irrigation and the use of pesticides.

The achievement of these objectives and others addressing constraints on land productivity, requires a new knowledge-base for creating sustainable, yield-stabilising technologies. They will only be realised when the necessary research and development infrastructures, guidelines, regulations, financing and public and private policies are in place. A technology will only succeed in an environment where political, social and economic policies are prepared to support it.

The Need for an Appropriate Biotechnology Strategy for African Food and Agriculture

The introduction of modern biotechnology into African countries should be viewed as the latest of the powerful new tools or means that advances in science have provided for the improvement of agriculture. The challenge is to give decisive momentum to activities involved in developing products that not only have an assured market and high economic returns but, are also products which take into account the needs of poor people which are, unfortunately, largely ignored. The development and application of modern biotechnology should avoid any adverse side-effects such as loss of germ plasm, displacement of exports, negative impact on the labour market, etc.

These brief preceding considerations pinpoint the need to adopt innovative strategies and mechanisms to introduce modern biotechnology into Africa. What kind of international co-operation should be foreseen in this case? The development in transfer of biotechnology to Africa is hampered, not only by the insufficiency of financial resources but also, by the inadequacy of mechanisms to analyse global technological trends, inadequate scientific and trained manpower, and unfavourable legislative, environmental and socio-economic frameworks.

It follows, then, that the successful development and application of biotechnology is possible only when the strong desire exists to build a

national base or capability, involving efficient regional or international co-operation.

Building National Capability

A strategy to build a national capability in biotechnology to benefit food production should include the following elements:

The Political Will

Governments should accept, and commit themselves to, the development and application of modern biotechnology. To achieve this, it is necessary to build a broad research and knowledge base in the biology and breeding, agronomy, physiology, pathology, biochemistry and genetics, of the manipulated organisms. The benefits offered by modern biotechnology cannot be realised without a sustained commitment to basic research.

Most biotechnologies, in developed countries, are oriented toward producing substitutes for the export commodities of developing countries, including those of Africa. Solving the food crisis in Africa should be one of the main priorities for developing and applying biotechnology but, this can be done only through government intervention. In short, governments should be committed to developing biotechnology, so that appropriate supportive inputs can be provided and the necessary biotechnology programmes can be prepared.

Formulation of Appropriate Policy

Biotechnology must conform to national agricultural research and development policies, balanced by technical realities and needs. For example, if bananas are a particularly important crop in a country, and the tools of biotechnology can be harnessed to increase the production, processing, and nutritive value of bananas, then bananas become a priority for biotechnology. A clear definition of national goals and objectives, including efficiency, equity and environmental concerns for agricultural commodities, helps this process. Policy guidance can provide for a research strategy that maximises available resources, building biotechnological capacity as an extension of the existing research capability. It is necessary for each African country to determine its priorities with a view to identifying its economic objectives and obtaining maximum advantage from available resources, without damaging its environment.

In this regard, measures should be taken to formulate an appropriate policy framework for biotechnology. Such a framework should include:

- the setting up of broad objectives and goals for the national biotechnology programme and a broad policy for managing access to relevant biotechnology for agricultural development
- the definition of the relative roles of the public and private sectors in research and development and commercialisation, as well as a policy regarding intellectual property rights
- the introduction of inventor certificates in order to maintain the nature of biotechnology-based innovations as a public service and to recognise researchers
- the establishment of guidelines for Biotechnological research and development with due attention to safety and environmental considerations
- the establishment of organisational machinery to implement the national biotechnology programme

The Identification of Priorities

African countries should concentrate on building capabilities in well-established, proven and relatively simple techniques, mainly those leading to increased agricultural productivity through tissue culture, or increased efficiency in food production and processing.

Priorities in biotechnology programmes should attach importance to the development of low-input, sustainable farming systems to benefit marginal and small farmers. These farmers generally operate at subsistence level and are naturally risk-averse. However, it is likely that the non-acceptance of new varieties will greatly increase if the varieties are developed in co-operation with local farmers, using their knowledge to improve local farming systems.

Human Resources Development

One of the most serious constraints holding back the development of biotechnology is the complexity of the discipline. Sub-Saharan Africa has an acute shortage of trained and experienced indigenous workforce.

African governments should, as a matter of urgency, start multi-disciplinary training programmes and integrated approaches to raise the numbers of urgently-needed biotechnology researchers and technicians at all levels.

Training scientific and technical support is the most crucial element in a strategy to build local capacity. In the immediate future, African

countries should train adequate numbers of biotechnologists abroad, while taking action at the same time to create strong faculties of well qualified experts in the interrelated disciplines that constitute biotechnology, at local universities.

Because of the rapid progress of biotechnology, access to basic scientific information is needed. But, because multinationals regard their Biotechnological technology as top secret, the flow of this information through the usual channels will remain very restricted. Therefore, alternative sources of information, through network systems or joint venture programmes, will have to be developed.

There is an urgent demand to establish and equip national universities and research institutes for the development and promotion of biotechnology. Both degree and post-graduate courses must be structured, and specialist training developed. This inevitably requires the direct involvement of the public and private sectors, and co-operation with foreign corporations and international agencies. Training should be introduced from the start, at undergraduate level, as part of classic biological disciplines such as microbiology, biochemistry, physiology, genetics, etc., and pursued intensively, in depth, at post-graduate level.

The continent must produce a strong team of geneticists, biochemists, physiologists, microbiologists, industrial chemists, biotechnical or process engineers, plant and animal breeders, laboratory technicians, and a wide range of other medium and high-level specialists, to maintain the equipment of the facilities.

As far as African countries are concerned, while making great efforts to train experienced scientists and highly qualified engineers, in the short term they would have to depend on licensing inventions and collaboration with multinationals, until they were able to build up their own centres and research teams.

Regional and International Co-operation

Regional and international co-operation is certainly one of the means of developing and applying modern biotechnology. It should enable:

- the undertaking of joint research programmes of common interest, to avoid duplication and to save scarce resources
- the pooling of resources and capabilities, to enable African countries to undertake projects they might not be able to carry out individually

Such co-operation has the advantage of involving the industrialised and African countries, within the framework of bilateral or multilateral agreements, as well as involving them with private institutions including multinationals. Joint ventures and the co-financing of projects, by public or private nationals and international institutions, are better ways of sharing technological expertise.

The establishment of Biotechnological centres and research teams inevitably requires heavy investment and the availability of foreign capital, which national governments may not be able to afford readily. Through international co-operation and support and the encouragement of the twinning of higher education and research institutions, Biotechnological centres can be established and maintained, joint advanced training programmes and investigations undertaken, an International Biotechnology Network established, biotechnology database and information exchange services developed and advice in formulating national policies and programmes in biotechnology can be provided for governments.

This report has examined the objectives and strategy to introduce and apply modern biotechnology in order to improve agricultural productivity and increase food production, without damaging the environment. In order to achieve this, a mechanism has been proposed, based on building national capability and strengthening, or developing, regional and international co-operation. Building national capability means:

- political will from African governments, which should accept, and commit themselves to, developing modern biotechnology, considered a powerful new tool for agricultural development and food production
- formulation of an appropriate policy to improve agricultural productivity
- identification of priorities for which biotechnology offers a comparative advantage and serves a demonstrable need, and the determination of relevant national policies
- human resources development by training manpower, by establishing and equipping national or sub-regional and regional universities and research institutes to develop and promote biotechnology

Regional and international co-operation is needed to develop and apply modern biotechnology, and to reverse the current tragic chronic food shortage, including malnutrition, hunger, famine, disease, poverty and death.

Finally, a stable political environment, strong political will and support from African governments and the international community will be the basic pre-requisites for success in achieving the cherished goal of sustained agricultural growth, which is vital for resolving the region's food crisis.

References

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