Agricultural Biotechnology: A menace or pathway to sustainable livelihoods in developing countries?*

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Abstract

Despite increasing availability of food globally, some 800 million people out of the global total of 6 billion are food insecure. The majority of these live in Asia (which accounts for 48%), Africa (35%) and Latin America and the Caribbean (17%). Because access to food depends on income, the cause of food insecurity in the developing world is poverty. Agriculture constitutes, for the majority of the poor in developing countries, the primary means of survival and livelihood sustenance. Agricultural biotechnology offers enormous potential to achieve, in short time frames, increases in product quantity and quality that used to take years of laborious plant and animal breeding. However, biotechnology has, to date, remained a technology of the North. Properly harnessed, biotechnology represents perhaps one of the most powerful tools ever available to address the hitherto intractable food production constraints of the South. The major limiting factor to the application of biotechnology in the South is poverty. It is principally in the hands of the private sector in the North, the operations of which are driven by profit objectives. The private sector places a higher value on biotechnology products than on the biological resources, principally derived from the South, that are used to create the products. Current debate on biotechnology is focused on its potential negative impacts on human and environmental health.

The potential positive impacts of biotechnology on the lives of poor people, its appropriation in the North with little flow to the South and the lack of mechanisms for sharing the benefits derived from the exploitation of biological resources harvested from the South are receiving much less attention than they deserve. Like any new technology, the risks and benefits of biotechnology should be assessed in a Cost-Benefit Analysis framework. With emphasis on Africa, this paper tries to answer the question: Is biotechnology a menace or an opportunity to address the pressing needs for sustainable livelihoods of poor people in developing countries? It argues that agricultural biotechnology has great opportunity to address poverty but recognizes that there are risks that need to be addressed. The paper also examines the potential role of the public sector – notably national governments in developing countries and development partners, the private sector as well as public-private partnerships – that will facilitate North-South transfer of relevant biotechnology. It is concluded that, risk assessment has to be an integral part of biotech R & D, but that the final verdict on a well-tested technology will be made by producers and consumers, so long as the technological and policy 'playing ground' is level.

Introduction

By the year 2050, it is estimated that the global human population will have reached 9 billion. Most of the population growth will occur in the cities of developing countries, principally Africa and Asia. To feed such a phenomenal population increase will require a doubling in food production. During the last doubling of the human population from 3 billion in the 1960s to 6 billion in 2000, food production increases kept up with population growth because a range of technologies were applied, albeit with varying degrees of adoption and successful application. These technologies included new seed varieties, improved cultivation techniques, application of pesticides and fertilizers and harvesting technologies.

Today in Africa, hunger, malnutrition and poverty are widespread. An estimated 25 to 30 million children are malnourished in the continent and the World Health Organization estimates that 54% of child mortality in African countries is associated with malnutrition. About one third of the children in sub-Saharan Africa (SSA) are stunted because of poor diet, while thousands of people die each day from hunger. Another one third of the continent's adult population, about 200 million, are food insecure and are forced to live below their full potential because they lack the energy and full health to function at their best. If current trends continue, by 2010 Africa would account for nearly two-thirds of the undernourished people in the world. This vicious cycle of hunger and poverty need to be broken.

In Africa, agriculture is the most important economic activity and offers the means to reverse the above trends and stimulate wider economic growth. This is because seventy percent of the people in sub-Saharan African live in rural areas and are dependent on agriculture for their livelihoods. However, African agriculture is performing dismally: Crop production is the lowest in the world. Yields of basic food grains, for example, are one-fifth those of China. Fertiliser use in Africa is 8 kilograms per hectare; in Latin America, it is over 60 kilograms per hectare, and in Asia, over 100 kilograms per hectare. Only 4 percent of Africa's farmland is irrigated; in the Middle East and Asia, the figures are 29 percent and 34 percent, respectively. The Green Revolution has had very little effect on the continent's agriculture in the last decade. In Asia and Latin America, between 60 percent and 80 percent of crop area is planted with modern varieties; in Africa, the figure is between 20 to 30 percent. As a result, Africa imports more than 25 percent of the grain it consumes. On the other hand, up to 40 percent of the harvest is lost to post-harvest damage.

Current opposition to biotechnology

*"To utilize biotechnology in product development requires investing immense resources – in equipment, skilled labour, patents, etc. This high expenditure favours the centralization of R & D and the concentration of industry. Such an R & D structure, however, is incapable of understanding, meeting and addressing the needs of smallholders under diverse, complex and changing circumstances. --- The result of such hyper-centralised breeding is varieties that are even less appropriate and less accessible to smallholders contending with complex … circumstances…"(**say some critics!)***

Charge 1: Biotechnology offers few real, sustainable benefits for small farmers in Africa. Biotechnology is a relatively clunky, expensive, elitist tool the application of which will only help to exacerbate marginalization of the poor. Moreover, instead of constituting a strategy for participatory R and D, biotechnology makes research even more centralized and un-participatory.
Charge 2: Investment in biotechnology takes away resources from more important and potentially more economically rewarding investments.
Charge 3: Promotion of biotechnology is a gimmick of developed countries to hoodwink Africa to continue its dependence on the North and support of the private sector enterprises of these countries.
Charge 4: Biotechnology products portend environmental/ecological and human health danger to Africa.
Charge 5: Embracing biotechnology will have negative impact on the economies of African States by compromising their ability to export to certain foreign markets, notably Europe.

The following section attempts to respond to the above charges, but not in a particular order. It is worth noting that, strictly speaking, many of the key sectors underpinning development have downsides or difficulties. There are institutional difficulties associated with the delivery of electricity to rural areas. Use of electricity by new users is a hazardous enterprise. Construction of roads is responsible for substantial landscape destruction, and many 'green-movement' activists and followers opposed to road construction have helped avoid construction of roads through certain delicate or special habitats or landscapes. The debate about biotechnology has to balance the potential benefits against the risks. Risks do exist and need to be addressed. However, this should not be used to prevent developing countries from reaping benefits that can obviously be obtained from an appropriate harnessing of relevant and suitable technologies.

Why Africa must include agricultural biotechnology in its development agenda

*"We cannot turn back the clock on agriculture and only use methods that were developed to feed a much smaller population. It took some 10,000 years to expand food production to the current level of about 5 billion tons per year. By 2025, we will have to nearly double current production again. This increase cannot be accomplished unless farmers across the world have access to current high-yielding crop production methods as well as new biotechnological breakthroughs that can increase the yields, dependability, and nutritional quality of our basic food crops. We need to bring common sense into the debate on agricultural science and technology and the sooner the better!" (***Norman E. Borlaug***).*

Can agricultural biotechnology address poverty?

Access to existing and new technologies in agriculture is a must if Africa is to emerge from its current hunger, malnutrition and poverty. Biotechnology is one of the new opportunities for Africa, with a crucial role to play in improving food production and human livelihoods in the continent. Potential contribution of applications of biotechnology in agriculture include: Production of higher yielding, drought/heat and/or disease/pest resistant crops and livestock; enhanced nutritional qualities and post-harvest characteristics of crops and

animal products; tolerance of crops to soils with high levels of heavy metals or salinity; introduction of herbicide resistance into crops; production of clean planting material through tissue and cell culture; production of vaccines to control major livestock diseases; and use of molecular genetic tools to understand the genetic diversity in plants and animals to better use and conserve them. It is incorrect and misleading to assert that Africa does not need biotechnology. Africa needs agricultural growth, and economic studies strongly indicate that accelerated productivity growth due to biotechnology will be crucial to reducing hunger and poverty. Biotechnology does not take away from other crucial investments; biotechnology, at this particular time, has to be the major focus of investment in agricultural development. It will complement and add value to other investments. The problem is that, considering its potential, there is gross under-investment in modern agricultural biotechnology in Africa by both national governments and international development agencies.

There is no doubt that current international agricultural biotechnology R and D does not have a focus on the food commodities that are crucial to the poor in developing countries. In Africa these would include such crops as cassava, sorghum, millet, cowpeas, pigeon peas, etc. Current private R & D efforts in Africa – mainly in South Africa, Zimbabwe and Kenya - is dominated by a few firms investing in low-risk, high return applications in a small number of high-return crops such as cut-flowers, commercial fruits and vegetables, and herbicide-resistant cotton and tobacco. The lack of investments in the 'pro-poor' crops is a direct reflection of the interests of the current investors in agricultural biotechnology. An important goal for Africa is to help define the agenda to include these key crops and, working with willing partners, to develop technologies and delivery pathways that take into account the needs and capabilities of the majority of African poor smallholder farmers. As pointed out later, multinational private companies are increasingly conscious of the need to get involved in biotechnology research on 'orphan crops', if only for their public relations. Again, national governments have to proactively engage these private sector companies.

Agricultural biotechnology and the private sector

It is indeed the case that currently, the public sector in general, and developing countries in particular, are unable to compete as multinational companies hold exclusive patents over a large proportion of the key genes and gene technologies required to produce a significant number of important biotech crops. For example, six companies, namely Monsanto/Pharmacia, DuPont, Syngenta, Dow, Aventis and Pulsar, hold about 74 percent of all U.S.A. patents in agricultural biotechnology (Shand, 2001). However, in making the case for biotechnology as an important opportunity for Africa, we need to take cognisance of the significant changes currently occurring in Africa. In particular, Africa is telling the world that it would like to develop its own solutions to its problems. The New Partnership for Africa's Development (NEPAD) explicitly recognizes the role that science and technology can play in agricultural production and the attainment of food security in Africa. It stresses the importance of strengthening the continent's scientific and technological capabilities to remove barriers to increased food production and

recognizes that removing many of the barriers (such as low crop/livestock productivity, poor soil fertility, high incidences of livestock diseases, drought, pests, etc.) will require deliberate and long-term investments in agricultural R&D, particularly in relevant fields of science and technology, and will include the development of innovative partnerships. In the field of biotechnology, partnership with the private sector – on mutually agreed terms – is essential. Multinational biotechnology companies from the North are obviously driven by profit objectives. African States may choose to work with international (public and private) partners or local companies as a means of accessing important new technologies. In doing this, Africa will have to make a strong case for the specific needs of its smallholder farmers. In this connection Africa needs a critical mass of human resources in crucial areas of technology development, application and commerce to be able to get into economically viable relationships with the cross-section of partners needed to fully exploit the benefits of the biotechnology era for the benefit of its people. Such alliances are already happening in Asia and indeed in a few countries in Africa. As the enabling technical and policy is made available, African farmers will be able to decide for themselves whether biotech applications in agriculture, including biotech crops, are in their economic interest.

Can agricultural biotechnology contribute to natural resource management?

Over some 5,000 years of crop and animal agriculture, the diversity of plants and animals that characterized the African landscape has been lost or the composition and distribution significantly altered, save for small pockets. This has happened not because of biotech crops and animals, but because of the need to feed an increasingly larger human population and our inability to increase productivity commensurately. As a result, ever-increasing areas of land have had to be put under crop and livestock production. The result has been loss of species diversity, depletion of soil fertility, soil erosion, spread of weeds, and emergence of new pests and diseases. What is needed is to develop approaches that will increase sustainability and improve productivity of the production systems. Agricultural biotechnology offers a means by which this can be achieved. Environmentalists have made a laudable contribution in raising awareness about the loss of diversity. It is ironic, therefore, that a cross-section of the same group should be taking a strong, fanatic opposition to technologies that have such a great potential to contribute to sustainable agriculture and environmental health. All the high potential land and much of the marginal land in Africa have been cultivated. What is left is generally marginal, fragile land – poor soil, drier areas, steep slopes, etc. To preserve these areas, productivity has to be increased on the less vulnerable lands so that the fragile areas can rejuvenate and the remaining areas with wild flora and fauna can be saved. If doubling food production has to be achieved by doubling the cultivated land, there will be little opportunity to conserve and sustainably use the forests or natural habitats left in Africa. Moreover, growing of productive crops, requiring less pesticide use and tilling, has direct implications to environmental health. Claims that cultivation of biotech crops such as Bt cotton are associated with reduced insect diversity have not been proven by research findings. Organic farming or a mix of ‘old’ technologies, including crop rotations with legumes, use of crop residues, integrated

(biological) pest control and the use of lime to decrease soil acidity, have many positive attributes. However, organic farming is driven more by ideology than by sound science. Organic farming is not efficient and, when the total picture is taken into account, it does not constitute environmental friendly agriculture. Specifically, organic farming can feed about 3 billion but not the present 6 billion or the over 9 billion that we will have in the next two decades. Elements of organic farming combined with modern biotechnology can provide a powerful means to develop environmentally friendly and sustainable agriculture.

Agricultural biotechnology, human nutrition and food safety

Modern biotechnology can improve the nutritional value or remove undesirable elements from human foods and livestock feeds. The benefits include: Removal of allergens and toxicants; production of higher protein crops – e.g. root crops and maize; higher vitamin A rice (the 'golden rice'), vitamin C fruits and vitamins A and E vegetables. The charge that biotech-derived foods/feeds are inherently unsafe to human health is patently incorrect. Biotech-generated crops are probably the most rigorously tested in terms of safety as food. Over 25,000 field trials have been conducted on more than 60 crops in 45 countries and no long-term effects have been detected. Tests include potential to cause allergic reactions and to confirm that the genetic modification in the food/feed is broken down by the digestive system. It has also been claimed that biotech crops fed to livestock could affect humans through ingestion of animal products. Studies (Ash *et al*, 2003) have shown that this is not the case. Thus, after years of research, there is no credible scientific evidence to suggest that biotech crops are any less safe than traditional food/feed crops. Nonetheless, the need to rigorously and consistently test all biotech-derived food/feed cannot be overemphasized. Unfortunately, it must be pointed out that Africa lags considerably behind in the development of the regulatory framework or bio-safety protocols, including standards for testing the safety of foods derived from biotechnology. In developing biotech R and D programs, Africa and its development partners need to give serious consideration to the development of human and institutional capacities in both application and regulation of the technology, a requirement of the Convention of Biological Diversity under the Cartagena Biosafety Protocol. A few African countries have developed (e.g. South Africa and Egypt) or are currently developing (e.g. Kenya) bio-safety regulatory instruments.

Risk of losing export markets

The fear of biotechnology in the European Union has, without doubt, affected development of biotechnology products in Africa. Not only have Africa's European public sector development partners contributed little to modern biotech R and D in Africa, but the ban placed by the EU on biotech products has also had a negative impact on biotech applications since the EU represents an important market for Africa's agricultural export. The reality is that most biotechnology applications for smallholder, food-insecure farmers in Africa are not likely to affect commodities exported to Europe. Unfortunately, misinformation has added to these concerns - that biotech genes will cross from one (locally consumed) species to another (export) species. The EU

stand in biotech remains an important stumbling block to the development of agricultural biotech R & D in Africa.

Way forward

Modern biotechnology alone will not eliminate poverty and hunger in Africa. Social and political institutions are the critical drivers for change, and these need to be reformed. However, biotechnology has an important role to play. The following urgent actions are needed:

1. Innovative institutional arrangements in agricultural biotech R and D
   - Public-private partnerships
   - Participatory technology development
2. Recognition of, and addressing risks. Risks are real. Risk is part of science and science is key to development. No technology has zero risk: From trains, to aeroplanes, electricity, etc. What is important is to analyse the costs (incorporating risks) and benefits. It is the role of governments to provide an enabling technical, economic and policy environment, including the requisite regulatory framework. Producers and consumers will then decide whether or not to produce or consume specific biotech crops/animals.
3. Public awareness to facilitate informed debates.

A case Study: ECF in Africa

East Coast fever is a deadly tick-borne disease of cattle caused by a protozoan blood parasite *Theileria parva*. The great deal of effort and resources that have been expended over the years in the control and management of ECF attest to the magnitude of the negative effect this disease has on livestock production in the eastern, central and southern Africa region. Losses in production from morbidity and mortality, costs of preventive measures and opportunity cost account for the economic importance of ECF. A total of 28 million cattle are at risk from this disease with 1 million deaths annually. It is estimated that ECF exacts losses amounting to $US300 million annually in the region. Well-to-do large-scale dairy farmers in the region have succeeded in keeping ECF-free exotic and improved herds through strict tick control, while poor smallholder cattle keepers continue to suffer massive losses of their stock as they do not have the resources to put in place effective tick-control programs.

Apart from tick control, a live vaccine is available and has been deployed in a some countries through specific R & D projects to protect cattle from ECF. This vaccine, though very effective, has several drawbacks limiting its wide and sustainable application. These include: the requirement for a cold chain for vaccine storage; need for trained personnel to administer the vaccine; the high cost of producing the vaccine; and absence of institutional and policy framework to produce the vaccine and support its delivery to farmers. In spite of this, recent experiences with the introduction of the live vaccine through pilot projects, has provided convincing evidence of significant demand for the technology. This suggests that an efficacious, cheaper and easy-to-deliver vaccine would be readily adopted.

The Department for International Development (DFID) of the UK is supporting research on the development of an improved sub-unit vaccine for ECF. This work involves identifying parasite components that are targets of protective immunity and formulating them into prototype vaccines for evaluation in cattle. When developed, this vaccine will impact on the poor smallholder livestock keepers. By securing the cattle assets (reducing significantly the risk of their loss from ECF), the vaccine will reduce the risk faced by the poor in increasing investment in income-generating activities, whether cattle-based or otherwise. Knowing that she can depend more than before on her cow to be there in case of some disaster, the farmer can take the risk of investing in small trade, or chickens, or a new cash crop, etc. Thus, this technological intervention will allow transition from subsistence to market-based farming with resultant enhanced well-being and better livelihoods.

Project purpose

Development of a vaccine for ECF to enable cost-effective and appropriate strategies to control, in a sustainable manner, a livestock disease that affects the livelihoods of the poor in smallholder production systems of eastern, central and southern Africa.

Beneficiaries

Conservative *ex ante* impact analysis in different production systems afflicted by ECF demonstrates significant economic benefits for the poor small-holder dairy, agro-pastoral and pastoral farmers. Net returns to a subunit ECF vaccine research of $160m with a benefit:cost ratio of 15:1 over the next 30 years have been estimated (based on an earlier vaccine developed strategy; the current strategy is considered to have higher probability of success and benefit:cost ratio). The above figures assume that the vaccine would be ready for dissemination in 6 years given a probability of research success of 50% and enough time until a maximum of 30% of farmers in affected areas adopt it. These economic benefits will accrue from the transition from subsistence to market-oriented dairy currently constrained by ECF disease risk, morbidity and mortality. In Africa, a significant number of small-holder dairy farmers are women whose livelihoods will be enhanced.

Potential impact

Ex-ante impact assessments in different production systems within the region have demonstrated significant economic benefits to smallholder farmers if they were to adopt vaccine-based control methods for ECF. The benefits will be in terms of reduced disease risk, reduced livestock mortality and morbidity for smallholder dairy, agro-pastoral and pastoral farmers and savings from dependency on other control methods. As indicated above, conservative *ex-ante* impact assessment of research on vaccine development for ECF indicates a benefit to cost ratio of 15 to 1. The new vaccine will have many advantages over the current live parasite vaccine. These will include the elimination of the low temperature cold chain requirement, reduced cost,

easier distribution and application, and an absence of reactions following vaccination. An overall demand of 1.8 million doses annually has been predicted, with expected adoption rates ranging from 5% in agro-pastoral and pastoral systems up to 50% in smallholder systems, the former being a conservative estimate. Likely intensification of the agro-pastoral system and changes to pastoral systems will increase both vaccine demand and its delivery over the next 20 years; poverty reduction impacts are likely to be greatest among the intensifying agro-pastoral and pastoral communities.

A successful ECF sub-unit vaccine will also have impact on vaccine development research in general and will inform vaccine research on such diseases as TB, HIV/AIDS and malaria.

Relevance to sustainable livelihoods

An improved ECF vaccine targeting the resource-poor smallholder livestock keepers, a majority of which in Africa are women, aims to provide a firm platform to transit from subsistence to market-oriented systems to lead to better and enhanced well-being. Apart from direct benefits of increased household incomes, the reduced usage of acaricides and therapeutics will result in a healthier environment and better quality animal food products.

Negative blanket statements about biotech will affect projects/programs such as this whose successful implementation will clearly have huge positive impacts on livelihoods of poor African farmers and consumers.

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