Limits on The Use of Genetically Modified Cotton In Africa: the Case of Burkina Faso

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Introduction

Development policies in Africa place a heavy emphasis on efforts to alleviate hunger, malnutrition and poverty. This approach is predicated on a substantial increase in agricultural output with methods that are environmentally sound. To achieve food self-sufficiency and eliminate hunger, existing methods generally involve increasing the amount of cultivated land. In many cases the plants are not very productive and the use of organic and inorganic fertilizers is very low. This results in greater pressure on the land, ongoing deforestation, depletion of the mineral content of soils and, ultimately, lower yields.

To stave off poverty, farmers grow cash crops such as cotton in the case of Burkina Faso. Here again, an increase in output means increasing the area under cultivation. Apart from the low use of fertilizers, the main obstacles to increased output

are insect pests and weeds. To address these constraints, the methods that have been developed involve the use of chemical pesticides. But it must be acknowledged that such methods, even though they may be effective, are likely to pollute the environment and disrupt the equilibrium of the ecosystem. Furthermore, the repeated and ongoing use of such pesticides may eventually produce insects that are resistant to these toxins.

Current cropping techniques have reached their limit, in terms of alleviating hunger and poverty, and could even aggravate these problems. It therefore makes more sense to find an alternative that could increase agricultural output, generate savings and also protect the environment in order to feed the ever increasing African population. The use of biotechnologies could be such an alternative.

Alternative Methods: Biotechnologies

It is hard to find a single definition for biotechnology in the literature. The term "biotechnology" first appeared in the French literature in 1979, in a report published by Professor François Gros et al. entitled La révolution biologique des technologies utilisant les propriétés du vivant à des fins pratiques et industrielles (The Biological Revolution of Technologies Using the Properties of Living Organisms for Practical and Industrial Purposes). As such, "biotechnology" may be defined as a set of techniques that use living organisms or parts of living organisms to develop -or modify products, improve plants or animals, or develop microorganisms for the specific needs of humans. It is not a discipline in and of itself but rather an area of inquiry that calls upon numerous disciplines such as genetics, molecular biology, biochemistry, embryology, cellular biology, chemistry, information technologies, robotics, etc.

Modern biotechnology, as defined in the Cartagena Protocol, encompasses:

a) the use of *in vitro* techniques with nucleic acids, including recombination of deoxyribonucleic acid (DNA) and direct introduction of nucleic acids into cells or organelles;

b) cellular fusion of organisms that do not belong to the same taxonomic family, overcoming natural barriers of the physiology of reproduction and recombination, separate from conventional techniques of reproduction and breeding.

Biotechnology also involves the ongoing development of new techniques and the availability of an ever greater variety of technologies. It encompasses traditional techniques (known to man since ancient times), widely used techniques developed over long periods of time (lactic and alcoholic fermentation, plant and animal domestication and breeding, cereal and leguminous crop rotations, etc.) and newer, so-called "modern" techniques – not yet proven in certain cases – including recombinant DNA, monoclonal antibodies and new methods for growing cells and tissues.

The techniques of recombinant DNA, generally referred to as "genetic engineering," emerged in the 1970s and are the subject of considerable attention. They involve transferring genetic material from one living organism to another in order to alter the second organism's genetic structure in profound ways and either cause the organism to produce new substances or provide the organism with new, more effective functions. Our *in vitro* capabilities now allow us to implant a whole range of genes in plants, animals and microorganisms. Such genetic manipulations can overcome the natural barriers of the physiology of reproduction and give life to transgenic organisms or, as they are commonly called, modified organisms.

With respect to agriculture, modern biotechnologies raise new hopes for developing countries faced with problems of food supply. Food production must not only keep pace with population growth but actually exceed it if citizens are to have access to food products of sufficient quality and quantity. To meet the challenge of survival, modern biotechnologies appear to hold tremendous potential.

In Burkina Faso, modern biotechnologies offer a clear advantage for developing the country's agricultural sector by achieving greater yields (through improved pest management, resistance to disease, better weed control). Farmers can increase their yields and still protect the environment by growing genetically modified plants. Crops that offer the potential to obtain high yields will have a direct impact on efforts to improve food security and eradicate poverty.

In terms of cash crops, cotton provides a useful example: this crop requires the extensive use of pesticides to control insects and weeds. But such practices, as noted above, may harm the environment.

Genetically modified cotton, if it proves effective under the growing conditions of Burkina Faso, would be a good alternative for increasing farmers' income while safeguarding the environment.

The Stakes of Biotechnologies for Africa and the Significance of Transgenic Cotton for Burkina Faso

Since the 1970s, biotechnologies have produced a true scientific, industrial and socio-economic revolution around the world. In the history of mankind, no scientific field of endeavor has ever before allowed the human race to approach so much real and potential progress, nor presented so many risks for people, for society and for the environment, even to the point of calling into question basic moral principles.

At the economic level, the biotechnologies of today are the technologies that provide the highest growth rates. The world market, with more than 2,500 biotechnology companies, largely dominated by the Americans, achieved annual growth rates of 20% to 25% and expanded from US $8 billion in 1992 to more

than US $83 billion (excluding agroprocessing) at the start of the 21st century.

During the year 2000, some 44 million hectares were planted with genetically enginreered organisms around the world, including 5 million hectares of transgenic cotton. The countries most heavily involved in growing transgenic plants are the United States, Canada, Argentina, Australia, New Zealand, China and India. A number of African countries have already taken steps to benefit from the recent technological advances, upon which the economic stakes of the future depend. Egypt, Zambia, Kenya and Uganda are now at the stage of conducting advanced trials. South Africa started marketing GE organisms in 1997. In the space of three years, 40% of the land planted to cotton in South Africa has been switched to transgenic cotton. The technology has been very rapidly adopted because of easily quantifiable economic and ecological benefits (yields 30% higher than conventional cotton and just one or two insecticide treatments per crop year instead of eight).

Thus, GE organisms are acquiring greater and greater strategic importance in international trade and relations. Estimates of growth in the world trade of transgenic plants are highly indicative of the "fever" surrounding this technology, and the figures speak for themselves.

In Africa, agriculture is the most important economic activity, occupying 60% to 80% of the population and accounting for 30% to 50% of GNP, with 80% of all food products grown on small farms. For ten years, agricultural output has declined for various reasons, leaving many countries of Sub-Saharan Africa increasingly dependent on food imports or food assistance. African crop yields are the lowest in the world. This situation is only exacerbated by post-harvest losses, sometimes as high as 40%, due to inadequate storage and preserving techniques.

Meanwhile, the continent's population is rapidly expanding and the phenomena of poverty, unemployment and malnutrition are becoming endemic. Over the last 60 years, the world population has tripled from 2 to 6 billion; in less than 12 years, it rose from 5 to 6 billion, i.e. an increase of 250,000 people per day. Statistics indicate that the world population will double over the next 20 years. Of the projected 8 billion people, 6.7 billion will live in the developing countries. The population of Africa will double, reaching 1.5 billion. With such a high population growth rate, agricultural output will also need to double by 2020 if there is to be enough for all.

In addition, environmental deterioration is becoming more and more pronounced in Africa, due to a variety of factors: erosion, overgrazing, depletion of the organic and mineral content of soils, proliferation of harmful insects, diseases, weeds, soil acidity, deforestation and overfishing.

An appropriate response to this state of affairs would be to increase the yields of arable soils in order to protect the environment. The challenge for agriculture in Africa could come down to a radical transformation permitting increased productivity by integrating improved cropping practices and new technologies, including modern biotechnologies, which would be key factors in increasing productivity on a sustainable basis.

The benefits of transgenic crops could include, among other effects, reduced costs, increased productivity due to improved yields, and environmental protection as a result of fewer chemical applications on crops and therefore less pollution of ground water. The quality of food products would also be improved (more vitamins and mineral salts, better taste). In brief, three types of products can be identified, each of them adaptable to different environments:

- Biotechnological products that offer agronomic advantages for farmers and the environment (development of plants resistant to harsh climates, drought, impoverished soils and insects);
- Biotechnological products that provide qualitative advantages to consumers and industry (rich in vitamins and trace elements):

  Scientists in Switzerland have discovered how to use biotechnology to increase the vitamin A and iron content of rice, the staple food of more than half the world's population. At the same time, Monsanto has developed a colza and mustard oil rich in vitamin A. This is significant progress in view of the fact that 230 million children around the world suffer from vitamin A deficiency;
- Industry or factory plants that naturally synthesize products beneficial to industry, consumers and the environment (vaccines, protein).

In the particular case of transgenic cotton, three groups are now available on the market:

- cotton plants with a gene that tolerates herbicides;
- cotton plants with the *Baccilus thuringensis (Bt)* gene, capable of effectively controlling lepidopterous caterpillars;
- cotton plants containing a combination of genes to tolerate herbicides and control caterpillars.

Bt cotton has been produced in the United States since 1996, as well as Mexico (1996), Argentina (1998), China (Mainland) (1996), Indonesia (1999), Australia (1996) and South Africa (1997). The 44 million hectares planted in transgenic cotton in 2000-2001 include 72% of the land on which cotton is grown in the United States, 40% in South Africa, 30% in Australia, 25% in Mexico, 15% in China (Mainland) and 5% in Argentina.

In all these countries, biosafety regulations are already in place. On the African continent, some of the countries mentioned above have instituted regulations, while others have apparently organized large-scale transgenic cotton trials with no such regulations. Nigeria has reportedly released US $26

million to stimulate technological advances in this area. Ghana has just finished developing its own regulations.

In closing this discussion, it should be noted that products of GE organisms are apparently already present in our countries, whether knowingly or not. Apart from pharmaceuticals derived from GE organisms, it is entirely possible that food products containing GE organisms find their way into our regular diet. For this reason, every effort should be made to encourage African countries to utilize the strengths and expertise of all parties to study and develop biosafety regulations that will enable them either to import or to reject GE organisms from a position of full knowledge.

Nevertheless, it must also be recognized that objective limits hinder the implementation of biotechnologies.

Limits on the Use of Methods and Products Derived from Modern Biotechnologies in Burkina Faso

Burkina Faso signed the Cartagena Protocol on May 24, 2000. In the area of agricultural research, the need for Burkina Faso to focus increasingly on the new techniques of biotechnology was clearly expressed. However, nothing has yet been done in this regard, since the country has no relevant legislation. For this reason, a workshop was held in Ouagadougou on March 20-22, 2001 in order to develop draft regulations on the use of GE organisms in Burkina Faso. A commission was formed to draw up guidelines, and its work is now nearly complete. A workshop will be organized in the very near future to adopt regulations that will then be submitted to legislators.

An informational meeting on biotechnologies had already taken place in Ouagadougou on May 10, 2000. Monsanto/Africa organized this informational session in order to explain the biotechnologies and the stakes at hand. The participants, mainly representatives of the National Union of Cotton Growers of Burkina Faso (*Union Nationale des Producteurs de Coton du Burkina Faso*: UNPCB), displayed keen interest in evaluating the viability of these technologies under African conditions.

The concerns about using and handling GE organisms in Burkina Faso, which are altogether legitimate, are focused on the biotechnological risks (risks to biological diversity and human and animal health). This matter has been widely debated, and the consensus is that, although the risks are real, they can be minimized and managed.

The most important barrier to be overcome for using GE organisms in Africa in general, and in Burkina Faso in particular, is still the lack of legislation, i.e. the development of a biosafety protocol for the country. In addition, there is no operational framework in Africa for real dialogue on these issues. The African Biotechnology Agency could readily fill this gap if its resources matched its mission statement. Lastly, there are problems of access to the technology, closely linked to the training of specialists, as well as general problems affecting all users of new biotechnologies and problems specific to African countries.

Biosafety

It is widely recognized that modern biotechnologies represent the best hope for a world experiencing exponential growth but that possesses very limited natural resources. All indications suggest that the benefits derived from applications of this science will lead to significant advances in agriculture, health, the environment and industry. But it also turns out that using the results of these biotechnologies, especially GE organisms, carries potential threats to biological diversity and human health. It is therefore of critical importance to institute biosafety measures.

At the present time, the largest categories of GE organisms are new seeds and pharmaceuticals. There are transgenic varieties of many species, from microorganisms to plants and animals: fish, poultry, swine, sheep, tomatoes, melons, wheat, rice, soy, colza, potatoes, cassava, tobacco, spruce, cotton, maize, etc. Transgenic fish with human genes already exist, and there is more and more talk about putting scorpion genes in maize, human genes in swine and bacteria, a gene from bacteria in plants, etc.

In view of the high stakes and potential risks of modern biotechnologies for both the environment and human health, the Cartagena Protocol on Biosafety, an outgrowth of the Convention on Biological Diversity, was developed.

Burkina Faso is a party to the Convention and has already signed the Protocol.

Burkina Faso therefore needs to develop an outline of national biosafety guidelines that can lead to regulations on the use of transgenic plants and the establishment of a national biosafety framework, in accordance with the Cartagena Protocol.

To explain the real limits on using transgenic products in Africa, a brief description of the Cartagena Protocol is necessary.

Brief Description of the Cartagena Protocol On Biosafety

It is important to provide information on the potential risks associated with modern biotechnologies and on the contents of the Cartagena Protocol in order to better understand the urgent need to develop national biosafety guidelines on the use of biotechnologies in Africa.

Biotechnological Risks

The use of biotechnologies entails certain risks. These risks include the possibility of seeing:

- microorganisms in the soil destroyed and plant survival compromised;
- more competitive transgenic bacteria and viruses;
- the emergence of new, resistant varieties that could over-

run non-targeted species, creating an imbalance within the ecosystem;

- spontaneous hybridization (gene transfers) with related species (either domesticated or wild), resulting in unanticipated changes in competitiveness, virulence or other characteristics of the non-targeted species;
- slightly modified DNA fragments escaping from laboratories;
- the appearance of DNA fragments in the blood from ingested food or other transgenic products.

These are the reasons why precautions must be taken to avoid or at least to minimize risks. The Cartagena Protocol was developed to help ensure an adequate degree of protection for the safe transfer, handling and use or to minimize the adverse effects of GE organisms.

Cartagena Protocol

The Convention on Biological Diversity called for the development of an international protocol on biosafety. This instrument, called the Cartagena (Colombia) Protocol on Biosafety, was negotiated and adopted on January 29, 2000 in Montreal (Canada).

Burkina Faso participated in the protocol negotiations from start to finish, signed the protocol on May 24, 2000 and would not hesitate to ratify it.

The protocol contains 40 articles and 3 annexes, organized as follows:

Articles

The first six articles deal with general issues, particularly:

- The objective, which is based on the principle of a precautionary approach;
- General provisions specifying the obligations of each party, namely to take necessary and appropriate legal, administrative and other measures to implement the protocol, and also to ensure that the development, handling, transport, use, transfer and release of any modified organisms are undertaken in a manner that prevents or reduces the risks. These provisions also emphasize the sovereign rights and independence of States. States are in no way restricted from taking action, based on their specific context, that is more protective of the conservation and sustainable use of biological diversity than called for in the protocol.

The protocol applies to all modified organisms except those contained in pharmaceuticals addressed by other relevant international agreements or organizations.

Articles 7-14 deal with different procedures for importing modified organisms and how these procedures are to be applied. Two main procedures are advocated:

- Procedures for modified organisms intended for intentional introduction into the environment of the Import Party:

1)Advanced informed agreement

This procedure applies prior to the first intentional transboundary movement of modified organisms for intentional introduction into the environment of the Import Party. Article 11 covers modified organisms intended for direct use as food or feed, or for processing. The advanced informed agreement also does not apply to modified organisms recognized by the Conference of the parties to the Protocol as having little effect on the environment and human health.

2) Notification

The responsibility for notification of import falls to the Export Party. Annex I of the protocol specifies the minimum information on modified organisms that the Export Party must provide in the notification, but the Import Party may also require other relevant information, depending on its particular concerns. The Export Party has the legal responsibility to ensure the accuracy of the information provided.

3) Acknowledgment of receipt of notification

The responsibility for providing acknowledgment of receipt of notification falls to the Import Party, which must provide the required information concerning the procedure to be followed within 90 days of receiving the notification.

4) Decision procedure

Taking into account the time needed to assess the risks, the Import Party has nine months after receiving the notification to communicate in writing its informed decision.

In all cases, the Conference of the parties must decide upon appropriate procedures and mechanisms to facilitate decision-making by the Import Parties.

- Procedures for modified organisms intended for direct use as food or feed, or for processing:

  A Party that makes a final decision regarding domestic use, including placing on the market, of a modified organism intended for direct use as food or feed, or for processing, must, within fifteen days of making that decision, inform the other parties through the Biosafety Clearinghouse. Annex II specifies the minimum amount of information to be provided. Particular attention is given to developing countries and countries where the economy is in transition, if they encounter difficulties, in order to help them better manage the domestic introduction of modified organisms through the Clearinghouse.

- Other procedures are also described in the protocol: review of decisions; simplified procedure; bilateral, regional and multilateral agreements and arrangements.

Articles 15 and 16 deal with risk assessment and risk management. Risk assessments are to be based on proven scientific methods, in accordance with Annex III of the protocol. The Import Party must ensure that the assessment is carried out

before the decision to import is made. The Import Party may require that the Export Party carry out the assessment or bear the cost of the assessment.

With respect to risk management, all parties must cooperate in identifying modified organisms or specific traits of modified organisms that may have adverse effects. In addition, each Party must take appropriate measures to prevent unintentional transboundary movements of modified organisms, including a risk assessment prior to the first release of a modified organism into the environment.

Article 17 addresses unintentional transboundary movements of modified organisms and emergency measures to be taken. Any Party initiating an unintentional transboundary movement must notify the affected or potentially affected states, the Biosafety Clearinghouse and, where appropriate, relevant international organizations.

Article 18 addresses the handling, transport, packaging and identification of modified organisms. This article concerns all modified organisms covered by the protocol. The measures to be taken by each Party should include requirements concerning safety conditions that the Export Party must fulfill for modified organisms covered by the protocol, specifically in relation to handling, transport, packaging and identification.

At the international level, the Conference of the parties should develop standards for the identification, handling, packaging and transport of modified organisms.

Article 19 deals with the institutional framework governing the protocol. This framework includes competent national authorities and national focal points. Each Party designates a national focal point to be responsible on its behalf for liaison with the Secretariat. Each Party also designates one or two competent national authorities to be responsible for performing the administrative functions required by the protocol.

Articles 20 and 21 deal with information-sharing. The parties must share any and all information that is useful in preventing biotechnological risks. Article 21 discusses confidential information.

To coordinate information concerning biotechnologies and modified organisms, a Biosafety Clearinghouse is established under Paragraph 3, Article 18 of the Convention on Biological Diversity.

Article 22 addresses capacity-building in the areas of biotechnology and biosafety, particularly in developing countries, the least developed countries, small island countries and countries with economies in transition. To be able to implement the protocol, such countries need scientific and technical training, as well as technical and institutional capacity-building. All parties and all national, regional and international organizations and institutions should cooperate in building these capacities.

Articles 23, 24 and 25 deal respectively with public awareness of, and participation in, biosafety; non-parties to the protocol; and illegal transboundary movements.

Articles 26 and 27 address socio-economic considerations, liability and redress. These articles encourage the parties to cooperate on research and information exchange.

Article 28 addresses financial mechanisms and resources for implementing the protocol.

Articles 29, 30, 31 and 32 describe the bodies related to the protocol: the Conference of the parties, serving as the meeting of the parties to the protocol; subsidiary bodies; the Secretariat; and the relationship with the Convention on Biological Diversity. Article 32 specifies that the provisions of the Convention apply to the protocol.

Articles 33, 34 and 35 deal with monitoring and evaluation mechanisms for implementation of the protocol.

The final articles (36-40) address the issue of how the protocol goes into effect.

Annexes

Annex I describes the information required in notifications to be provided by the Export Party under Articles 8, 10 and 13.

Annex II describes the information to be provided for any modified organism intended for direct use as food or feed, or for processing.

Annex III describes the points to be taken into account in risk assessments.

Eighty countries have signed the protocol (including Burkina Faso on May 24, 2000), but only two countries have ratified it so far. The United States signed the Convention on Biological Diversity but has not yet ratified this Convention. As a result, although the United States participated in negotiating the Cartagena Protocol on Biosafety, it has not yet signed it, because no country that is not a member of the Convention may join the Protocol.

A number of African countries have developed a biosafety framework. This work remains to be done in Burkina Faso, and is one of the main objectives of current activities.

Purpose of Biotechnological Risk Assessment

The purpose of a biotechnological risk assessment is to identify and assess the potential adverse effects of modified organisms on the conservation and sustainable use of biological diversity within the potential or probable target environment, including risks to human health. Risks, however small, do indeed exist, and a threshold of acceptability must always be established. It is also necessary to establish accountability and seek redress for any damage resulting from modified organisms.

The risk assessment is used by the competent authorities to make informed decisions about modified organisms. Risks associated with modified organisms or products derived from

them should be examined in terms of the risks posed by the receiving organisms or by related, unmodified organisms within the potential or probable target environment.

A risk assessment should be performed on a case-by-case basis. The nature and degree of accuracy of the information that is needed may vary, depending on the particular modified organism, its intended use and the potential or probable target environment.

Method of Biotechnological Risk Assessment

The method of risk assessment consists of two main steps:

- identification of the risk
- quantification of the risk

Risk assessment goes hand in hand with risk management. The risk must first be assessed in order to take measures to minimize it.

The following elements are indispensable parts of a risk assessment:

- characteristics of the donor: vector and insert (transferred DNA)
- characteristics of the recipient (prior to modification of its genome)
- characteristics of the modified organism
- characteristics of the target environment
- information on the intended use of the modified organism

African Biotechnology Agency

By creating the African Biotechnology Agency (ABA) in 1992, the member countries (Algeria, Burkina Faso, Burundi, Cameroon, Côte d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Kenya, Mauritius, Morocco, Nigeria, Senegal, Tunisia and Zimbabwe) sought to establish a community-wide mechanism in order to prepare present and future generations of Africans for this new human adventure. Africa is organizing itself to participate on an equal footing with other regions of the world over the coming decades in this adventure of emerging technologies.

The meeting of African ministers held in Algiers on February 3-5, 1992 was the founding conference of the African Biotechnology Agency. The agency is headquartered in Algiers, Algeria. Agenda 21 of the United Nations Conference on the Environment and Development called for the creation of the ABA, with the long-term objective of promoting a strategy to develop new and traditional biotechnologies in order to effectively address issues of development, environmental protection and the quality of life in Africa.

ABA Agenda

The ABA agenda focuses on the following priorities:

- Plant biotechnologies (micro-propagation of food-producing plants and tree species; genetic improvement)
- Human and animal health (production of vaccines and diagnostic products)
- Animal production (production of semen and embryos; development of agricultural by-products)
- Protection and conservation of nature (industrial and urban waste treatment; micro-propagation of forest species)
- Industrial production (production of proteins of unicellular organisms and metabolites; food technology)
- Biodiversity, biosafety and bioethics

ABA Mission

- Build the national capacities of member countries in the area of biotechnology, specifically by carrying out training and research and setting up infrastructure and equipment
- Coordinate and promote cooperative research programs in key biotechnological fields to further the development of member countries
- Facilitate the dissemination of scientific and technical information at the regional and subregional level, as well as experience-sharing
- Encourage the production, distribution and marketing of biotechnological products consistent with the objectives of sustainable development and the need to protect the environment
- Develop and standardize legislation on biosafety, intellectual property, patents and inventions and develop entrepreneurship

Organizational Structure and Management of the ABA

The ABA has a Board of Governors, a Scientific and Technical Council and a Secretariat.

Board of Governors

This body is composed of representatives of member countries. In addition, the Board may grant associate membership status to any organization or institution considered to play a useful role in achieving the ABA's objectives. The Board steers the activities and approves the budget.

Scientific and Technical Council

The Council is composed of experts from the member countries and associate experts. This body provides advice to the Board on scientific and technical issues related to the program of activities.

Secretariat

The Secretariat is composed of the managing director, two deputy directors, experts (program facilitators) and officials in charge of administration, finances and communications.

The headquarters agreement was concluded with the Govern-

ment of Algeria on October 14, 1997. Collaborative relations have already been established with most of the member countries, which have appointed their respective members of the Scientific and Technical Council and designated their national focal institutions responsible for coordinating joint projects with the ABA.

Problems Associated with the Development of Biotechnologies

Biotechnologies carry great hope, especially for the least developed countries. However, it must be recognized that they also create difficulties and risks. Some general problems affect all countries:

- *Ethical and regulatory problems*: The perception of these problems may vary, depending on the society to which one belongs and one's location.
- *Biosafety problems*: Doesn't the use of GE organisms (transgenic bacteria, viruses, plants and animals) pose a threat to humans, biodiversity and the environment?
- *Problems in protecting intellectual property*: Doesn't the principle of intellectual property sometimes extend beyond the goal of rewarding innovation and creativity and deprive some populations of the advantages of a modified organism that is part of the world heritage, or even related scientific knowledge, under the pretext of confidentiality?

Other problems specific to developing countries are exacerbated by the phenomenon of globalization:

- *Disruption of the world's agroprocessing equilibrium*, further widening the gap between developing and industrialized countries: In this context, Africa is in the process of forfeiting all its advantages, particularly in agriculture. Sugar provides a striking example, as enzymatic extraction of fructose from starch has drastically disrupted the world market. Similarly, synthetic fibers have cut into the production of jute and sisal.

  Africa continues to face serious problems of food shortages. Will the continent be able to purchase transgenic seeds when the rest of the world is able to do so?

- *Inequality of the rules that govern the globalized marketplace*: Regulations favor those who make the rules and who dominate the market. The recent banana "war" between the European Union and the United States is one example.

Conclusions and Prospects

Negotiations on biological diversity, particularly within the context of the Convention on Biological Diversity, have uncovered major conflicts of interest regarding resources and have sparked a fundamental debate on risks associated with technological change and on fair and ethical behavior.

How should we respond to concerns about the potential risks and benefits of genetically GE organisms? How should we address the ethical and commercial issues raised? The recently developed protocol on biosafety provides a way to take into account consumers' concerns about GE organisms.

On January 29, 2000, after five years of negotiations, representatives of more than 130 countries finally concluded an agreement in Montreal concerning the Protocol on Biosafety. This legally binding document aims to protect the environment from the risks associated with transboundary movements of GE organisms produced by modern biotechnologies. The challenge was to determine whether a country could restrict imports of GE organisms (including crops, seeds, viruses and viroids) based on the risks to the environment, biological diversity and human health.

This protocol is also the first agreement to regulate trade in GE organisms. It requires that exporters provide the competent national authorities of the importing country with information on the origin and destination of the GE organisms prior to import. The protocol permits countries to block imports of GE organisms as a precautionary measure when there is insufficient scientific proof of their harmlessness. It is thus incumbent upon producers to provide such proof that their GE organisms are harmless, in contrast to WTO provisions, which require that governments seeking to prevent imports must provide evidence to support their position.

However, the protocol does not address the safety of fields producing transgenic plants at the dissemination/extension stage.

Genetically modified plants have shown that they can help farmers to significantly improve their productivity when they are accompanied by appropriate economic and social reforms. Biotechnologies in Africa should be considered a key element for increasing agricultural output, eliminating poverty and protecting the environment.

Farmers benefit from the use of biotechnologies, regardless of the size of their farms. Most farmers in Africa have small-scale operations, under five hectares. By growing transgenic crops, they can increase their yields, control insects more effectively and protect the environment.

On the Makhatini plateaus of northern Kwazulu Natal in South Africa, small farmers have begun to grow transgenic cotton, increasing their yield by 33% and eliminating six insecticide treatments. Their net income has increased by 27%. In Hebei, a province of China (Mainland), the average yield has increased by 39%, generating a 57% increase in income, where 13 insecticide treatments were previously required. Better yields combined with fewer insecticide treatments translate into more money.

Farmers are good observers. They purchase what works best, and this technology has rapidly advanced because it is considered effective. In view of steadily increasing food requirements in Africa and the desire to achieve self-sufficiency, African agriculture should take advantage of the capacity of biotechnologies to raise productivity. Africa sidestepped the Green

Revolution, but it would be a mistake for this to happen again with the Biotechnological Revolution. Accordingly, it is proposed that policies for developing and implementing these emerging technologies take the following path:

A national biotechnology committee should be established in every African country after broad consultation among potential actors, in order to define short, medium and long-term objectives in the area of emerging technologies.

Given the competition between conventional products and those derived from biotechnologies, African countries should diversify their output and promote biotechnologies to achieve food self-sufficiency, reduce poverty and meet the challenge of globalization.

In terms of scientific development, the manner in which concepts are used is in flux. Biology, to develop as a science, needed chemistry, physics, mathematics, etc. As a result of biotechnologies, we are witnessing a reversal of this trend, as biology becomes a source of models for other sciences: robots patterned on insects, microchips patterned on neurons, etc. A high priority should be placed on a total reform of schools and universities in order to produce qualified individuals who can properly utilize biotechnologies.

African countries should hasten to implement regulations guaranteeing intellectual property in order to protect their plants and animals from international piracy and to give researchers the right and the duty to protect farmers from being forced to accept only seeds produced outside the continent;

National guidelines should be established to protect local biodiversity from anarchic management. Given the fear of losing rare species forever, each country should establish a gene bank for future generations;

Efforts should be made to draft national biosafety guidelines that can lead to regulations on the use of transgenic plants and the development of a national biosafety framework;

Every African country should attach great importance to ethical considerations, and the welfare of the underprivileged should be the first priority;

African governments should encourage and promote subregional and regional cooperation in the development and use of biotechnologies through seminars, conferences, collaborative research, networking, etc.

Every new scientific discovery or development can have positive or negative impacts on society. It is incumbent upon the users of the technology to make rational choices, based on what is best for mankind. Biotechnologies are part of the picture. This is why precautions need to be taken in order to avoid a disaster. We have already embarked on this human adventure, and each of us must contribute as best we can to ensure that the adventure is successful and that we arrive at our intended destination.

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