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AGRICULTURAL BIOTECHNOLOGY AND FOOD SECURITY: IMPLICATIONS FOR THE CARIBBEAN

Compton Paul, *Executive Secretary, PROCICARIBE, CARDI, UWI Campus, St. Augustine, Trinidad*

ABSTRACT: Potential candidates of biotechnology such as poverty alleviation and enhanced food security and nutrition in developing countries have received little attention. Serageldin (1999) is of the opinion that biotechnology can contribute to future food security if it benefits sustainable small-farm agriculture but important questions relating to ethics, intellectual property rights, and biosafety must be addressed. In the Caribbean where new agricultural land is scarce, farmers must make gains in productivity if they are to compete in the global marketplace. While it is recognised that the region's agriculture must encompass a broader vision that includes effective policies; genetic improvement; sustainable production systems that incorporate integrated pest management and sound natural resource management; synergies among livestock, agroforestry, cropping systems and aquaculture; attention to post harvest technologies and quality assurance systems; and marketing and agribusiness. While current application of modern biotechnology is focused on industrial country agriculture, biotechnology holds great promise as a paradigm shift necessary for solving the problems of food security, poverty alleviation and environmental protection of the region. Collaboration among public and private sectors, NGOs, universities and other institutions, and other R&D stakeholders will be necessary to enable the complexity of issues surrounding biotechnology to be adequately addressed. The Caribbean cannot and must not stand idly by while others make use of the gene revolution and place the region at a disadvantage in its efforts to compete in the global marketplace.

INTRODUCTION

The main challenge in ensuring food security in the Caribbean region will be to sustain efficient traditional crop production while diversifying to non-traditional and increasing productivity in fast-growing commodities and higher-value products. The sector must feed a growing population while facing increasing competition from abroad. Greater attention must be given to the economies of production and the identification, selection, adaptation and transfer of technologies which are capable of enhancing the commercial viability and sustainability of production and marketing systems. The focus must be on food security, increased exports and improved income and productivity in the agricultural sector (Parasram and Paul, 1996).

The region must focus on specific commodities that offer the greatest comparative advantage either as primary products or through added value while targeting industries that are efficient. Niche markets in North America and Europe are important for extra-regional exports while regional and domestic markets must target the tourism and hospitality sectors and supermarkets.

Caribbean agriculture employs more than 20% of the labour force in several countries and is considered a key to the alleviation of poverty and food security. Generally, the poor depend on agriculture for 40-100% of their income (Mc Intosh, 1996). They farm marginal hillsides and cause severe erosion of soils leading to lower productivity, deforestation, overgrazing, biodiversity and habitat loss, and environmental degradation. About 38% (13 million) of the region's people are considered poor; in Haiti, 94% of the population lives below the poverty line. The integrated poverty index shows that Jamaica, Dominica, Haiti, Guyana and the Dominican Republic are the poorest countries (Paul, 2000c).

While agriculture provides an effective solution to the poverty and food security problem of the region, governments must provide the correct policies and infrastructure that provide services in areas where they have special advantage, e.g., rural areas where resource poor farmers operate. These policies at the national and regional levels must be based on the needs of farmers and the marketplace. Special consideration must be given to small farmers that face the prospect of annihilation in the face of trade liberalisation; unless they organise themselves into production and marketing blocs that are supported by an enabling policy and marketing environment, they will have to abandon farming.

Sustainable development of the Caribbean's agricultural sector will require advanced technology generation and application as the region's farmers intensify agriculture on decreasing arable land. There must be integration of genetic enhancement efforts with those in production systems, post-harvest technology, marketing and agribusiness development. More research must be directed to develop appropriate technology for sustainable intensification of agriculture in resource poor areas and where ecosystems are fragile.

Biotechnology is a modern tool of agricultural research that can contribute to food security by increasing agricultural productivity on smallholder farms of the Caribbean. But this cutting-edge technology raises important questions relating to ethics, intellectual property rights, and biosafety. However, governments must ensure that access to potential benefits from biotechnologies are guaranteed for poor people and environmental conservation.

WHAT IS BIOTECHNOLOGY?

Biotechnology includes any technique that uses living organisms, or substances from living organisms, to make or modify a product, to improve plants or animals, or to develop micro-organisms for specific uses (Cohen, 1994).

Bio-engineering is a part of biotechnology and is based on the discovery that certain enzymes can cut the DNA molecule at specific sites while others can join the pieces in new combinations (recombinant DNA molecules). This has increased scientists' ability to transfer genes from DNA across species boundaries, thus creating transgenic plants and animals (Cohen, 1994). One way of transferring genes is by the insertion of the desirable gene into the bacterium *Agrobacterium tumefaciens* and then infecting the recipient plant with the bacterium – the bacterium infects by inserting some of its own DNA directly into the DNA of the plant. The cells containing the new desired gene are identified and grown into a whole plant using cell culture technology. Another transfer technology is by coating small tungsten balls with DNA containing the desired genes and physically shooting the balls into the recipient plant cells (gene gun approach). Some of the genes come off the balls and are incorporated into the DNA of the recipient plant.

The development of *in vitro* tissue and cell culture techniques has occurred parallel with advances in molecular biology and genetic engineering. Tissue culture techniques make it possible to regenerate a whole plant from a small piece of tissue, and even from a single cell, by growing it in a suitable medium.

APPLICATIONS OF BIOTECHNOLOGY

Crop Improvement

Diagnosis of pests and diseases has been improved by molecular techniques. Tissue culture techniques enable the production of disease-free plantlets and the construction of transgenic plants by enabling the regeneration of transformed cells containing desirable genes. Micropropagation techniques enable rapid multiplication of vegetatively propagated crops and three species.

In 1999, approximately 40M ha of land were planted worldwide with transgenic varieties of over 20 plant species. The main countries where these are grown are the USA, Argentina, Australia, Canada, France, China, Mexico, South Africa and Spain. The commercially important varieties are soybean, corn, cotton, rapeseed, tobacco, tomato, potato and squash (James, 1999). The traits of the transgenics are mostly insect resistance, higher nutritional quality, herbicide tolerance, delayed fruit ripening and virus resistance. Benefits include better pest and disease control, higher productivity, lower cost of production, and reduced pesticide levels in the environment.

The use of genetic markers, maps, and genome information is improving both the accuracy and time to commercial use of single and polygenic traits in plant breeding.

The technical ability to transfer genes across biological organisms has markedly expanded the range of useful traits that ultimately can be applied to the development of new crop cultivars. Plant genome studies are enabling the application of recombinant DNA technology to crop improvement by identifying the genes that control agriculturally important traits and how they act to do so (Serageldin and Persley, 2000).

Characterising Biodiversity: Genomics plays a key role in the characterisation and conservation of genetic resources by identifying useful genes in germplasm accessions and wild species among the biodiversity.

Bioinformatics: Genomic data must be compiled, managed, and analysed for use in molecular biology, genome sequencing, and comparative genetics useful to genetic improvement of crops and animals. The development of genetic databases and the integration of bioinformatics systems at the national, regional and international levels are essential.

Livestock Improvement: In the Caribbean, constraints to livestock improvement include genetics, health, and nutrition. Biotechnology is being applied to speed up reproduction processes to enable more efficient selection of breeds with improved productivity. Transgenic livestock such as pigs can be used as a source of tissue and organs as transplants into humans. Human biological pharmaceuticals are presently being produced from sheep milk. Work is being carried out to find genes for disease tolerance, heat tolerance, and other adaptive and productive traits in wildlife and transferring these to domestic livestock. Molecular technologies are being used to study livestock parasites and other pathogens so that vaccines can be produced against the parasites.

Fish and Aquaculture: Molecular marking, genome mapping, trait selection, sex manipulation, and disease diagnosis are some of the biotechnology activities being used to increase fish stocks and feed efficiency conversion to protein.

CONSTRAINTS TO THE APPLICATION OF BIOTECHNOLOGY

The key policy constraints to the application of biotechnology are ethics, intellectual property rights and biosafety.

Ethics

The exploiting of the developing world's indigenous genetic resources by transnational corporations that then sell patented transformed superior plants and animals back to developing countries at high prices (biopiracy) holds questions of ethics. The transnational enterprises argue that the biodiversity in public access resources such as forests and seas should be exploited for genes useful to all mankind including the developing countries themselves.

There are also several questions of an economic, social, ecological, religious, political, or cultural nature that require open debate and regulation at the national, regional and international levels.

Intellectual Property Rights (IPR)

Scientific products of biotechnology may be protected by plant variety protection, patents, and /or trade secrets. IPR affects the commercialisation and trans-boundary movement of genetic resources and products. The 1995 WTO Agreement on Trade-related aspects of IPR (TRIPs) requires all members to adopt legislation to ensure minimum protection standards for their intellectual property. As developed countries have moved to protect their intellectual products of biotechnology, developing countries have moved to protect their genetic resources. In 1992, the Convention on Biological Diversity (CBD) enabled benefit sharing among countries if financial returns accrue from exported genetic resources.

Since the private sector holds property rights to most biotechnology products, the public sector should seek to cooperate with the private sector in research and product development. National governments should develop multilateral agreements for germplasm acquisition and transfer.

Biosafety

Biosafety involves food safety and environmental safety. Public concern over adverse effects of genetically modified foods has been based on risks related to toxins, allergens and carcinogens. Although many consumers in North America, Europe and China have been eating genetically improved food over the past several years without any demonstrated adverse effects on their health, the long-term effects are unknown. Food labeling can provide information useful for consumers' decisions on using the foods. Supporters of biotechnology argue that the testing and regulatory processes applied to genetically modified foods are capable of addressing consumers' concerns.

Critics are concerned by the potential environmental damage that might be caused by transgenic crops crossing with related species and producing superweeds resistant to herbicides or by their effects on other parts of the ecosystem (for example, genetic pollution through pollen or seed dispersal, or transfer of foreign genes to micro-organisms).

The Cartagena Protocol on Biosafety was signed by 130 countries that are signatories to the CBD in January 2000 and sets out obligations for international transfer of living modified organisms that my threaten biodiversity. The Protocol also outlines general procedures for risk assessment. But the safe use of biotechnology products requires efficient regulatory systems at the institutional and national levels, guidelines for field tests and release, labeling of novel products, and scientific research on possible short and long-term effects on the environment. Of course, national and/or regional capacity to follow these guidelines is critical (Serageldin and Persley, 2000).

IMPLICATIONS FOR THE CARIBBEAN

Scientific and technical capabilities for the development and use of biotechnologies are growing in the region. Biotechnologies are being utilised in the preservation, handling, exchange and massive propagation of plants, genetic improvement of plants, and symbiotic nitrogen fixation. Emphasis is on cell research, the most common techniques being cell culture, cloning of buds and meristems, anther and ovary culture, and protoplast culture and fusion all of which require relatively low cost equipment and give short-term results. Less importance is given to molecular biology, although genetic engineering techniques are used in Cuba and at UWI Campuses in Jamaica, Barbados and Trinidad (Chaverra, 1984).

Several international codes of ethics, protocols, and regulations (Biosafety Protocol; International Code of Conduct for the release of GMO's; Third World Network Model Biosafety Law; Codex Alimentarius Commission of FAO; and Technical Barriers to Trade (TBT), Sanitary and Phytosanitary (SPS) and TRIPs Agreements of the WTO) can assist Caribbean countries to develop regulatory frameworks and in establishing standards for the safe development, manufacture, use, release, trade and trans-boundary movement of GMO's. But the countries will require scientific and technical expertise and information systems for all aspects including risk assessment and public awareness. Therefore, there will be the need for institutional capacity development and multidisciplinary teams dedicated to finding more sustainable farming systems. This is even more important since the larger farmers are likely to capture most of the benefits from biotechnology unless small farmers have access to delivery systems, extension services, markets, transport and infrastructure.

Because improved plant material produced by biotechnology is owned by a few private multinational corporations, there is no focus on small farmers (Pinstrup Andersen and Cohen, 1999). This means that in order to tackle food security by the use of biotechnology in the Caribbean, staples such as root crops, tropical fruits and vegetables, and livestock, need to be addressed. Also, Caribbean problems of drought, poor soil fertility (nitrogen, phosphorus, trace elements), pests and diseases, low productivity and nutritional quality, and the storage life of primary products, need to be researched. But such research must be done by public institutions such as the UWI and CARDI which need to form strategic alliances with the private sector and with IARC's and other RARO's so as to ensure that biotechnology serves the poor small farmers. The best approach appears to be the use of conventional breeding and tissue culture technologies rather than the use of transgenics which are extremely expensive to produce and subject to IPR, ethics, and biosafety restrictions.

As Caribbean countries attempt to manage and protect their genetic resources, they will need to collaborate with each other. The Caribbean Plant Genetic Resources Network (CAPGERNET) under PROCICARIBE has a membership of 18 countries and can serve as the mechanism for this collaboration. CAPGERNET also has strong linkages with IARC's such as The International Plant Genetic Resources Institute (IPGRI).

The region must assess the potential social and economic benefits of biotechnology against the costs and potential risks involved. As they import products from countries that grow GMO's they must be watchful and carry out the necessary testing even if there is labeling. This is even more important since the region will face restrictions on its exports to countries such as those of the EU most of which do not permit the importation of GM products.

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