CARIBBEAN FOOD CROPS SOCIETY

40

Fortieth

Annual Meeting 2004

Proceedings of the Caribbean Food Crops Society. 40:235-245. 2004

THE PAST, PRESENT AND FUTURE OF AGROBIOTECHNOLOGY IN THE CARIBBEAN REGION

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ABSTRACT: Many small farms growing complexes of crops and animals mainly for local consumption, and a few major farms, growing mainly plantation crops for export, characterize agriculture in the Caribbean. Throughout the region, agricultural production has been falling. There is an urgent need for the application of technology, especially in terms of crop improvement. Recently, there is a quiet and growing trend towards using biotechnology to augment the more traditional breeding methods to increase crop yields. Some of the crops being enhanced include hot pepper, anthuriums, papaya, cotton, medicinal plants and even sugarcane by marker-assisted breeding and by transformation. These developments have more-or-less been happening in isolation with Cuba being the most advanced and Haiti the least. Associated with these developments has been an increasing trend towards regional networking with several attempts starting in 1990 and continuing to present. There is at the moment no regulatory/policy biotechnology or biosafety framework in the region although several Caribbean countries (15) are developing regulatory frameworks with the assistance of UNEP/GEF for eventual signing of the CBD Cartagena protocol. Several national and regional bodies e.g. IICA, FAO, CARDI, UWI, IDIAF, and specialists in several Caribbean countries are now joining forces to establish a regional agenda in biotechnology and a Consultative Group for AgroBiotechnology in the Caribbean (CGABC) whose first order of business will be to develop a regional biosafety framework and establish regional projects in agrobiotechnology. The significance of these developments will be discussed.

INTRODUCTION

The new millennium is as good a point as any to reflect on where we are coming from as a Caribbean people, and where we are going, as it pertains to the development of agriculture. Agriculture has always been a part of the Caribbean's development. Its modern genesis can probably be found in the large-scale plantations when sugar was "King" because before this, agriculture was at a subsistence level. Agriculture, however, if it is to serve the needs of the Caribbean people, will need to diversify and become more competitive by increased application of (bio)technology.

The Caribbean consists of many island states (24) and other countries (Belize, Guyana, French Guiana and Suriname), which traditionally are considered as part of the Caribbean. The Caribbean is considered to be a "hotspot"- an area with a large percentage of endemic flora and fauna, but with significant impaction and alteration by human activity. The Caribbean has 2.3% endemic plant species and 2.9% endemic vertebrate species on 0.15% of the earth's surface. Only 10% of the natural vegetation remains. The Caribbean "hotspot" includes most of the Caribbean islands and the southern tip of Florida spanning 263,535 km^2 of land and 4.31 million km^2 of ocean. In the Caribbean, the majority of the agricultural crops have their origin elsewhere but there are a lot of local landraces and variations. The Caribbean also has many niche crops such as pimento, ginger, hot pepper, ackee, coffee and nutmeg around which agriculture is

slowly diversifying.

CHARACTERISTICS OF CARIBBEAN AGRICULTURE

Caribbean agriculture has characteristically been dependent on a few plantation crops e.g. sugarcane, rice and banana although the main agricultural crop differs with country (Table 1). Sugarcane still represents 27% of total crop output in the Caribbean (Mitchell and Ahmad, 2003). Most, if not all of these commodity crops are losing their preferential markets and prices are dropping (e.g. there was a 64%, in real terms, in banana prices between 1990 and 2000) while inputs and market demands are rising. Farm size in the region is characteristically small, and uncompetitive. The planting material tends to be unimproved and diseased. Soil conditions, over the years, have tended to deteriorate due to many years of monocropping without crop rotation or rest. On top of this, there have been relatively low levels of R&D applied to agriculture over the years. Where research is done, it does not get implemented as widely as hoped probably because the linkages between research, primary production, agroprocessing and markets are poor (Bauer, 2002).

Collaboration among researchers in the region has also been low and key opportunities are being missed. Technology urgently needs to be applied to agriculture if yields are to be increased. Increasingly, biotechnology is being applied to Caribbean Agriculture with promising results (Sasson, 2000). If biotechnology is to come to the service of Caribbean agriculture – all these negative characteristics of Caribbean agriculture will have to be addressed.

AGRICULTURAL PRODUCTION IN THE CARIBBEAN

Agricultural production in the Caribbean has been dropping, when compared to our neighbours: Central America, Andes, Mexico, and the Southern Cone of South America (Figure 1). The reasons for the drop in agricultural production are many but probably include: unfavorable weather, increased disease incidences, new diseases, use of diseased planting material, and deterioration of soil conditions. A few examples will suffice. The citrus tristeza disease was reported in Jamaica from 1959 but severe strains of the virus were discovered in 1992.

The Brown Citrus aphid recently was found in Jamaica and Cuba in 1993 after migration into the Caribbean from Venezuela in 1989 (Edman and Young 1998). Ginger has been grown commercially in Jamaica since 1547 but recently, in 1995, an abnormal incidence of rhizome rot was experienced with a 30% average loss at harvest in 1997 (Chung 1998). This increase in virulent disease strains can be countered by the use of improved plant varieties; produced by conventional or marker-assisted breeding or by transformation. Cultural practices can be improved by the use of biopesticides, organic and biofertilizers and soil ameliorants. The application of biotechnology to agriculture in the Caribbean is beginning to influence productivity but there is a lot more that needs to be done.

AGRICULTURAL RESEARCH AND DEVELOPMENT IN THE CARIBBEAN

Cuba has the most developed agricultural research and development system in the Caribbean with 60 agencies and 1500-2000 FTE (full-time equivalents) (Roseboom et al., 2001). The rest of the Caribbean has approximately 150 agencies and about 1000 agricultural

researchers conducting research in crop (56%), livestock (13%), natural resource management (14%), forestry (3%), fisheries (5%) and post-harvest (5%) production. Haiti is the least developed. Of the other 26 countries in the Caribbean - 12 had less than 10 FTE, 20 had less than 50 FTE and none had more than 200 FTE. Of the 116 agricultural research agencies that gave data, 84 had <10 FTE and 62 had less than 5 FTE. About a third of the crop research capacity in the Caribbean focuses on traditional export crops: sugar, cocoa, coffee and banana. Another third focuses on vegetable, fruits and ornamentals. The remaining third consists of a broad range of other crops. The relatively small degree of livestock research focuses on small ruminants (26%), cattle (24%), pigs (19%), animal health (13%), animal feed (9%) and poultry (9%) and has produced several tropical breeds (Roseboom et al., 2001).

Biotechnology has been used to augment more traditional Caribbean agricultural research in several key areas (CAFP, 1999; Mitchell and Ahmad, 2003). These include the following:

- Clonal multiplication - for experimental use and for production of large quantities of disease-indexed planting material (micropropagation, somatic embryogenesis)
- Characterization of biodiversity/ Bioprospecting (Molecular biology, Natural Products)
- Increased disease resistance (marker-assisted breeding)
- Biopesticides/ bioinoculants/ biofertilizers – improvement of soils, for organic agriculture
- Diagnostics for disease detection including gemini viruses (molecular biology)
- Increased genetic efficiency (tissue culture, genetic engineering)
- Bioenergy (Fermentation)
- Bioinformatics (Information gathering, analysis and dissemination)
- Biolivestock (Embryo transfer)

Although the Caribbean, as a whole, has been able to develop their agrobiotechnology to an advanced level, several problems remain:

- Uneven and Low capacity – infrastructure, human, and capital
- Low national and international investments in agrobiotechnology R&D
- Low recurrent budgets
- Very low entrepreneurial and innovation training
- IP protection low and underutilized
- Low co-ordination and collaboration between research groups
- No regional policy or regulatory framework for biotechnology or/and biosafety
- Lack of knowledge and use of regional opportunities.

POLICIES AND REGULATIONS

Biotechnology as a whole does not need to be regulated. Marker-assisted breeding can be used to speed up conventional breeding without needing regulations. With the advent of genetic engineering, however, there are potential risks to human health (allergies) and to biodiversity (especially endemic species) – which is greater in the tropics than in temperate countries – so

there is need for regulations. In every country in which biotechnology has been applied to agriculture, regulations have been adopted. A new variety is released after assessment of agronomic performance, proximate analysis, and antinutritive factors (McHughen, 2002).

Transgenic plants are also assessed in this manner as well as by genetic analysis and biological activity of the inserted DNA including its stability, food equivalency, toxicity and allergenicity trials, yield trials and testing for environmental effects (pathogenicity to other organisms, possibility of outcrossing, gene transfer, interaction with other organisms, invasiveness, etc). Regulations also include plans for containment and eradication in the event of escape (McHughen, 2002). The best biosafety regulations allow for decisions to be made based on the most current health and ecological data.

WHY THE INTEREST IN GMOs?

World populations are increasing and the amount of arable land is decreasing so the only way to provide enough food for the population is by increasing yields. The yields of the green revolution were achieved by application of expensive inputs and were not conducive to soil fertility. To further increase yields, the plants themselves have to be improved – by breeding, marker-assisted breeding and/or by genetic engineering. Many countries are now growing genetically engineered crops (Figure 2).

The use of genetically engineered crops has increased dramatically because farmers are experiencing greater profit margins. In 1996 there were 3 million ha of transgenic crops and by 1998 this had jumped to 34 million ha. In 1996, in the US alone, there were 15 genetically novel products on the market worth US$380 million (Izquierdo and Riva, 2000). In 1998, there were 1,300 biotechnology companies in the US, with more than 100,000 employees. In 2003 the global area in GM crops was 67.7 million hectares, grown by 7 million farmers in 18 countries, with a global market value of US $ 4.5 billion, and an increase of 15% in area over 2002 (James, 2003). Almost one-third of the global transgenic crop was grown in developing countries. Brazil and the Philippines approved planting of GM crops for the first time in 2003.

PLANT GENETIC ENGINEERING IN THE CARIBBEAN

The first Genetically Modified Organisms (GMOs) were planted in Latin America and the Caribbean (LAC) without any regulations. The first regulations governing the release of GMOs into the environment appeared by the late 1980s – early 1990s in Brazil, Cuba and Mexico. In Mexico – field trials of locally-produced transgenic tobacco potato and chili pepper were authorized in 1980s, but released only in 1995. The reason for the time gap was due to concerns because of the high local biological diversity, insufficient capacity of producers to manage the transgenic crop, and the non-existence of an adequate regulatory framework (Sasson, 2000).

The Caribbean has the local capability to produce transgenic plants in Cuba, Jamaica, Trinidad and Tobago and the USVI (Sasson, 2000; Mitchell and Ahmad, 2003). Field testing of many of these transgenic crops is already being carried out while the transgenic crops in the USVI have already been deregulated (Zimmerman pers comm). The USVI and Puerto Rico, as US states, follow USDA/FDA guidelines. For the rest of the Caribbean there is no regional policy or regulatory framework for biosafety. National policies have not yet been ratified.
Transgenic crops in the Caribbean:

- Cuba – sugarcane, banana, plantain, potato, papaya, tomato, corn, sweet potato, rice, coffee, citrus, pineapple
- Jamaica – papaya, cotton, tomato, pepper
- T&T – anthuriums, cacao
- USVI – sweet potato, cassava, papaya

Some introduced traits: resistance to ring spot virus (papaya), enhanced protein content (sweet potato), rust and smut resistance, modified lignin content (sugar-cane), leaf roll virus (potato), gemini virus resistance (tomato), and glufosinate-tolerance (papaya, maize) (Sasson 2000).

NETWORKING EFFORTS FOR A REGIONAL STRATEGY IN AGROBIOTECHNOLOGY

Every review done on Caribbean agriculture comes to the same conclusion: although enhancing the scale of agricultural research through regional cooperation and networking is not a new idea, it is one that should be pursued more intensively and with more conviction (Roseboom et al 2001). In the Caribbean, we have much to share with each other, as each country has been developing its own capabilities, often in isolation from each other. Indeed, there has been recognition of this fact, as there has been an increasing trend towards networking within the Caribbean region and this trend is continuing up to the present (Box 1).

Box 1. Regional networks and institutions relevant to AgroBiotechnology in the Caribbean.

Date of inception of initiative	
1942	Interamerican Institute for Co-operation in Agriculture, IICA (www.iica.int/home.asp) – now in 34 member countries throughout the Americas from Canada to Chile
1948	University of the West Indies, UWI (www.uwicentre.edu.jm/) – three campuses and 12 centres throughout the Caribbean – serves 15 Caribbean countries.
1975	Caribbean Agricultural Research and Development, CARDI (www.cardi.org) – produced the Caribbean Agricultural Science and Technology Networking System, PROCICARIBE (www.procicaribe.org) in collaboration with IDB, IICA and 22 member states in 1996. This includes several networks including the Caribbean Agricultural Information Service, CAIS (http://www.caisnet.org).
1990	Technical co-operation Network on Plant Biotechnology in Latin America and the Caribbean, REDBIO/FAO (http://www.redbio.org/) – 549 labs in 32 LAC countries
1991	Caribbean Biotechnology Network, CBN – directory listed 12 countries and 57 Caribbean biotechnologists (DaSilva and Taylor 1998)
1993	SIMBIOSIS (www.bdt.org.br/bdt/simbiosis) – initiative of Chile – several countries using this facility. Expanded into the Caribbean in 1998.
1995	IICA Caribbean Regional Centre - http://www.agroinfo.org/caribbean/iicacarc/
1996	UNU/BIOLAC – has provided 127 fellowships – 21 from Caribbean (Cuba, DR, Barbados) (Daza 1998, Sasson 2000)
1999	REDBIO-Caribbean – 15 countries, 40 Caribbean biotechnologists
1999	Increase in regional agrobiotechnology projects in the Caribbean: OAS 1999-2001 – 4 countries; CARDI Hot pepper - many countries; Gemini viruses – 5 countries

REGIONAL STRATEGY FOR AGROBIOTECHNOLOGY

In spite of the regional networks presently in place, a regional strategy for agrobiotechnology is still needed. Even the gathering of the data presented in this paper is the result of the present effort towards developing a regional agenda. A concerted effort is needed so that present research and development can be safely utilized. There is, at the momen, no regulatory/policy biotechnology or biosafety framework in the region although several Caribbean countries (15) are developing regulatory frameworks with the assistance of UNEP/GEF for eventual signing of the CBD Cartagena protocol (http://www.unep.ch/biosafety/). The regulatory framework in Puerto Rico and the United States Virgin Islands as states of the USA follows USDA/FDA/APHIS guidelines. Other than these countries, Cuba has the most developed working biosafety regulatory framework in the Caribbean. A regional focus can speed up development of a regional biosafety framework (Verastegui et al., 2004, http://www.unep.ch/biosafety/). Such a focus will also:

- allow for a coordinated response
- increase national and regional capacity for R&D
- enhance collaboration
- allow for better data capture, analysis and relay
- allow for better planning and utilization of existing and future capacity, and
- allow for development of consistent policy and regulations

RESPONSE TO WORLD BIOTECHNOLOGY TRENDS BY CARIBBEAN AGROBIOTECHNOLOGISTS AND POLICY MAKERS

Although there are regional agricultural institutions (UWI, IICA, CARDI, FAO) in the Caribbean, it was felt that a biotechnology focus would assist in the further application of biotechnology to agriculture to increase its competitiveness. In March 2004, a group of regional biotechnologists and policy makers, with the support of IICA, met in the Dominican Republic to discuss ways to garner support for Caribbean biotechnology and how to take the opportunity of REDBIO2004 to present a regional agenda. Analysis of previous attempts at biotechnology networking and activities in the region was carried out and key issues were discussed (Mitchell, 2004). The outcome was the commissioning of a discussion paper that was presented at REDBIO2004, under a special work section to initiate a consultation process with the participants from the Caribbean countries, including Cuba to receive their inputs on two initiatives at the draft level; an agenda on agrobiotechnology and the constitution of the Consultative Group for Agricultural Biotechnology in the Caribbean (CGABC). Once the proposals have been finished and discussed with several stakeholders at the national and regional level, they will be taken to regional governments for endorsement after a consultation process.

THE FUTURE FOR AGROBIOTECHNOLOGY IN THE CARIBBEAN

Several national and regional bodies, as mentioned above, e.g. IICA, CARDI, UWI, IDIAF, FAO and specialists from several Caribbean countries have joined forces to formulate a proposal to establish a regional agenda in biotechnology. It is recognized that biotechnology has to serve the needs of agriculture and therefore its application has to be carefully planned within existing initiatives. Collaboration and co-ordination will encourage funding as economies of scale will be realized. It is proposed that a regional body be created to drive the above process.

The components of a regional agenda should address areas such as the following:

- Information and prospective analysis – bioinformatics, database and webpage development, networking between regional biotechnologists, e-newsletters - information capture, analysis and relay, developing networks with existing agricultural and biotechnology network and information systems.

- Policy and regulations – harmonization of biosafety conceptual frameworks, policy development, involvement of scientists in policy and trade issues, working with regional government mandates.
- Research and development – strengthening of entire science base, collaboration, critical mass of scientists, equipment, projects and discretionary funds, cutting-edge applied to pressing problems, regional projects.
- Capacity building – for S&T, R&D but also in biosafety, policy, law, commercialization, intellectual property and trade related activities, taking advantage of existing opportunities.
- Commercialization and trade – taking developed innovations to the marketplace ensuring that the benefit remains in the country with as wide a base as possible, incubator centres, bio-parks.
- Education and public perception – informing the public about safe use of agrobiotechnology, preparation of educational material: guides, programs and syllabuses.

It is proposed that a Consultative Group for AgroBiotechnology in the Caribbean (CGABC) be established to drive this regional agenda. The success of this agenda will ultimately depend on us and your support is important as we develop as a region – as a Caribbean people.

ACKNOWLEDGEMENTS

The present effort towards developing a regional agrobiotechnology agenda as reported in this paper represents the work of many Caribbean Biotechnologists and this paper is written in support of this collaborative effort. Key personnel assisting in this process include Arlington Chesney (IICA, Director of Operations, Caribbean Region and Advisor to the Director General on Caribbean Affairs), Enrique Alaracon (IICA, Costa Rica), Aaron Parke (IICA, Trinidad), Rufino Perez (IDIAF, Dominican Republic), Maria Perez (GEPROP, Cuba), Cyril Roberts (CARDI, Barbados), Malachy Dottin (Grenada) and Pathmanathan Umaharan (UWI, Trinidad and Tobago). The financial and technical assistance of IICA and CTA in this process is gratefully acknowledged. The author also acknowledges with thanks funding from USDA that made the trip to USVI possible and the group presentations at CFCS a success.

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Table 1. Main Agricultural Crops in seven Caribbean countries (as a percentage of total area planted in 2000). Source: ECLAC, Agricultural Development Unit, based on figures of FAO, as given in IICA and ECLAC (2002).

Country	Sugarcane	Rice	Fruit*	Corn	Root and Tubers	Citrus	Vegetables	Coffee
Bahamas	50.1	0	4.9	13.2	2.0	2.4	19.2	0
Barbados	87.7	0	1.8	7.8	0.3	0	2.4	0
Guyana	39.8	51.0	2.9	2.6	2.0	0.9	0.2	0.5
Haiti	2.7	8.4	13.6	43.4	12.2	2.0	0.2	8.7
Jamaica	46.3	0	22.0	2.1	1.7	16.4	3.7	6.1
DR	17.0	19.5	10.2	3.9	4.8	32.5	2.0	32.5
T&T	3.8	86.9	4.6	0.1	0.5	0.4	0.3	0.4

*Fruit includes bananas

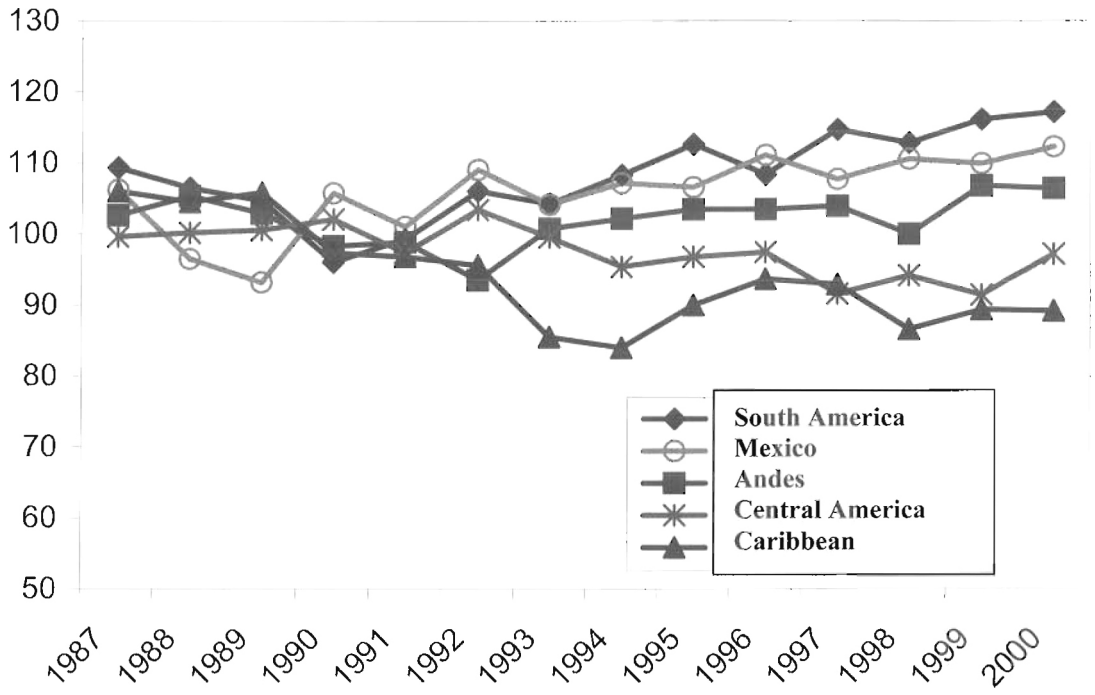

Figure 1. Agricultural production per capita - (includes cereals, root & tubers, meat, milk and eggs) Source: FAO. data, elaborated by the Directorate of Technology and Innovation, IICA

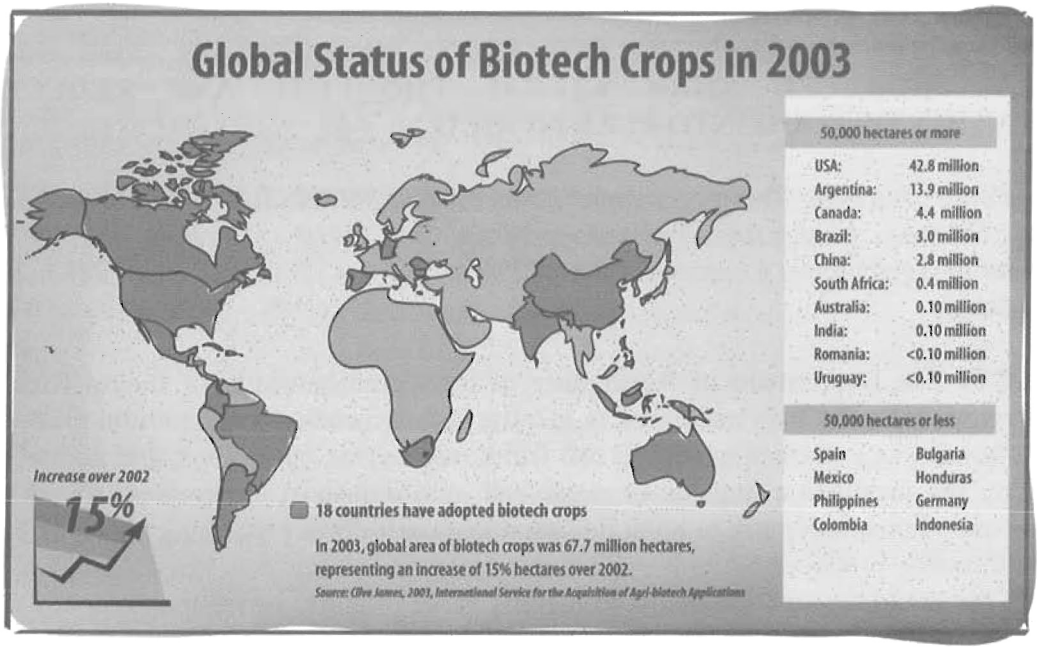

Figure 2. Global Status of Biotechnology Crops in 2003.