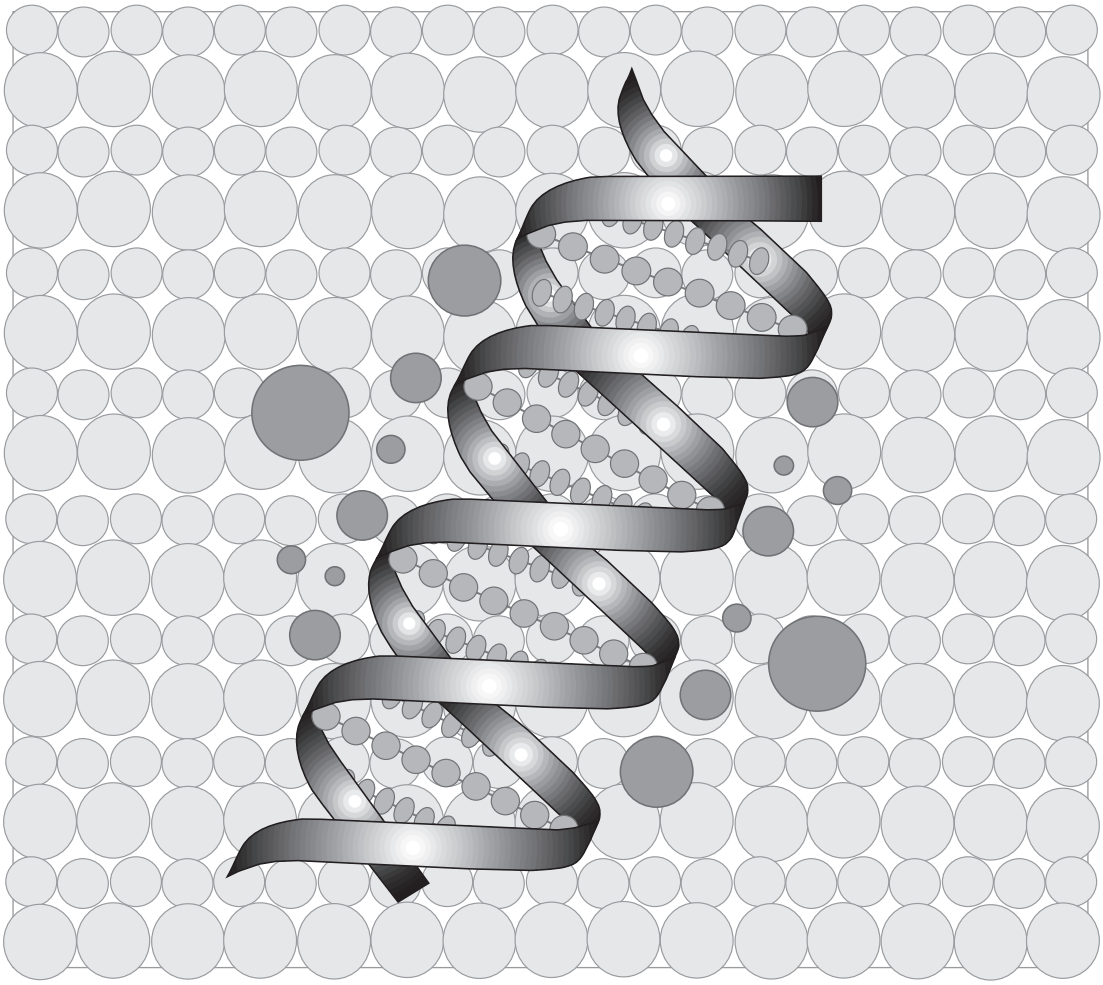
The Status of Agricultural Biotechnology in Selected West and Central African Countries



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Consultative Group on International Agricultural Research

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Foreword

The survey was conducted following the approval of a special request I made to the International Institute of Tropical Agriculture (IITA). In 1999 I carried out a survey on the status of biotechnology capacity in Eastern and Southern Africa under a consultancy with the Food and Agriculture Organization of the United Nations. As the head of a major national agricultural research institute in West Africa (The Council for Scientific and Industrial Research—Ghana) it was my desire to establish similar baseline information for West and Central Africa to assist with networking among similar scientific institutions. The Ghana–Nigeria initiative for fast-track collaboration further made the study relevant. Given the shift in emphasis by the Ghana government towards capacity building in biotechnology, such a study could create the platform for the envisaged networking.

W.S. Alhassan
Visiting scientist

Summary

In the light of dwindling input resources for agriculture, the Green Revolution-based technology which used liberal amounts of chemical fertilizers, irrigation, land, and improved plant cultivars must give place to newer technologies which can greatly economize on the Green Revolution technology inputs. Modern biotechnology is an integral part of these new efficient technologies. The tools of biotechnology vary in complexity from tissue culture to the use of genetic markers in plant and animal breeding, and genetic engineering.

The objectives of this survey were to present an update on current biotechnology capacity (human, infrastructure, and financial support) in Cameroon, Ghana, Côte d'Ivoire, Nigeria, and Senegal, which were the survey countries. The biotechnology policy of these countries involving biosafety, research, and development policy was to be documented. The basis of a regional cooperation in the creation and operation of centers of excellence in agricultural biotechnology was to be determined. Other objectives included the extent of technology transfer to farmers and private sector agencies for commercialization and the creation of a platform for networking among scientists.

The study methodology was through structured questionnaires and visits. The survey targets were the national agricultural research system (NARS), Conférence des responsables africains et français de la recherche agronomique (CORAF), West African Council for Agricultural Research and Development (WECARD), government ministries for science and technology, international agricultural research centers (IARCs) and donor agencies.

The survey was conducted from the beginning of August to the end of October 2000. Thirty-six out of 38 institutions of the NARS responded to the questionnaire. All government ministries and most IARCs responded to the questionnaires. Response from donors was low.

The most frequently used biotechnology tool in all countries surveyed was tissue culture. The predominant crops produced from tissue culture were cassava, banana, plantain, and oil palm. Oil palm tissue culture plantlets were most developed in Côte d'Ivoire whilst other tree crop tissue culture was most developed in Senegal. The next most frequently used biotechnology tool was deoxyribonucleic acid (DNA) fingerprinting or gene mapping.

Most of the biotechnology laboratories in francophone countries were regarded as suitable for biotechnology work whereas most of those in anglophone countries were not considered suitable due to the unreliable electric power supply. Nigerian laboratories were the most unsuitable on account of this. Côte d'Ivoire had the most advanced biotechnology research center. All countries were generally receptive to the idea of a regional center of excellence.

Biotechnology manpower strength was best in Nigeria, followed by Ghana, Cameroon, Senegal, and Côte d'Ivoire. Cameroon and Côte d'Ivoire were the only countries that

had brought their biosafety laws to the point of legislation. The Cameroonian biosafety law was the only one containing the precautionary principle. All countries surveyed were prepared to harmonize their biosafety laws with those of others in the region.

The most important constraints to biotechnology in West Africa were finance, laboratory equipment, access to reagents, manpower, and information exchange. All governments were committed to building human and material capacity in biotechnology but this commitment was, apart from Côte d'Ivoire, not backed with adequate funding support. CORAF/WECARD had no clearly defined biotechnology capacity building policy for this region. None of the countries surveyed had any laws to deal with the issue of biopiracy though they were conscious of the need for such laws. CORAF/WECARD is urged to take the initiative in the creation of a regional center of excellence.

The IARCs were the International Institute of Tropical Agriculture (IITA), the West Africa Rice Development Association (WARDA), the International Livestock Research Institute (ILRI), and the International Service for National Agricultural Research (ISNAR). IITA was the most active for biotechnology research and training of their NARS partners.The most active donors for biotechnology capacity building and research support were the Rockefeller Foundation and the United States Agency for International Development (USAID). Other suggestions for the way forward in biotechnology for West Africa are also included in this report.

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Acronyms and abbreviations

AAB	Agence africaine de biotechnologie. African Agency for Biotechnology
ABSP	Agricultural Biotechnology for Sustainable Productivity
ARIS	advanced research institutes
ARO	agricultural research organizations
ASARECA	Association for Strengthening Agricultural Research in Eastern and Southern Africa
ATRIP	Agricultural Trade and Investment Program
BIOEARN	East Africa Regional Biotechnology Programme and Research Network
BNARI	Biotechnology and Nuclear Research Institute
CAMBIA	Centre for the Application of Molecular Biology to International Agriculture
CBEN	Centre de biotechnologie/ Ecole normale
CERAAS	Centre d'etude régional pour l'amélioration d'adaptation à la sécheresse
CGIAR	Consultative Group on International Agricultural Research
CIRAD	Centre de coopération internationale en recherche agonomique pour le développement
CNRA	Centre national de recherche agronomique
CORAF	Conférence des responsables africains et français de la recherche agronomique
CRBP	Centre de recherches régionales sur bananiers et plantains
CRIG	Cocoa Research Institute of Ghana
CRIN	Cocoa Research Institute of Nigeria
CSIR	Council for Scientific and Industrial Research
CSIR–CRI	Crops Research Institute
CSIR–FRI	Food Research Institute
CSIR–SRI	Soil Research Institute
CSIR–STEPRI	Science and Technology Policy Research Institute
CSIR–WRI	Water Research Institute
Danida	Danish International Development Agency
DFID	Department for International Development
DGIS	Directorate General for International Cooperation (translated)
DNA	deoxyribonucleic acid
ECA	Economic Commission for Africa
ECOWAS	Economic Community of West African States
EMBL	European Molecular Biology Laboratory
FAO	Food and Agriculture Organization of the United Nations
GAEC	Ghana Atomic Energy Commission
GMO	genetically modified organism
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IARC	international agricultural research center
IAR&T	Institute of Agricultural Research and Training
IBS	Intermediate Biotechnology Service
ICGEB	International Centre for Genetic Engineering and Biotechnology
IDRC	International Development Research Centre
IFA	international funding agencies

IFPRI	International Food Policy Research Institute
ILCA	International Livestock Research Institute for Africa
IITA	International Institute of Tropical Agriculture
ILRAD	International Laboratory for Research on Animal Diseases
ILRI	International Livestock Research Institute
INIBAP	International Network for the Improvement of Banana and Plantain
IRA	Institute of Agronomic Research (now IRAD)
IRAD	Institute of Agricultural Research for Development
IRAD–CRBP	Centre de recherches régionales sur bananiers et plantains
IRD	Institut de recherches pour le développement
IREN	Institut de recherche sur les energies nouvelles
ISAAA	International Service for the Acquisition of Agricultural Biotechnology Applications
ISNAR	International Service for National Agricultural Research
ISRA	Institut Sénégalais de recherches agricoles
ISRA/URCIV	Unite de recherches de culture en vitro
ISRA/LNERV	Laboratoire national d'elevage et de recherches vétérinaires
KARI	Kenyan Agricultural Research Institute
MIRCEN	Microbiology Resources Research Center (translated)
MOFA–VSD	Ministry of Food and Agriculture, Veterinary Services Dpartment
MSU	Michigan State University
NACGRAB	National Centre for Genetic Resources and Biotechnology
NARS	national agricultural research systems
NAU	Nnamdi Azikiwe University
NIFOR	Nigeria Institute for Oil Palm Research
NIHORT	Nigerian Institute of Horticulture
NRCRI	National Root Crops Research Institute
NVRI	National Veterinary Research Institute
PQS	Plant Quarantine Service
RCSA	Regional Centre for Southern Africa
ROTREP	Root and Tuber Research Project
SADC	Southern African Development Community
SIDA	Swedish International Development Agency
SIRDC	Scientific and Industrial Research and Development Centre
UCAD	Université Cheik Anta Diop
UNDP	United Nations Development Program
UNESCO	United Nations Educational Scientific and Cultural Organization
UNIJOS	University of Jos
UNN	University of Nigeria, Nsukka
UPOV	International Union for the Protection of New Varieties
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WARDA	West Africa Rice Development Association
WECARD	West African Council for Agricultural Research and Development
WTO	World Trade Organization

1

Introduction

Projections by the International Food Policy Research Institute (IFPRI) indicate that global food production will continue to outstrip population growth and that per capita food production between 1995 and 2020 is supposed to increase by 7% (Pinstrup-Andersen et al.1999). However, the global food distribution pattern is such that 840 million people or 13% of the world population, mostly of the developing world, will face food insecurity. Most of these people will go to bed hungry each day. About 170 million school children are malnourished. Approximately, 5 million of these children die every year from nutrition-related illnesses. Many will go blind from vitamin A deficiency while anemia due to iron deficiency will predispose millions of women and children to various diseases (Pinstrup-Andersen 1999). It has been recognized that agricultural biotechnology can help farmers to produce more from improved crop cultivars that are pest resistant, drought tolerant, and efficient in nitrogen fixation. The edible plant parts can also be genetically modified to provide consumers with more micronutrients to correct for the deficiencies mentioned above.

Biotechnology is defined as any technique that uses living organisms or parts thereof to make or modify a product, improve plants or animals, or develop microorganisms for specific uses. All the characteristics of any given organism are encoded within its genetic material, which is a collection of deoxyribonucleic acid (DNA) molecules that exists in each cell of the organism. The complete set of DNA molecules in the organism makes up the genome. The genome contains the functional units called genes, i.e., the hereditary material (Serageldin and Persley 2000).

The elements of the Green Revolution, which sadly by-passed Africa, were improved plant cultivars, irrigation, chemical fertilizers, and mechanization (Lewis 1982). In the light of dwindling arable land and other input resources, a different set of technologies would be required for the new millennium. Modern biotechnology would be an integral part of these technologies. Apart from addressing the above problems of plant agriculture, biotechnology would also strengthen animal agriculture through vaccine production, more powerful diagnostic procedures, and embryo transfer techniques. Thus, biotechnology is a tool to be used to solve problems that do not lend themselves to ready solution by conventional means.

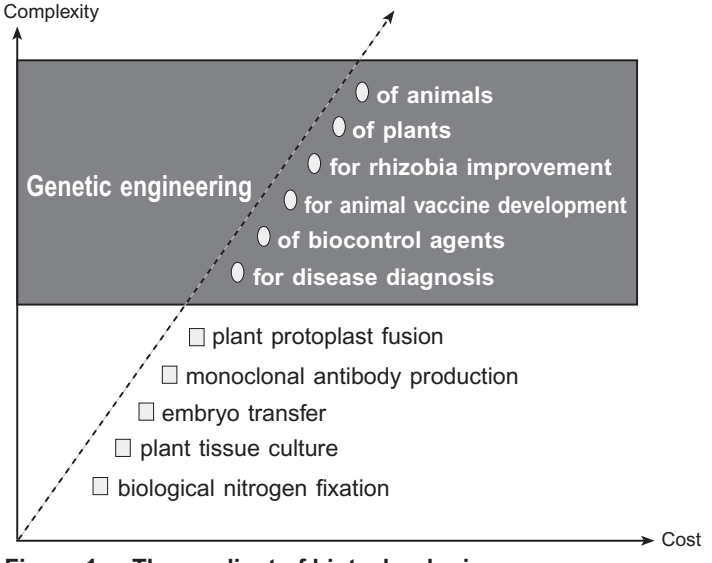

Figure 1. The gradient of biotechnologies.
Source: Sasson 1993.

The tools of biotechnology vary in complexity from tissue culture through to the use of genetic markers to assist with identification and selection, and recombinant DNA or genetic engineering (Figs. 1 and 2).

Tissue culture, the simplest of the modern biotechnologies, is currently the most widely used in Africa for the:

- large-scale production of disease-free planting material;
- induction and selection of useful mutants at cellular level (e.g., high salt tolerance, high lysine content);
- embryo rescue (after interspecific crossing);
- protoplast fusion (interspecific hybridization);
- plant regeneration after genetic engineering (e.g., incorporating new genes into crops); and
- conservation of germplasm.

Africa needs to master the advanced biotechnologies because food crops, which are crucial for developing country agriculture, may not be candidate crops for the private sector biotechnology research of the developed countries. Africa must also be wary of the possible substitution of genetically engineered products for tropical agriculture exports. Industrial countries may not adequately compensate developing countries for their indigenous genetic resources used in genetic engineering (Sasson 1993; Serageldin and Persely 2000). Such pirated genes could steal Africa's comparative advantage in the primary commodities such as vanilla, palm kernel and coconut oils, and synthetic chocolate powder. Though the know-how exists to make these products, it is not cost-effective at the moment.

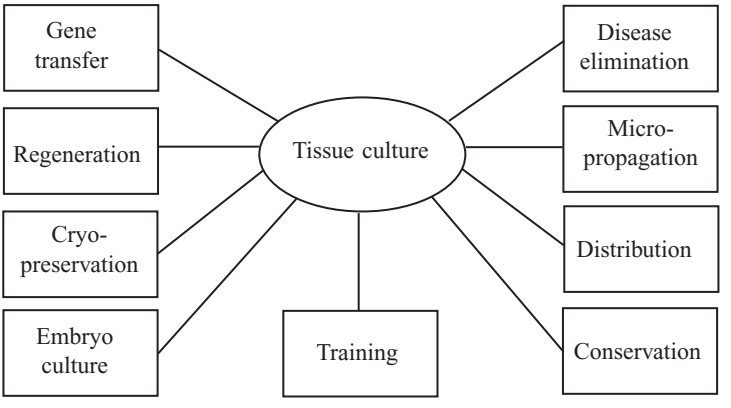

Figure 2. Tissue culture of root and tuber crops.
Source: IITA, Ibadan, Nigeria.

Benefits of agricultural biotechnology to the farmer are better weed and insect control, increased yields, and greater flexibility of farm operations. For the consumer, there are lowered food costs, healthier foods, and improved nutrient quality.

Africa needs to build the human and material capacity to reap the benefits of biotechnology and to be able to speak for itself on issues of biotechnology. Since the application of the tools of modern biotechnology to product development and service delivery is expensive, a case can be made for the harmonizing of resources, human and material, for a common goal in the region.

Currently, there is a new initiative sparked by Ghana and Nigeria to fast-track collaboration in ECOWAS through the revitalization of cooperation in science and technology, trade, industry, communication, and a common currency. The building of core competency in biotechnology in the region could benefit from the ECOWAS fast-track initiative.

The author, under FAO sponsorship, undertook a study tour to Eastern and Southern Africa to assess their status on biotechnology in August 1999. The survey revealed that tissue culture was well established there and was at the level of commercialization by the private sector for pyrethrum, pineapple, banana, tobacco, and cut flowers. Molecular biology work was advanced in all countries of the region, except in Uganda. Biosafety guidelines in all countries were at an advanced stage of legislation. This finding substantiated the one earlier established by Cohen (1999). A strong regional network, the East Africa Regional Biotechnology Program and Research Network (BIO-EARN) exists. The Swedish International Development Agency (SIDA) funds this network. Capacity building through manpower and infrastructure development are vital components of the aid package (Alhassan 1999).

A regional biosafety focal point was established for all the countries in Eastern and Southern Africa in 1996 designed to play a catalytic role in the development of biosafety in the region. The Scientific and Industrial Research and Development Center (SIRDC)

Harare, Zimbabwe, was appointed headquarters for the focal point. Unfortunately, the focal point has not functioned due to financial difficulties. The expected financial support from the Netherlands Directorate General for International Cooperation (DGIS) to run the network did not materialize, nor did the countries of the region provide support.

In the past, Cohen (1999), Sasson (1993), Okonkwo (1996), and Alhassan (1999) have conducted studies on biotechnology in Africa similar to the one herein reported. The uniqueness of the study herein reported lies in the countries surveyed, plus the focus and depth of this report.

1.1 Study objectives

Ghana and Nigeria have begun an ECOWAS fast-track initiative to collaborate in key socioeconomic areas including the harmonization of their science and technology goals. Both countries have appointed Ministers of State to help implement this initiative. It is hoped that the current study will provide needed information to feed into the plans for science and technology cooperation in the two countries as well as the region in a crucial scientific endeavor, namely, biotechnology capacity building. Côte d'Ivoire, Cameroon, and Senegal were also included in this survey.

The study objectives were therefore to:

- present an update on current biotechnology capacity (human, infrastructure, and financial support) in the survey countries;
- determine national policy in terms of priority setting and biopolicy (biosafety, research and development focus, public awareness creation);
- review the role of the NARS, IARCs, government ministries, and agricultural research organizations (AROs) in biotechnology capacity building;
- establish a basis for regional cooperation in the creation and operation of centers of excellence in agricultural biotechnology;
- determine the extent of linkages, nationally and internationally, in biotechnology;
- assess the extent of transfer of the technology to farmers and private sector agencies for commercialization; and
- create a platform for networking among scientists and policymakers in biotechnology in the region.

1.2 Key deliverables

The key deliverables at the end of the study should be:

- recommendations for the harmonization of biosafety guidelines within the region;
- proposals for the creation of national and regional centers of excellence in biotechnology; and
- identification of roles for government agencies, NARS, WECARD/CORAF, IARCs, and advanced research institutes (ARIs) in biotechnology capacity building, nationally and regionally.

2

Study methodology

Specific questionnaires dealing with various aspects of biotechnology institutional capacity were formulated for the target groups, namely NARS, university departments, CORAF/WECARD, government ministries for science and technology, IARCs, ARIs, and donor agencies. For donor agencies and IARCs, extensive correspondence by e-mail and searches on the web sites were adopted. The selection of NARS institutions and individuals to be contacted was assisted by a 1996 compilation of biotechnology manpower in Africa (Okonkwo 1996). In addition to the questionnaires, visits were made to the surveyed countries to hold further discussions and inspect laboratory facilities. The geographic location of countries visited is indicated in Figure 3.

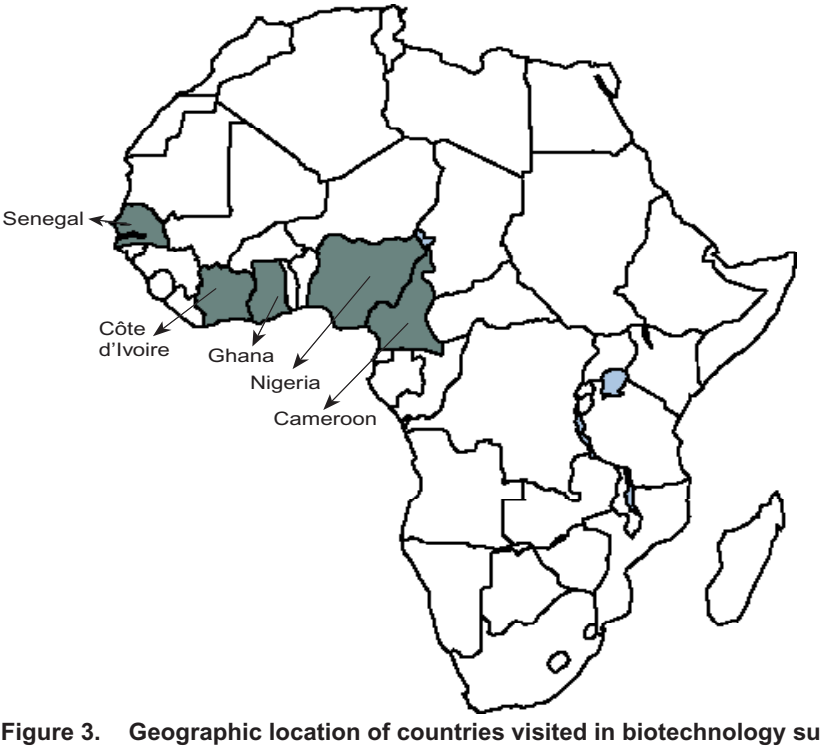

Figure 3. Geographic location of countries visited in biotechnology survey.

The visit to Nigerian institutions, the most extensive, lasted from 26 August to 6 September 2000. The visits to Senegal, Côte d'Ivoire, and Cameroon were conducted from 16 to 28 September 2000. No visit was conducted to Ghana since data already collected by the author in 1999 were updated by correspondence.

To assist in determining the adequacy of laboratories, the minimum infrastructure required for the proper functioning of a standard laboratory in tissue culture, fermentation, or molecular biology was drawn up and the respective laboratories matched against it for adequacy. The minimum standard for adequacy (Tables 1a, 1b, 1c) was drawn in consultation with scientists at IITA (Ibadan, Nigeria). To facilitate future networking arrangements, the e-mail addresses of all contact persons are available in Annex 1. To determine the effectiveness of IITA's training support in biotechnology, a tracer study of professionals who had benefited from IITA training over the years was conducted.

Table 1a. Minimum equipment standards for normal laboratory function for tissue culture.

Item	Quantity
Kitchen (media preparation, cleaning, sterilization)	1
Laminar flow/transfer room/inoculation room	1
Various media	Some
Assorted glassware	Some
pH meter	1
Autoclave	1
Growth chamber/culture room	1
Balances	2
Stable power supply/electric generator	Yes: 1 for generator
Stirrer/hotplate	1
Water still	1
Air conditioner	1
Freezer	1
Refrigerator	1
Assorted reagents	Some

Table 1b. Minimum equipment standards for normal laboratory function for fermentation.

Item	Quantity
Fermentors below 5 l capacity	1
Incubators	2
Autoclave	1
pH meter	1
Assorted refrigeration units	2
Centrifuge	1
Assorted glassware	Some
Water still for double distillation	1
Balances	Yes
Container/biosafety facility	1
Assorted reagents	Some

Table 1c. Minimum equipment standards for normal laboratory function for molecular biology.

Item	Quantity
PCR machine1	
Laminar flow chamber	1
Electrophoresis equipment	3
Assorted deep freezers	3 (4°C, –20°C, –80°C)
Incubator	1
Cold room	1
Autoclave	1
Film processing room	1
Water still for double distillation,	
Deionized, sterilized water	1
Assorted centrifuges	2
pH meter	1
Balances	2
Sample preparation room	1
Assorted glassware	Many
Stable power supply/standby generator	Yes: 1 for generator
Container/biosafety facility	1
UV light box	1
Spectrophotometer	1
Fluorometer	1
Ice maker	1
Water bath	1
Shaker	1
Stirrer	1
Vortex	1

3

Findings

The recovery of questionnaires from NARS institutions and government ministries was excellent. Thirty-six out of 38 institutions responded to questionnaires. All government ministries responded to questionnaires and facilitated contacts with the NARS. The personal follow-up visits might have greatly assisted the recovery of questionnaires. The soliciting of responses from donor agencies was most problematic as most of this was by e-mail. Either there was no direct response, or the questionnaires were passed to other desk officers who either did not respond or sent inadequate information. In many cases, donor web sites visited did not have the necessary information.

3.1 Cameroon

The umbrella organization for agricultural research in Cameroon is the Institute of Agricultural Research for Development (IRAD). Returns to questionnaires were received from three of IRAD's institutes dealing with biotechnology, namely, IRAD/JP Johnson Biotechnology Laboratory at Ekona, IRAD/Animal Production and Fisheries Division at Nkolbison, Yaoundé, and the IRAD/Centre de Recherches Regionales sur Bananiers et Plantains (CRBP) at Njombe. The only university institution with agricultural biotechnology laboratories visited was the Centre de Biotechnologie/Ecole Normale at Université de Yaoundé (CBEN).

The most frequently used agricultural biotechnology tool in Cameroon was tissue culture. All the tissue culture laboratories were regarded as functional (Table 2). The most adequately endowed of these laboratories was the CRBP at Njombe. The laboratory was started in 1988 as a regional laboratory with European Union funding. The CRBP involves Cameroon, Central African Republic, and Gabon. The collaborating research institutes in these countries are the Institute of Agricultural Research for Development (IRAD), Cameroon, the Agricultural Research Institute of Gabon, and the Central African Institute of Agricultural Research.

The CRBP collaborates with the International Network for the Improvement of Banana and Plantain (INIBAP). CRBP distributes clean planting material to nine countries in West and Central Africa. Tissue culture plantlets are distributed for hardening at the receiving

Table 2. Minimum criteria for function status of laboratory—Cameroon.

Institution	Constancy of electricity	Tissue	Fermentation culture	Molecular biology
Biotechnology Centre, Univ. Yaoundé	Yes	Adequate	Not applicable	Inadequate
IRAD/JP Johnson, Ekona	Yes	Adequate	Not applicable	Inadequate
IRAD/Animal Production and Fisheries	Yes	Adequate	Not applicable	Adequate
IRAD/CRBP Njombe	Yes	Adequate	Not applicable	Not applicable

countries. An expatriate managed the laboratory with a Cameroonian counterpart. At the time of visit (27 September 2000) the expatriate had left the country, leaving the Cameroonian counterpart (Dr Emmanuel Youmbi) in charge.

The tissue culture laboratory at Ekona (JP Johnson Biotechnology Laboratory), is a large facility but with the barest minimum of equipment for tissue culture work. The laboratory was established through USAID support in 1985 under the Root and Tuber Research Project (ROTREP). The USAID contributed US$6 million while the Cameroonian government contributed US$2 million to the project. The project was funded for a 5-year period (August 1986–August 1991), and funds were also secured for an extended phase (1992–1994). The purpose of establishing the laboratory was to:

- study the etiology and other aspects of the root rot disease of cocoyam;
- develop tissue culture techniques for producing disease-free plantlets of root crops, (cocoyam, cassava, yam, and sweetpotato);
- disseminate root crops planting material to farmers;
- train a team of Cameroonian scientists in plant pathology, tissue culture, and biotechnology of root and tuber crops grown in Cameroon; and
- create a modern tissue culture and biotechnology laboratory for rapid seed-stock multiplication, virus indexing, and research, which could benefit Cameroon and countries of the region.

The following three American partner institutions formed a consortium to run the laboratory along with the Institute of Agronomic Research (IRA, Cameroon, now IRAD):

- The University of Maryland at Eastern Shore
- Florida A&M University, Tallahassee, Florida
- Alabama A&M University, Muscle Shoals, Alabama.

The Cameroonian government was supposed to fully support the laboratory after 1994 when the US government withdrew. Unfortunately this support has not been adequate. Most of the equipment is either broken down or obsolete. The local staff are barely coping with the repairs since spare parts for the obsolete equipment are not available, even from the manufacturers. Despite the depressing state of the laboratory, work is ongoing with locally improvised equipment, albeit at a low ebb. Tissue culture-derived clean cassava cuttings are distributed to farmers. Active research on cocoyam root-rot, which is a major problem in Cameroon, is ongoing.

The strict assignment of roles in tissue culture activity in Cameroon makes for the efficient use of resources. Thus, while the Ekona laboratory specializes on root and tuber crops, the Njombe laboratory concentrates on banana and plantain. The University of Yaoundé, because of its teaching and research functions, also works on these crops but to a lesser degree.

The tissue culture laboratory at the Biotechnology Center in the University of Yaoundé is basically a teaching and research laboratory for staff and postgraduate students. Tissue culture is done on a large variety of crops, including root crops and cocoa. The laboratory has plans to go into molecular biology. The plans include work on the transformation of some crops for disease resistance.

The IRAD/Animal Production and Fisheries Division laboratory at Nkolbisson has excellent facilities for animal tissue culture and molecular biology work. It is the only national laboratory in the agricultural sector with a well-equipped molecular biology laboratory. A similar well-equipped plant-based laboratory would be desirable since both the IRAD/JP Johnson Biotechnology Laboratory and the Biotechnology Research Center at the University of Yaoundé have expressed the desire to go into molecular characterization and marker-assisted breeding.

Funding support in biotechnology from both government and donor agencies is considered inadequate. No biotechnology activity was commercialized; neither was there any linkage with the private sector or ARIs. There was no evidence of biotechnology linkage with institutions in the region, except for one with the Plant Biotechnology Laboratory in Libreville (Gabon). International linkages were with the African Biosciences Network and the Agence Africaine de Biotechnologie (Algeria).

In the view of respondents to the questionnaires, the key constraints limiting the optimal use of the laboratories, in order of importance, were equipment, finance, human resources, laboratory reagents, and information exchange, with the last three ranked equally.

Cameroon had a total of 22 well-trained scientists, all Cameroonian, in core molecular biotechnology, 13 of whom were PhD holders. Cameroon ranked third among the countries surveyed in trained manpower in core molecular biotechnology (Table 3). There were relatively few people in the other biological areas with exposure to molecular biology (Table 4). Further details on an institutional basis are provided in Annexes 3 and 7.

Table 3. Personnel with postgraduate training in core molecular biology by gender in survey countries.

	PhD		MSc		Nationality	
Country	Male	Female	Male	Female	Native	Foreign
Cameroon	13	–	5	4	22	–
Ghana	10	2	4	5	20	1
Côte d'Ivoire	6	1	1	–	8	–
Nigeria	31	7	22	5	65	–
Senegal	17	2	12	7	28	10

Table 4. Ancillary fields of staff with supplementary molecular biology training in survey countries.

	Cameroon		Ghana		Côte d'Ivoire		Nigeria		Senegal	
Ancillary field	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc
Breeding	1	2	3	1	–	–	12	3	7	5
Agronomy	1	3	2	4	1	–	5	–	–	–
Virology	–	1	2	2	–	–	11	7	2	1
Plant pathology	–	1	3	2	–	–	6	1	1	–
Nematology	–	–	–	–	–	–	3	–	–	–
Entomology	–	–	2	1	1	–	4	–	–	–
Microbiology	–	–	1	7	3	–	34	17	2	1
Biochemistry	–	–	1	2	6	–	11	6	2	–
Parasitology	–	–	1	2	–	–	6	–	3	–
Immunogenetics	–	–	1	2	1	–	5	–	2	–
Cytogenetics	–	–	–	–	–	–	4	2	–	–
Mycology	–	–		–	–	–	2	1	–	–
Seed technology	–	–		1	–	–	–	–	–	–
Vaccine technology	–	–	–	–	–	–	–	–	3	–
Artificial insemination	–	–	–	–	–	–	–	–	3	1
Total	2	7	16	24	12	–	103	37	25	8

The Cameroonian government has shown commitment to biotechnology by being one of the two countries among those surveyed with a biosafety draft bill ready for enactment (Table 5). An African Development Bank 5-year program is about to take off to revamp the agricultural research infrastructure, including biotechnology. The loan is worth US$8 million. A parallel US$2.4 million loan from the World Bank is available to assist in agricultural technology transfer activities. It is hoped these donor initiatives would be sustained after the external funds have elapsed.

Table 5. Status of biosafety law enactment and enforcement.

	Status of enactment					Status of enforcement			
Country	DCA	GD	DGA	DBP	LE	BCIF	BCINF	NBC	SA
Cameroon	Yes	Yes	Yes	Yes	No	No	Yes	No	No
Ghana	Yes	Yes	No	No	No	No	No	Yes	No
Côte d'Ivoire	Yes	Yes	Yes	Yes	No	No	Yes	No	No
Nigeria	Yes	Yes	No	No	No	No	No	Yes	No
Senegal	Yes	No	No	No	No	No	No	Yes	No

DCA = Drafting committee appointed
GD = Guidelines drafted
DGA = Draft guidelines accepted
DBP = Draft bill prepared
LE = Law enacted
BCIF = Biosafety Committee in place
BCINF = Biosafety Committee in place, not functioning
NBC = No Biosafety Committee
SA = Secretariat appointed

3.2 Ghana

Out of nine institutions within the NARS involved with biotechnology, seven submitted responses. Ghana was the only country visited by the author in August 1999 on a biotechnology survey sponsored by the FAO to East, Southern, and West Africa. The West African phase of the survey could not proceed beyond Ghana. The information on Ghana gathered last year, where appropriate, supplemented parts of this report. The umbrella research organization in the country is the Council for Scientific and Industrial Research (CSIR). Updated information was received from the Cocoa Research Institute of Ghana (CRIG), CSIR–Soil Research Institute (CSIR–SRI), the CSIR–Crops Research Institute (CSIR–CRI), the CSIR–Water Research Institute (CSIR–WRI), and the CSIR–Food Research Institute (CSIR–FRI). The CSIR–Science and Technology Policy Research Institute (CSIR–STEPRI), which carries out policy research in science and technology including biotechnology, was also surveyed but since its capacity building needs were manpower, transport, and communication facilities, it was not analyzed with the rest of the submissions.

Other institutes surveyed were the Biotechnology and Nuclear Research Institute (BNARI) of the Ghana Atomic Energy Commission (GAEC), and the Veterinary Services Department of the Ministry of Food and Agriculture (MOFA–VSD). Only two out of four laboratories engaged in tissue culture were regarded to have the minimum equipment for effective work (Table 6). They are the CRIG and CSIR–CRI laboratories. Inadequate equipment and lack of a guaranteed source of stable power supply were the grounds for the disqualification of the other two. Though regarded as nonfunctional, BNARI has the biggest tissue culture laboratory in the country. Out of four laboratories working in fermentation, only the CSIR–WRI laboratory had the minimum facility to undertake such work. None of the other laboratories had a fermentor, neither did they have stable power supply.

Table 6. Minimum criteria for function status of laboratory—Ghana.

Institution	Constancy of electricity	Tissue culture	Fermentation	Molecular biology
BNARI	No	Inadequate *	Inadequate	Inadequate
CRIG	Yes	Adequate	Not applicable	Adequate
CSIR–CRI	Yes	Adequate	Not applicable	Inadequate
CSIR–FRI	No	Not applicable	Inadequate *	Inadequate
CSIR–SRI	No	Inadequate	Inadequate	Inadequate
CSIR–WRI	Yes	Not applicable	Adequate	Inadequate
MOFA–VSD	Yes	Not applicable	Not applicable	Adequate

*No constant electricity supply is the only problem. Those marked "Inadequate" without (*) lack constant electricity and equipment.

BNARI – Biotechnology and Nuclear Agricultural Research Institute
CRIG – Cocoa Research Institute of Ghana
FRI – Food Research Institute of Ghana
SRI – Soil Research Institute of Ghana
WRI – Water Research Institute of Ghana
VSD – Veterinary Services Department

For molecular biology work, only two out the seven laboratories working in this field were regarded as having the barest minimum equipment to be considered functional. The only source of disqualification for the CSIR–FRI laboratory is the lack of a source of stable power supply. The crop science department at University of Ghana, which has a small laboratory for molecular biology, could not be evaluated for lack of adequate information. This was also the case with the tissue culture facility of the botany department at University of Ghana, which is used by the United Nations University/Institute for Natural Resources in Africa for conducting international courses in plant tissue culture.

The surveyed institutions had total manpower strength of 21, half of whom were PhD holders. All members of staff were Ghanaian except for one foreigner with CRIG. The numerical strength of the Ghanaian manpower in core molecular biology is almost equal to that of Cameroon (Table 3). Ghana, however, has a good number of staff, specialized in relevant biological fields, having ancillary training in molecular biology (Table 4). Further details on institutional manpower are provided in Annexes 2 and 9. The most frequently used biotechnology tools in Ghana were tissue culture and DNA fingerprinting or gene mapping. The emphasis was almost the same between them. The most frequently applied production area was diagnostics followed by micropropagation of planting material. An identified industrial application was the production of starter cultures by CSIR–FRI and CSIR–SRI. Researchers at CSIR–FRI are working in food fermentation and those at CSIR–SRI in biofertilizers. The tissue culture laboratory at CSIR–CRI (Kumasi) has a linkage with the CSIR–IITA–GTZ seed project. All the seven institutions were unanimous in pointing out the inadequacy of funding from government budget. Three considered funding from donor sources as adequate while the remainder considered this source as inadequate. Public–private sector linkages were either available or under study. About half the institutions surveyed had already commercialized their biotechnology products, which consisted of plantain, banana, and pineapple plantlets, and vaccines.

Local linkages, albeit informal, existed among various institutions. The Biotechnology Development Program funded by the United Kingdom Department for International Development (DFID) provides a linkage between the University of Strathclyde, the CSIR–STEPRI, and BNARI. Other international linkages involve the African Fermentation Group and Food Fermentation Cyber Congress.

The most important constraints facing biotechnology work are equipment, laboratory reagents, and finance. All respondents saw the merit in the creation of a regional center of excellence in biotechnology, one for anglophone countries and the other for francophone countries of West and Central Africa. They were also supportive of the idea of creating a national center of excellence.

3.3 Côte d'Ivoire

The Centre National de Recherche Agronomique (CNRA) is the umbrella organization for agricultural research in Côte d'Ivoire. It has a central biotechnology laboratory at Adipodome on the outskirts of Abidjan (km 17, route de Dabou). The other key biotechnology

Table 7. Minimum criteria for function status of laboratory—Côte d'Ivoire.

Institution	Constancy of electricity	Tissue culture	Fermentation	Molecular biology
CNRA–Central Biochem. Lab.	Yes	Adequate	Not applicable	Yes
Univ. Bobo–IREN	Yes	Not applicable	Inadequate	Not applicable
Univ.Cocody–Biochem. Lab.	Yes	Not applicable	Inadequate	Not applicable
Oceanography Research Center	Yes	Adequate	Not applicable	Adequate

laboratory, also under CNRA, is the one devoted to oil palm tissue culture at La Me. Apart from the CNRA, the Renewable Energy Research Centre, Institut de Recherche sur les Energies Nouvelles (IREN) of the Université Abobo Adjame, the biotechnology laboratory at the Université de Cocody, and the Centre de Recherches Oceanologiques at Abidjan were visited.

All laboratories in Côte d'Ivoire requiring the use of tissue culture or molecular biology were considered adequately equipped (Table 7). Those of the universities involved with fermentation were not considered so well equipped according to the criteria of the survey established in Table 2. The CNRA biotechnology center is a newly constructed ultra-modern facility for molecular biology and tissue culture. The laboratory was commissioned in 1998 with a working space for 200 scientists and technicians. It has four laboratories designated for each of molecular plant pathology, molecular genetics, molecular biology proper, and tissue culture. The laboratory was built and equipped largely by the Ivorian government with support from the Spanish government. In addition to the new tissue culture laboratory, there is an old but highly functional laboratory on the same compound, which was very active at the time of visit (September 2000). The tissue culture laboratory devoted solely to oil palm at La Me is fairly old but large and highly functional. The facility enjoys years of fruitful cooperation with French researchers from CIRAD (Montpellier, France) in oil palm tissue culture.

The inadequate fermentation facilities at the universities are soon to be replaced by a new facility at the Renewable Energy Center at the Université Abobo Adjame. At the time of visit, the building was yet to be commissioned and the order of new equipment which had arrived was to be installed.

The weakest point in biotechnology capacity of Côte d'Ivoire is perhaps the low base in trained manpower. There were only eight trained people in core biotechnology, seven of them with PhD (Table 3). The bulk of the personnel in agricultural biotechnology were the staff at the CNRA (Annex 4). Staff from ancillary fields with supplementary training in molecular biology were not many, either (Table 4). An active cooperation exists between CNRA and the universities. Postgraduate research done at the biotechnology research center should improve the manpower situation in the near future. Further details of manpower on an institutional basis are provided in Annexes 4 and 8.

The most frequently used biotechnology tools were tissue culture for the large-scale production of planting material and gene mapping for marker-assisted breeding. Following

the restructuring of CNRA, all staff with biotechnology competence have been relocated at the new center in Adipodome except those working on oil palm.

The only internal linkage mentioned was between the biochemistry laboratory of the Université de Cocody and CNRA. There is a linkage between the International Center for Genetic Engineering and Biotechnology (ICGEB) and CNRA. There are no biotechnology products commercialized yet and no formal linkages with the private sector. The constraints facing biotechnology in Côte d'Ivoire, as listed in the order of importance, were finance, lack of public awareness on biotechnology, and equipment infrastructure. The idea of a national and regional center of excellence in biotechnology was acceptable to respondents. There was a general desire to go into the production of biofertilizers and various cultures in the future.

3.4 Nigeria

The biggest number of institutions surveyed (17) was from Nigeria. Seven of these institutions were university-based, while one was the Federal Polytechnic at Bauchi, and research institutions were the remainder. The university institutions were Nnamdi Azikiwe University (NAU) at Awka, Institute of Agricultural Research and Training (IAR & T) of the Obafemi Awolowo University, Moor Plantation at Ibadan, Ahmadu Bello University in Zaria, University of Ibadan; botany department at University of Nigeria in Nsukka (UNN), microbiology department (UNN), Michael Okpara University at Umudike, and University of Jos (UNIJOS). The research establishments were Nigeria Institute for Oil Palm Research (NIFOR) at Benin City, Plant Quarantine Service (PQS) at Moor Plantation in Ibadan, National Root Crops Research Institute (NRCRI) at Umudike, Cocoa Research Institute of Nigeria (CRIN) at Ibadan, Sheda Science and Technology Complex at Abuja, National Center for Genetic Resources and Biotechnology (NACGRAB) at the Moor Plantation at Ibadan, Nigerian Horticultural Research Institute (NIHORT) in Ibadan, and the National Veterinary Research Institute (NVRI) at Vom, near Jos.

Nearly half of the institutions visited were not considered to have functional biotechnology laboratories due to the lack of stable power supply. Of the 14 laboratories using tissue culture, only five were considered to be functional on the basis of stable power supply and possession of the minimal required equipment (Table 8). The hardest hit were the university laboratories, none of which qualified for operation under the set criteria (Table 1) except for UNIJOS. Apart from NAU and UNN (microbiology), none of the seven institutions whose laboratories do fermentation was regarded to have the minimum facilities for work in this field. The worst hit was the area of molecular biology. Only three of the 11 institutions with molecular biology laboratories were minimally equipped to carry out research in the field as per the established criteria. Thus for the Nigerian institutions surveyed, only 36% of those working in tissue culture, 29% of those in fementation, and 27% of those in molecular biology had minimum facilities to qualify in the respective fields. In terms of laboratory infrastructure the Nigerian situation was easily the worst in the region. In contrast, however, the manpower situation was easily the best in the region.

Table 8. Minimum criteria for function status of laboratory—Nigeria.

Institution	Constancy of electricity	Tissue culture	Fermentation	Molecular biology
NAU	Yes	Inadequate	Yes	Inadequate
NIFOR	Yes	Yes	Not applicable	Inadequate
PQS	No	Inadequate*	Not applicable	Not Applicable
NRCRI	Yes	Yes	Not applicable	Not Applicable
SHEDA	Yes	Inadequate	Inadequate	Yes
CRIN	No	Inadequate*	Inadequate*	Inadequate*
NACGRAB	Yes	Yes	Not applicable	Inadequate
NIHORT	No	Inadequate*	Not applicable	Not Applicable
IAR&T/OAU	No	Inadequate*	Not applicable	Inadequate
ABU–IAR	Yes	Inadequate	Inadequate	Inadequate
UI	No	Inadequate*	Not applicable	Inadequate*
NVRI	Yes	Yes	Not applicable	Yes
FED.POLY. BAU	Yes	Not applicable	Inadequate	Inadequate
UNN (MICROB)	Yes	Not applicable	Adequate	Not Applicable
UNN (BOT)	No	Inadequate*	Not applicable	Not Applicable
MOU	No	Not applicable	Inadequate	Not Applicable
UNIJOS	Yes	Adequate	Inadequate	Inadequate

*No constant electricity supply is the only problem. Others marked "Inadequate" without (*) have both electricity and equipment problems.

NAU – Nnamdi Azikiwe University
NIFOR – Nigeria Institute for Oil Palm Research
PQS – Plant Quarantine Service
NRCRI – National Root Crops Research Institute
SHEDA – Shedu Science and Technology Complex
CRIN – Cocoa Research Institute of Nigeria
NACGRAB – National Center for Genetic Resources and Biotechnology
NIHORT – Nigerian Horticultural Research Institute
IAR&T – Institute of Agricultural Research and Training
ABU–IAR – Ahmadu Bello University, Institute of Agricultural Research
UI – University of Ibadan
NVRI – National Veterinary Research Institute
FED POLY BAU – Federal Polytechnic, Bauchi
UNN – University of Nigeria, Nsukka
MOU – Michael Okpara University
UNIJOS – University of Jos

Sixty-five highly trained personnel, 58% of whom are Nigerian PhD holders, was the caliber of personnel in core molecular biology from the 17 institutions surveyed (Table 3). In addition to these, many others were available from ancillary biological fields with supplementary training in molecular biology (Table 4). A disproportionately large number of these were from the field of microbiology. Further institutional manpower details are as provided in Annexes 6 and 10.

The most frequently used tool in biotechnology in Nigeria was tissue culture followed distantly by recombinant DNA transformation (or genetic engineering), gene mapping,

and DNA sequencing. The production of planting material was the most active area of application of biotechnology followed distantly by diagnostics, biofertilizer, and vaccine production. The industrial application areas of biotechnology were starter culture and lysine or methionine production. All the 17 institutions surveyed were unanimous in indicating that funding from government sources was inadequate, and most indicated that donor funding sources were also inadequate. Nearly all institutions had no formal linkages with the private sector. Only 18% of the respondents indicated that they had commercialized biotechnology products. A vast majority (70%) of the returns indicated plans to commercialize their biotechnology products. About half of the respondents had linkages with other sister institutions. Most had formal linkages with international organizations in biotechnology. These included ICGEB, African Biosciences Network, INIBAP, and the UNESCO Biotechnology Advisory Council.

The most important constraints listed by order of importance were finance, equipment, and human resources. Many were receptive of the idea of a national or regional center of excellence but stressed the need to strengthen national laboratories first. The most important issue occupying the minds of institutions for the future was the equipping of the laboratories.

3.5 Senegal

Four research institutions were surveyed. Two of these were affiliated with the Institut Sénégalais de Recherches Agricoles (ISRA), the Senegalese Institute of Agricultural Research. These were ISRA/Unite de Recherches en Culture in Vitro (URCIV), and ISRA/Laboratoire National d'Elevage et de Recherches Veterinaires (LNERV). The rest were the Laboratoire de Microbiologie/Institut de Recherche pour le Développement (IRD)/ISRA/Université Cheik Anta Diop (UCAD)/Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) and the Centre d'Etude Regional pour l'Amélioration d'Adaptation à la Sécheresse (CERAAS). CERAAS is a regional institution devoted to research on plants adapted to drought. All the laboratories surveyed which use tissue culture as a biotechnology tool had met at least the minimum equipment requirements for the tissue culture work (Table 9).

Of the three laboratories engaged in fermentation work, only CERAAS, which lacked a fermentor, failed to meet the minimum criteria for work in the area. All the laboratories in molecular biology had met the minimum requirements (Table 9). The laboratories generally

Table 9. Minimum criteria for function status of laboratory—Senegal.

Institution	Constancy of electricity	Tissue culture	Fermentation	Molecular biology
ISRA–Biotech.Centre/URCI	Yes	Yes	Not applicable	Not applicable
IRD–Microbiology Laboratory	Yes	Not applicable	Yes	Yes
CERAAS	Yes	Yes	Inadequate	Yes
ISRA–LNERV	Yes	Yes	Yes	Yes

were well endowed with facilities for biotechnology. The microbiology/IRD laboratory was an advanced French laboratory. The ISRA/URCIV laboratory was barely functional during the visit. Though a well-equipped, modern, tissue culture outfit, it was starved of operational funds. It was a depressing sight near the well-endowed microbiology/IRD laboratory which was bustling with activity. The ISRA tissue culture laboratory, established in 1990 to produce planting material to combat desertification, had gained a lot of expertise in the tissue culture of savanna tree crops over years. The savanna tree crops include mahogany, baobab, and *Acacia* species.

Senegal is relatively well endowed with well-qualified staff in molecular biology. Out of the 38 staff working in agricultural biotechnology, 10 were foreigners while the remainder were Senegalese. Over half of the staff were PhD holders (Table 3). Next to Ghana and Nigeria, Senegal had the largest number of staff from ancillary biology fields who had supplementary training in molecular biology (Table 4). Further details are provided in Annexes 5 and 11. The most frequently used biotechnology tool was tissue culture followed by gene mapping or DNA fingerprinting. Planting material production was the area in which biotechnology was most applied.

Inadequate funding by government was unanimously identified by all institutions surveyed. The tissue culture laboratory was the most emphatic in this rating of the government. The institutions surveyed had not commercialized their biotechnology products; however, half planned to do so in the near future.

Most of the institutions formed linkages with one another. International linkages involved the African Agency for Biotechnology (AAB, Algeria). The most important constraint listed related to equipment. The others, ranked equally, were finance, human resources, and laboratory reagents. While most endorsed the idea of a regional center of excellence, some pointed to AAB and Microbiology Resources Research Center (MIRCEN) as already established centers of excellence. MIRCEN is the UNESCO-established regional center for microbiology in Senegal. The plans for the future included human resources development and the production of biofertilizers.

3.6 General government perspectives on biotechnology

All responses by government functionaries were unanimous on the inadequacy of funding for biotechnology-related research and development. This is perhaps a reflection of the generally low funding of scientific research in the countries surveyed.

Apart from Ghana, where a specific commitment from the national budget was made for biotechnology capacity building, most governments' funding for biotechnology capacity building was low. Even in Ghana 3.7 billion cedis (about US$5.7 million) for year 2000 was (as at October 2000) yet to be released to the NARS. Apart from Ghana, most governments' funding for agricultural research did not have a specific heading for biotechnology but was part of the global budget to the relevant institutions.

While all governments considered biotechnology an important tool for research and development, the needed funding did not generally support this priority investment.

Table 10. Ministerial responsibility for biotechnology research and development and biosafety enforcement.

Country	Biotechnology research and development	Biosafety enforcement
Cameroon	Ministry of Scientific and Technical Research	Ministry of Environment and Forestry
Ghana	Ministry of Environment Science and Technology	Same as for biotechnology research
Côte d'Ivoire	Ministry of Higher Education and Scientific Research (Direction de la Recherche du Ministre de la Recherche Scientifique)	Same as for scientific research
Nigeria	Federal Ministry of Science and Technology	Ministry of Environment
Senegal	Ministry of Higher Education and Scientific Research (Ministre de l'Enseignement Superieur de la Recherche Scientifique)	Same as for biotechnology research and development

The focus of biotechnology application was to attain increased agricultural productivity, health diagnostics and cures, environmental cleansing, and food processing. All countries devoted human and material resources to addressing the issue of biosafety guidelines or legislation. Cameroon and Côte d'Ivoire had brought their biosafety draft laws to a point of legislation while the rest were still working to perfect their biosafety guidelines to enable the legal drafting to begin. All countries in the region were willing to harmonize their biosafety laws to ease transboundary movement and exchange of genetically modified organisms. Currently all governments are actively supporting tissue culture projects for the rapid multiplication of vegetatively propagated material. Government ministries working closely together on biotechnology issues are the ministries responsible for scientific and technological research, food and agriculture, trade and industry, the environment and, in Ghana, the ministry of justice also participates. All governments recognized the need to increase public awareness on biotechnology issues through media programs and workshops. Though concerned about issues of germplasm conservation and biopiracy, no country had in placi intellectual property rights laws to regulate the exploitation of genetic resources. Ghana and Côte d'Ivoire were currently working on such laws.

The constraints facing all governments in biotechnology capacity building were listed (most important first) as finance, equipment infrastructure, information exchange, and human resources. The government ministries with oversight responsibility over biotechnology and biosafety issues are indicated in Table 10.

3.7 WECARD/CORAF

WECARD/CORAF is a regional organization for West and Central Africa that specializes in agricultural research cooperation. It was founded in 1987 as a club of African and French Directors, later it became the Conference of West and Central African Agricultural Research Directors (CORAF—French acronym). It was renamed during the 1999 twelfth

Table 11. Priority areas for regional cooperation in agricultural research in West and Central Africa.

Sector/Commodities	Production systems
Cotton	Rain-fed systems based on cereals
Legumes	Rain-fed systems based on cotton
Oil palms	Irrigated systems
Roots and tubers	Peri-urban systems
Meat, milk and fish	Forest systems
Maize, rice, millet, sorghum	Agropastoral systems
Coffee, cocoa, rubber	Agroforest systems
Wood	
Bananas	
Fruits and vegetables	
Crosscutting themes	
Management of genetic and biotechnological resources	
Transfer of technologies	
Institutional support: information, communication, biometrics	

Source: WECARD/CORAF Annual Report. 1999.

plenary meeting in Bangui as the West and Central African Council for Agricultural Research and Development (WECARD/CORAF) with the previous acronym CORAF retained for historical reasons. WECARD/CORAF stands for institutional and scientific partnership and cooperation between NARS, ARIs, and IARCs.

The WECARD/CORAF strategic plan for 2000–2014, and also revealed in its 1999 Annual Report, lists the priority areas for regional cooperation in agricultural research in West and Central Africa under three broad categories as sector/commodities, production systems, and crosscutting themes (Table 11). A 6-week electronic conference was organized by WECARD/CORAF in 1999. It was based on working groups that discussed and formulated concrete proposals on various topics including biotechnology and genetic resources. Though acknowledged as a research tool, WECARD/CORAF has not yet defined the specific areas in which biotechnology is to be applied nor defined the cooperative mechanisms to build capacity in this crucial generic technology. Studies such as the one herein reported are needed to enable the regional organization to determine its level of intervention.

3.8 International agricultural research centers and advanced research institutes

Most (16) of the IARCs belong to the Consultative Group on International Agricultural Research (CGIAR). The goal of CGIAR is to improve food security, reduce poverty, and protect the environment in developing countries. The IARCs considered for this survey were those with headquarters in the region or sufficiently active in

biotechnology-related research in West and Central Africa. The following IARCs were examined through personal contacts or material gathered from hard copy publications or the internet:

- International Institute of Tropical Agriculture (IITA)
- West Africa Rice Development Association (WARDA)
- International Livestock Research Institute (ILRI)
- International Service for National Agricultural Research (ISNAR)

3.8.1 International Institute of Tropical Agriculture

IITA was founded in 1967 as an international agricultural research institute. It is funded by both the CGIAR and bilaterally from national and private donor agencies. IITA conducts research, training, and has germplasm and information exchange activities in partnership with regional bodies and international programs in many parts of sub-Saharan Africa. IITA has research stations located on an agroecological basis in the humid forest (Yaoundé, Cameroon), the high rainfall area (Onne, near Port Harcourt, Nigeria), the dry savanna (Kano, Nigeria), the moist coastal savanna (Cotonou, Republic of Benin) and the midaltitudes (Namoulonge, Uganda). The headquarters are at Ibadan (Nigeria). IITA research focuses on smallholder cropping systems in the humid and subhumid tropics of Africa. Its mandate crops are cassava, maize, plantain and banana, yam, cowpea, and soybean. With the expansion of its farming system activities under the new strategic plan, tree crop systems could allow the broadening of the mandate crop base.

IITA has very strong linkages with a number of ARIs in Europe, America, and Australia for its biotechnology research activities.

The areas of biotechnology research and application at the IITA are:

- disease elimination, micropropagation, conservation and exchange of germplasm;
- cryopreservation of cassava and yam;
- transformation and regeneration of cowpea, *Musa*, cassava, and yam;
- isolation of desirable genes;
- molecular mapping and marker-assisted selection;
- molecular diagnostics; and
- strengthening of NARS capacity in biotechnology research.

These activities are carried out at IITA and (in some cases) in collaboration with NARS and ARIs. IITA is easily the most active IARC in the region in terms of its geographic spread, research program, and linkages with the NARS. The current study is relevant to IITA and any IARCs operating in the region that might wish to link up with the NARS for collaborative research in biotechnology. The survey provided a means to assess the effectiveness of IITA's training in biotechnology as well as to seek views on NARS perception of its linkages with IITA in the area of biotechnology-related research.

From 1981 to 1998, IITA conducted group training in biotechnology for NARS researchers from the five survey countries. About 56% of them (as at October 2000) were still working in biotechnology while 19% had quit biotechnology. The whereabouts of

Table 12. Location of IITA 1981–1998 biotechnology trainees as at 2000.

Country of trainee	Trainee Location: In Biotech	Trainee Location: Quit Biotech	Trainee Location: Unknown	Total	Retained (%)
Cameroon	8	1	–	9	89
Ghana	5	3	2	10	50
Côte d'Ivoire	–	–	2	2	–
Nigeria	22	8	10	40	55
Senegal	–	–	2	2	–
Total	35	12	16	63	56

the remainder (25%) could not be established. The total number of trainees involved in the survey for the training period within the five countries was 63 (Table 12). There were a number of IITA trainees registered as graduate students in various universities carrying out their research in the different aspects of biotechnology.

The following were the views of some of the NARS on IITA's role in biotechnology capacity building.

- IITA's insistence on its mandate crops restricts collaboration with NARS that could benefit from IITA's assistance to solve their kind of biotechnology-based problem.
- Some arrangements could be made through IITA for the acquisition of reagents more dependably than is currently the case.
- IITA scientists should assist less experienced scientists from the NARS in biotechnology research proposal writing to attract funds. Joint proposals should be encouraged.
- NARS were all appreciative of the biotechnology training given them by IITA.
- IITA has in recent times assisted the Nigerian government in the formulation of its biosafety guidelines. It has also helped in the past with the training of Nigerian government nominees in germplasm characterization, marker-assisted selection, and with implementing biosafety guidelines. These services could be made available to other governments in the region on request.

3.8.2 West Africa Rice Development Association

WARDA was formed in 1971 by 11 countries with the assistance of the United Nations Development Program (UNDP), the Food and Agriculture Organization of the United Nations (FAO), and the Economic Commission for Africa (ECA). It now consists of 17 countries in West and Central Africa. WARDA is an autonomous intergovernmental association. Its mission is to strengthen sub-Saharan Africa's capability for technology generation, technology transfer, and policy formulation, in order to increase the sustainable productivity of rice-based cropping systems while conserving the natural resource base and contributing to the food security of poor rural and urban households.

WARDA has a tissue culture laboratory to complement its molecular biology work. The biotechnology work is largely on anther culture. It has given assistance to the Ivorian government in formulating its biosafety law. Given the number of molecular biologists (only 2) and laboratory infrastructure, routine group training may not be feasible as practised by IITA but specialized biotechnology training, such as anther culture, could be given to individual scientists.

3.8.3 International Livestock Research Institute

ILRI was created in 1995 following the merger of two existing institutes, the International Livestock Research Center for Africa (ILCA) and the International Laboratory for Research on Animal Diseases (ILRAD). The mission of ILRI is to improve the productivity of smallholder livestock and mixed crop—livestock systems while protecting the natural resources that support these systems. The headquarters of ILRI are in Nairobi (Kenya). The bulk of the research on livestock production is in Addis Ababa, Ethiopia, while the work on animal diseases is still carried on at Nairobi. The laboratories at Nairobi are extensive and well equipped for molecular biology work.

ILRI undertakes research involving the use of recombinant DNA techniques to produce vaccines against East Coast Fever. Improved diagnostics based on monoclonal antibodies is a component of the biotechnology research. ILCA has very good facilities for group, technical, and postgraduate training (Alhassan 1999). Most of ILRI's training in biotechnology has benefited scientists in East and Southern Africa. NARS contacted on the need to link their biotechnology work with ILRI indicated that the emphasis of ILRI's work on East Coast Fever in cattle would not make such linkages feasible. Most NARS actively using molecular techniques in animal research were those in veterinary research.

ILRI's use of molecular markers in breed characterization is of general interest and could enhance the capacity of the NARS in the region for such work. In general, there did not appear to be any collaborative research in biotechnology between the NARS surveyed and ILRI.

3.8.4 The International Service for National Agricultural Research

ISNAR was established in 1979 with a mission to "support the institutional development of agricultural research in developing countries."

The headquarters are in The Hague, the Netherlands. ISNAR has set up since 1992 an Intermediary Biotechnology Service (IBS) to offer independent advice to the NARS in developing countries. It advises on issues of biotechnology management and policy. Currently, the Association for the Strengthening of Agricultural Research in Eastern and Central Africa (ASARECA), with the funding support of the UNDP and the USAID/MSU (Michigan State University) commissioned ISNAR to review and document current and planned biotechnology activities of the ASARECA networks. ASARECA is the counterpart of WECARD/CORAF in West and Central Africa. None of the institutions surveyed mention any linkages with ISNAR in biotechnology capacity building.

3.9 Donor reaction

Contacts with donor agencies for information on current funding levels for biotechnology and their policy towards program support in the area of biotechnology yielded very little response. Out of 20 agencies contacted by e-mail, only four responded. Most of those who did not respond had very little relevant information posted on the internet. The Rockefeller Foundation had extensive information on their website on their biotechnology funding projects. The responses from donors are presented below:

3.9.1 Danish International Development Agency

The Danish International Development Agency (Danida) is not much involved with biotechnology directly. Since it contributes to core funding of the CGIAR, Danida could be indirectly involved with funding biotechnology activities in the region. Danida, however, supports the activities of the International Service for the Acquisition of Agricultural Biotechnology Applications (ISAAA) with an annual grant of US$100 000 to support its biosafety and biotechnology application projects. ISAAA is a nonprofit organization with a global mandate to facilitate the transfer and application of tested biotechnological innovations to assist agricultural development. The African office for ISAAA is in Nairobi (Kenya).

3.9.2 International Development Research Centre

International Development Research Centre (IDRC), whose regional office for West and Central Africa is in Dakar (Senegal), currently has no specific biotechnology program of support. Biodiversity is, however, a major program and IDRC will support biotechnology if this leads to solving a problem in biodiversity. IDRC can finance workshops on issues of biosafety and will help in information dissemination in biotechnology. It will not normally build capacity by way of training or equipping laboratories.

3.9.3 Rockefeller Foundation

The African regional office for the Rockefeller Foundation is in Nairobi (Kenya). Biotechnology capacity building is an area of active support for Africa. The focus countries are Kenya, Malawi, Uganda, and Zimbabwe, all in East and Southern Africa. Nevertheless, a few training fellowships have been granted to West Africans. About four PhD candidates and two MSc students are supported yearly. Countries currently benefiting from graduate training support are Mali, Ghana, Côte d'Ivoire, and Nigeria.

The current priority area of interest for biotechnology research is on food crops (maize, sorghum, millet, rice, cowpea, banana, and cassava) to reduce postharvest losses in low-input farming systems of sub-Saharan Africa (Joseph D. Devries, personal communication, 2000). Currently, the annual budget in support of biotechnology research in sub-Saharan Africa is US$0.7m. This is in addition to US$4m voted annually for crop breeding and seed systems. As at October 2000, WARDA, IITA, and CNRA enjoyed support for biotechnology work in breeding and seed systems in sub-Saharan Africa.

The Rockefeller Foundation recognizes the potential of CNRA in Côte d'Ivoire as a regional center of excellence in biotechnology but was as yet not active. This view is supported by the fact that during the author's visit to the CNRA biotechnology center in Côte d'Ivoire, most items of equipment were still being installed. The Rockefeller Foundation will support biotechnology capacity building proposals including support for networking scientists or institutions, but such proposals should be comprehensive.

3.9.4 The United States Agency for International Development

USAID, like the Rockefeller Foundation, devotes most of its funding in biotechnology capacity building in Africa to East and Southern Africa. In 1991, Michigan State University (MSU) entered into a multiyear cooperative agreement with USAID to develop research relationships with emerging countries to train their scientists effectively to utilize biotechnology in enhancing plant agricultural products. The project was called Agricultural Biotechnology for Sustainable Productivity (ABSP). USAID has the following relevant programs in Africa (Josette Lewis, personal communication, 2000):

- Regional Biotechnology and Biosafety Program in East and Central Africa

The goal is to develop and promote the transfer of biotechnology applications that would address key agricultural constraints in East and Central Africa. It is envisaged that this will involve collaborative research between African and US public and private sectors, IARCs, and other ARIs, possibly through a competitive funding mechanism. The program will also deal with the development and harmonization of biosafety issues.

ABSP, led by MSU, in cooperation with USAID's Africa Bureau and USAID's regional office in East Africa (REDSO), is providing support for ASARECA to develop and implement the program.

- Biosafety Regulatory Training in Southern Africa

The purpose of this program is to provide technical training in biosafety regulatory implementation. The program is designed to strengthen science-based regulation in the Southern African Development Community (SADC) to meet US trade and science-based standards of the World Trade Organization (WTO) Sanitary and Phytosanitary (SPS) Agreement. Six countries will benefit from this program.

ABSP, USAID's Africa Bureau, and the Regional Center for Southern Africa (RCSA) will initiate the program this year. ARC/VOPI (South Africa) will implement the program.

- Public Communication on Biotechnology

The Africa Bureau, through the Agricultural Trade and Investment Program (ATRIP), has provided a grant to United States Department of Agriculture (USDA) to work with IARCs, the US 1890 Universities, and African organizations to promote communication with the public by policymakers and scientists on biotechnology issues, such as concerns about food and environmental safety. Three workshops under this program will be held:

a planning workshop in Ghana, and training workshops in East and Southern Africa. USDA is working through nongovernmental organizations, the African Biotechnology Stakeholders Forum in East Africa, and AfricaBio in South Africa. The IARCs providing technical support are CIMMYT (Mexico) and IITA.

- Livestock Vaccines through Biotechnology

USAID Global Bureau and USAID Greater Horn of Africa Initiative have supported the development and testing of a recombinant DNA vaccine against the livestock disease, Rinderpest. This vaccine was developed by the University of California at Davis. It is being transferred to East Africa.

A genetically engineered heart-water vaccine developed by the University of Florida with support from USAID RCSA is ready for testing in Zimbabwe and South Africa. A company has been identified to produce this vaccine commercially in Africa.

- Genetically Engineered Crops in Kenya and South Africa

In 1990, USAID initiated an innovative partnership between the Kenyan Agricultural Research Institute (KARI) and Monsanto Company to develop virus-resistant sweetpotato through transgenics. USAID subsequently withdrew its support but Monsanto continued with KARI and now the Kenya government has granted biosafety approval for KARI to field test the developed transgenic sweetpotato. This is the first time such a test is being carried anywhere in sub-Saharan Africa outside South Africa. ABSP will initiate testing insect-resistant Irish potatoes in South Africa in 2001. These potatoes will require little, if any, pesticide spraying.

- Intellectual Property Rights and Trade

A regional workshop was held in East Africa on the impact of intellectual property rights associated with biotechnology and crop cultivars on trade and technology transfer in the region. The WTO Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS) requires countries to provide a minimum level of protection for crop cultivars. This would help an understanding of the WTO requirement.

The above USAID initiatives for Africa are very comprehensive and quite laudable. It is hoped that the training initiatives will reach as soon as possible other parts of Africa outside East and Southern Africa.

3.9.5 Food and Agriculture Organization of the United Nations

FAO, though not a donor agency, plays a crucial role in biotechnology capacity building in the region and indeed globally through awareness creation. FAO provides information through electronic and print media on various aspects of biosafety and biotechnology application. Recently, highly informative electronic conferences have been held on issues of biotechnology application relevant to Africa.

4

Discussion of findings

The results of the survey provide the necessary insight into the current standing of the various research laboratories in issues of biotechnology development and application. While there might not be much variation in current levels of biotechnology application research among countries surveyed (tissue culture application to planting material production is most common), there is considerable variation in the capacity for biotechnology work among countries. Facilities for biotechnology research were generally better in the francophone countries. The within-country variability in strength of laboratories was generally greater for anglophone than for francophone countries.

4.1 Strengths

The available manpower within the survey countries is their source of strength. The exception appears to be Côte d'Ivoire where the number of experts in molecular biology (8) was smaller than in the other surveyed countries. If, however, the concentration of staff per laboratory is considered, then Côte d'Ivoire has better strength because seven of the eight professionals are in a single laboratory, the central biotechnology laboratory of CNRA. The new biotechnology center of CNRA, when fully commissioned, is supposed to have a work force of 200 staff. There will be the need to accelerate the pace of manpower training for the laboratory.

In the case of Nigeria, the sheer numerical strength of molecular biologists, further supported by the overwhelming numbers of those in the ancillary fields but with training in biotechnology, underscores its strength in manpower.

With a total of 28 nationals and 10 expatriates spread in four laboratories, Senegal is easily one of the best endowed in the region in terms of high caliber biotechnology manpower. When the contribution of biotechnologists from the ancillary biological fields is considered, Ghana has a strong manpower base, very comparable to the situation in Cameroon for core molecular biology professionals.

Senegal appears to have the best equipment infrastructure, followed by Côte d'Ivoire. The francophone countries are generally better endowed with laboratory infrastructure than the anglophone countries. This could be attributed to the greater consolidation of infrastructure or institutions in the francophone countries.

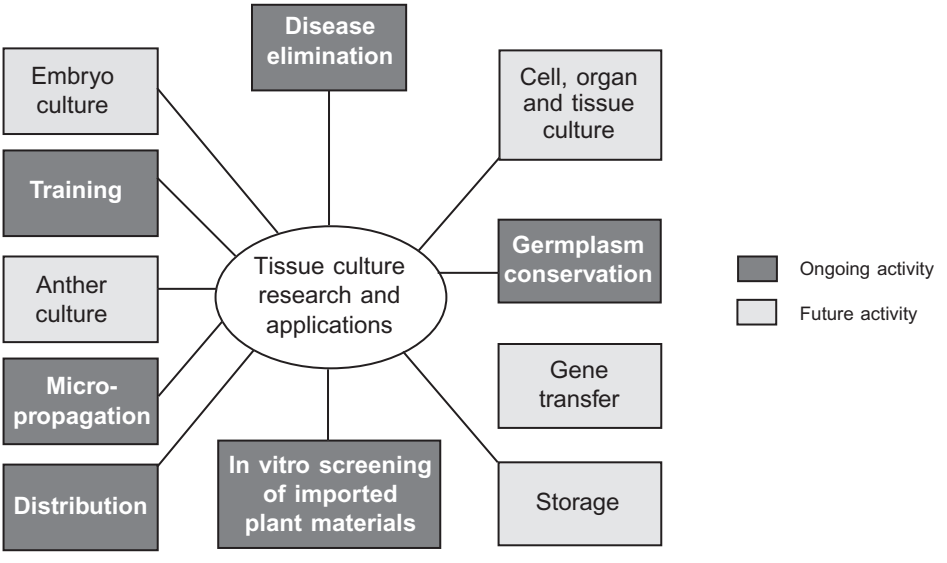

Figure 4. Biotechnology activities at Nigerian Plant Quarantine Service.
Source: Nigerian Plant Quarantine Service.

All governments in the target countries were aware of the potentials of biotechnology as well as its potentially negative attributes and are beginning to address the identified funding constraints, either through budgetary allocations or donor support.

An initiative started by the Nigerian Plant Quarantine Service, worthy of emulation by other countries, is the use of tissue culture techniques in their plant quarantine service delivery to screen plant material, clean up plants, and multiply the cleaned up material for distribution (Fig. 4) (Adejare, personal communication, 2000).

4.2 Weaknesses

These fall into the categories of poor funding, poor laboratory equipment, lack or inadequacy of laboratory reagents, inadequate physical space, unstable power supply, poor public perception of biotechnology, poor communication facilities and poor access to information by scientists. Komen et al. (2000) in their 1998 survey of three of these target countries listed manpower, human resources, and infrastructure as the major constraints facing the institutions. The current study reveals that where there was donor intervention, the above demerits were addressed to a large degree.

Although there is some awareness on biotechnology issues by governments, this needs to be heightened through greater budgetary releases to research institutions to ensure the effective application of biotechnology tools to solve the problems of agriculture and the environment.

Modern communication facilities, such as stable telephone and internet facilities, are *sine qua non* for keeping scientists well-informed and able to network with each other. The

lack of these facilities was serious in the case of Ghana, Cameroon, and Nigeria. Nigeria's situation was easily the worst. Governments in these countries must show much greater commitment than hitherto if the highly trained manpower is to be retained.

The current legislative framework with no legislated biosafety rules and no intellectual property rights laws to encourage innovation and allow the acquisition of new biotechnologies for further research and development represents a major handicap.

4.3 Creation of centers of excellence

Biotechnology research and development is expensive in terms of the facilities used for the research. Some collaboration among laboratories is required to maximize the benefits of complementary strengths. This practice of collaboration is also prevalent in the developed countries where certain laboratories, designated as centers of excellence, play a regional role in collaborative research. Examples of these are the European Molecular Biology Laboratory (EMBL) with its main laboratory at Heidelberg, Germany, and the Center for the Application of Molecular Biology to International Agriculture (CAMBIA), located in Canberra, Australia. CAMBIA is a tax-exempted, not-for-profit organization, funded by philanthropic organizations and international development investors (CAMBIA 2000). EMBL was established by 16 West European countries plus Israel (EMBL 2000). Apart from its main laboratory in Germany, it has four laboratories in other European countries. EMBL's mission is to:

- conduct basic research in molecular biology,
- provide essential services to scientists in its member states,
- provide high-level training to its staff, students, and visitors, and
- develop new instrumentation for biological research.

The Agence Africaine de Biotechnologie (AAB, African Agency for Biotechnology, in English) has its headquarters in Algeria (AAB 2000). AAB was set up to address cross-regional issues on biotechnology capacity building. Two historical events led to its formation.

- The 1990 release by UNESCO, in collaboration with UNDP, suggested biotechnology centers of excellence in 16 African countries (Algeria, Burkina Faso, Burundi, Cameroon, Côte d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Mauritius, Kenya, Morocco, Nigeria, Senegal, Tunisia, and Zimbabwe).
- The PanAfrican Symposium in Abidjan on Science and Technology for the Environment and Development recommended, as a priority action, the creation of a PanAfrican institution for biotechnology in a period of 5 years. The AAB started work in 1997 with the election of its governing council in Algeria.

The mission of AAB is to:

- reinforce the national capacity of member nations in matters of biotechnology;
- coordinate and promote cooperative research programs in the application of biotechnology prioritized for the development of member states;

- encourage the dissemination of scientific and technical information at the regional level and also encourage the sharing of experience;
- encourage the production, distribution, and commercialization of biotechnology products while ensuring sustainable development and the protection of the environment; and
- develop and harmonize the laws on bioethics, and intellectual property rights on patents and inventions.

Perhaps being such a new organization, the impact of the AAB is not being felt at the moment. It was well known and mentioned in the francophone countries visited but hardly mentioned in the anglophone countries. Having a much broader regional mandate, it should work more closely with the already existing regional organizations such as WECARD/CORAF and ASARECA. It also has to advertise its activities more intensively in the anglophone countries and the composition of its governing council should reflect their participation.

For the creation of regional laboratories of excellence, national laboratories must first of all address the basic infrastructure deficiencies that are currently very extensive in the case of Nigeria, Ghana, and Cameroon. In addition to the supply of the minimal laboratory facilities listed in Table 1, which must include arrangements for a constant source of electricity supply, the following must be in place to qualify laboratories for consideration as centers of excellence:

- adequate laboratory space;
- constant water supply;
- security for laboratory equipment and supplies,
- reliable telephone and email/internet connectivity;
- office space for visiting scientists;
- staff accommodation and guest house facilities;
- reliable supply of reagents;
- mobility/vehicles;
- motivated and well-trained staff in the critical areas; and
- proof must be advanced of arrangements to sustain laboratories built with donor support after the donor phase has ended.

The above will be essential also for a national laboratory of excellence.

A synthesis from both the EMBL and CAMBIA models could be applicable for laboratories of excellence in West and Central Africa. In addition to the above considerations, it would seem that a commodity-based approach, as currently practised by CRBP in Cameroon, would be an interesting option, worth pursuing. A forum of member countries under the WECARD/CORAF umbrella and with the cooperation of AAB could be empowered to take a decision on the matter. The capacity of IITA in training in biotechnology should be considered in determining what collaborative role it could play in such a center.

4.4 Status of biosafety laws and prospects for harmonization

The absence of a regulatory framework for biosafety and intellectual property rights was earlier identified as a source of weakness. It is, however, gratifying to note that all the survey countries, being signatories to the Convention on Biological Diversity, are making frantic efforts to have their biosafety laws in place.

Cameroon and Côte d'Ivoire have their biosafety laws ready for enactment while Ghana and Nigeria are still working to perfect their draft guidelines. Senegal is yet to produce its draft biosafety guidelines (Table 5). The Cameroonian and Ivorian draft laws as well as the draft guidelines for Ghana and Nigeria are similar in many respects. There are, however, differences in detail, the Cameroonian laws having more detailed provisions than the rest. These details are in agreement with the provisions in the model biosafety law published by the Third World Network (Nijar 1999).

All the biosafety regulations are similar in the areas of the creation of national biosafety committees and their broad functions. Other areas of broad agreement are risk containment measures such as confinement details, quarantine provisions, and movement and dissemination of genetically modified organisms (GMOs). While some of the countries agreed on some provisions of the law, others differed. These are listed below.

- The Ivorian law shows the highest level commitment to biosafety issues by creating an interministerial commission on biosafety and putting its permanent secretariat at the Office of the Prime Minister. None of the other countries provided for this arrangement.
- Both the Cameroonian and Ivorian laws make provision for labelling of products containing GMOs but the Ghanaian and Nigerian guidelines do not mention this aspect.
- Both the Cameroonian and Ivorian laws have a clause for international cooperation for the exchange of information. Information such as the effects of GMOs on humans, animals, and the environment shall be made freely available. The goal is to promote the management of GMOs without the risks. Ghana and Nigeria do not have this insertion in their draft guidelines.
- Côte d'Ivoire has an interesting clause on benefit-sharing, which is not in the provisions of any of the other countries. Article 38 of Côte d'Ivoire draft biosafety law states, "All GMOs or their derivatives from biological material originating from Côte d'Ivoire (existing naturally or created or modified in Côte d'Ivoire) shall not be commercialized on the international market unless with the agreement of Côte d'Ivoire based on fair and equitable sharing of the benefits derived from its exploitation and commercialization."
- The Cameroonian law provides for areas of exemption that are not in the other regulations. Thus, Title I General Provisions Article 2(1) states, "This law and its ensuing regulations shall not apply to organisms whose heritable materials have been modified by the use of traditional breeding/mating methods for the development of plants or animals under natural conditions."

Article 2(2) states that unless the GMOs used are parent organisms, the law and regulations shall not apply to the production with the aid of cell technology of genetically modified plant cells when the same result can be obtained by means of traditional methods of cultivation; or animal cells in culture where the cell materials have been obtained from different individuals of the same species and when the cells could have been produced by natural reproduction and the use of such plant or animal cells."

Article (3) states that it shall not apply to techniques involving gene therapy relating to genetic mutation and cloning, except where such genetic mutation is used for health purposes aimed at correcting certain deficiencies.

- The Cameroonian law provides for the precautionary principle, which is missing in the provisions of the rest of the countries. Thus Title I General Provisions Article 3 states as follows, "Government may, by Decree, prohibit any activity involving GMOs based on the precautionary principle or new scientific evidence."
- Article 29 states, "Risk assessment in all activities dealing with GMOs shall take into consideration the precautionary principle and shall be conducted as appropriate to ensure safety to humans, animal and plant health, biodiversity, and the environment." The law defines the precautionary principle as "When there is a reason to suspect threats of serious, irreversible damage, lack of scientific evidence should not be used as a basis for postponement of preventive measures." In addition, only the Cameroonian law:
  - provides for the classification of safety levels to be dealt with;
  - provides for the power to destroy GMOs in the case of illegal use and the setting up of a commission of enquiry;
  - provides details of the procedure for applications for handling GMOs with set response deadlines; and
  - has an incentive clause which gives tax rebates to companies that have developed GMOs locally under the provisions of the law. None of the other countries' regulations have this provision.

Both the Cameroonian and Ivorian laws provide for the amendment of the act in the light of new findings but neither the Ghanaian nor the Nigerian draft guidelines have this provision. In general, both the Ghanaian and Nigerian draft guidelines (which are identical) allow for greater flexibility in risk assessment. This is on the premise that there can be no zero risk.

The insertion of the precautionary principle into the biosafety laws of African countries has been criticized on the grounds that it is not realistic because, as noted above, an absolutely risk-free situation is not true to life. Egypt, Zambia, and Uganda are the other countries in Africa known to have inserted the clause into their biosafety laws. It is questionable to apply the precautionary principle in situations of hunger and food insecurity. As pointed out (Mugabe 2000), countries that are very knowledgeable on matters related to GMOs can indicate the level of scientific uncertainty associated with

the hazards of handling GMO products. Those that do not invest in scientific inquiry are likely to misuse the precautionary principle to unduly control or restrain technological advancement.

Apart from the insertion of the precautionary principle into the Cameroonian draft law, the biosafety provisions of the countries surveyed can be easily harmonized. Indeed, all had indicated during the survey their willingness to harmonize their biosafety laws. It is hoped that biosafety laws would accelerate the acquisition of GMO technology because these would be within the guideline of national laws. It would also encourage GMO trade among countries in the region or products containing GMOs.

4.5 Intellectual property rights issues

The need to protect genetic resources and to curb biopiracy is recognized by the countries covered by this survey; however, none of them has any legislation in place to deal with it. Biopiracy could take various forms including the undertaken cloning of genes designed from the local environment and subsequent patenting of such pirated genes. The protection of genetic resources is a problematic area, currently the subject for various biodiversity meetings on the international scene. The issues of benefit sharing from genetic resources taken from local communities are complex and must be addressed. Since the International Union for the Protection of New Varieties (UPOV) provides for the protection of new plant cultivars, countries could apply to join to protect plant cultivars developed by their scientists in cases where the new plant cultivars meet the UPOV criteria. To be eligible the plant must be:

- novel,
- uniform,
- stable, and
- must have a generic name.

Some form of protection must be provided to recoup the cost of investment in the development of new agricultural products from the application of biotechnology, particularly where these products are commercialized. Côte d'Ivoire, however, has a clause relevant to benefit sharing in its biosafety law.

4.6 Donor support

The current low donor support to the West and Central African region in biotechnology research and development capacity building needs to be addressed to be able to attract attention similar to that given to East and Southern Africa. As governments in West and Central Africa make the necessary commitment in their own countries to capacity building and as the biosafety protocols are in place, the attraction of donor attention will follow naturally. With the networking suggested and the commitment of resources, partners will come from the North not as mere donors but as partners. There is the need to articulate viable biotechnology policies for development.

5

The way forward

The strengths of the NARS unearthed must be exploited while the points of weakness must be redressed. Capacity building in Africa in agricultural biotechnology is crucial to the long-term struggle against food insecurity and poverty. The extent and complexity of the abiotic and biotic stresses as well as the need to intensify agriculture make it mandatory that African scientists build the capacity needed to take up the challenges. The following specific courses of action are suggested:

- Countries in the region should have their biosafety laws in place or be on the verge of having the laws in place.
- WECARD/CORAF, AAB, IITA, and WARDA should, with the necessary donor support, assist the countries in the region to start drafting the necessary provisions for their intellectual property laws.
- The deplorable state of laboratory infrastructure should be addressed forthwith. Recourse to a bilateral or multilateral donor should be made for immediate funding. The situation is desperate with university laboratory infrastructure. Alongside the donor support, a sustainable funding mechanism, such as commodity levying for agricultural research support, should be put in place. Research institutions should also be made to link up with the private sector to commercialize any of their available technology.
- A means of ensuring stable power supply to the laboratories must be determined especially for Nigeria and, to a lesser extent, Ghana.
- To maximize the use of laboratory resources and the talents of highly trained manpower, consolidation of laboratories should start at the national level. A special task force under the ministry responsible for science and technology and the ministry responsible for higher education must be set up to determine which laboratories should be merged and elevated to national laboratories of excellence. This consolidation appears to have been done in the francophone countries but not the anglophone countries.
- WECARD/CORAF and AAB should take up the issue of creating regional centers of excellence in biotechnology on commodity lines to emphasize the

fact that biotechnology is a tool to solve identified problems. The management of these laboratories could take a cue from the management of CRBP in Cameroon and EMBL in Germany.

- The WECARD/CORAF and AAB team, with about two consultants, should visit and hold discussions with the respective ministers for science and technology, higher education and agriculture on the concept and seek their commitment. Some donor agency may be approached to assist with the initial effort.
- IITA and WARDA should assist countries in the region who do not as yet have their biosafety laws in place to produce their draft biosafety regulations.
- The harmonization of biosafety laws should begin with Ghana and Nigeria that are following common biosafety guidelines. The initiative for this should come from the Secretariat coordinating the ECOWAS fast-track collaboration initiative in Abuja (Nigeria).
- The USAID initiative in Southern Africa on training in the implementation of biosafety regulatory procedures should be extended to West and Central Africa through IITA which already has the track record for such training. The training should be for countries that already have their biosafety laws in place or are on the verge of having the laws in place.
- WECARD/CORAF, AAB, IITA, and WARDA should, with the necessary donor support, assist the countries in the region to start drafting the necessary provisions for their intellectual property laws in the area of genetic resources exploitation.
- The recommendations of this report will be submitted to the ministries of science and technology of the countries of this survey for study and adoption after further modification, as appropriate.
- Ghana and Nigeria under the ECOWAS fast-track arrangement should be encouraged to take the necessary steps to study and implement this report in the identified areas of critical capacity building and in the creation of joint laboratories of excellence.

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19. Mrs S.Y. Ng	Nigeria	International Institute of Tropical Agriculture (IITA), Idi-Ose, Oyo Road, Ibadan, Nigeria	234–2–241–2626	S.Ng@cgiar.org
20. Dr J. Machuka	Nigeria	International Institute of Tropical Agriculture (IITA), Idi-Ose, Oyo Road, Ibadan, Nigeria	234–2–241–2626	J.Machuka@cgiar.org
21. Dr M. Gedil	Nigeria	International Institute of Tropical Agriculture (IITA), Idi-Ose, Oyo Road, Ibadan, Nigeria	234–2–241–2626	
22. Dr A. Melake-Berhan	Nigeria	International Institute of Tropical Agriculture (IITA), Idi-Ose, Oyo Road, Ibadan, Nigeria	234–2–241–2626	

Annex 1. contd.

Contact Person	Country	Institution/Address	Phone	Email
23. Prof. G.H. Ogbadu	Nigeria	Sheda Science and Technology Complex, Biotechnology and Genetic Engineering Advanced Lab. PMB 186, Garki, Abuja	234–9–5233916	Sheduscience@hyperia.com
24. Prof. C.P.E. Omaliko	Nigeria	Federal Ministry of Science and Technology Abuja	234–9–5235765	
25. Prof. Nduka Okafor	Nigeria	Nnamdi Azikiwe University, Applied Microbiology and Brewing Dept. Awka	234–42–459360	Fadib@infoweb.abs.net
26. Dr (Mrs) M.E. Bafor	Nigeria	Nigeria Institute for Oil Palm Research (NIFOR) PMB 1030, Benin City	234–52–602485	Nifor@infoweb.abs.net
27. Dr U. Omoti	Nigeria	NIFOR, PMB 1030, Benin City	234–52–602485	Nifor@infoweb.abs.net
28. Dr J.O. Odewale	Nigeria	Tissue Culture Unit, NIFOR, PMB 1030, Benin		
29. Dr O. Asemota	Nigeria	Molecular Biology Unit, NIFOR, PMB 1030, Benin		
30. Dr (Mrs) E.N.A. Mbanaso	Nigeria	National Root Crops Research Institute Plant Biotechnology Unit NRCRI Umudike PMB 7006, Umuahia, Abia State	234–82–440237/440471	Ephta@infoweb.abs.net
31. Dr E.B. Esan	Nigeria	Cocoa Research Institute of Nigeria (CRIN), Ibadan		Detak@skannet.com
32. Mr M.B. Sarumi	Nigeria	Federal Ministry of Sci. and Tech. National Center for Genetic Resources & Biotech (NACGRAB), Moor Plantation, PMB 5382 Ibadan	234–2–2312601 2313095	Nacgrab@skunnet.com
33. Dr B.A. Ogunbodede	Nigeria	Institute of Agricultural Research and Training Obafemi Awolowo University, Tissue Culture Unit, Moor Plantation, PMB 5029, Ibadan	234–2–231523	
34. Dr Jacob Kwaya	Nigeria	Biotech Research & Training Project (Proposed), Faculty of Vet. Med. ABU, Zaria	234–69–551046 (House)	Jkwaga@abu.edu.ng
35. Dr S.O. Alabi	Nigeria	IAR Dept. of Plant Sci., ABU, Zaria	234–69–550571–4 or 550795	Careazar@skannet.com

Annex 1. contd.

Contact Person	Country	Institution/Address	Phone	Email
36. Head of Dept.	Nigeria	Vet. Med. University of Ibadan	234–2–8101100	Rajoj@skannet.com
37. Dr K.A. Majiyagbe	Nigeria	Nigeria National Vet. Research Institute PO Box 115, Vom, Plateau State	234–73–460370	Majiagbe@unijos.skannet.com
38. Mr B.A. Adelaja	Nigeria	National Res. Inst. NIHORT, PMB 5432, Ibadan	234–2–2412501	Nihort@infoweb.abs.net
39 Dr B.N. Okolo	Nigeria	Dept. of Microbiology, University of Nigeria, Nsukka	234–42–255699	Batokolo@infoweb.abs.net
40 Dr C.E.A. Okezie	Nigeria	Dept. of Botany, University of Nigeria, Nsukka	234–42–770613	Misunn@aol.com
41. Dr I.A. Okwujiako	Nigeria	Biological Science Dept., Michael Okpara, University of Agric., Umudike, Abia State		
42. Prof. C.I.C. Ogbonna	Nigeria	Biotech. Res. Unit, Dept. of Botany, University of Jos, Jos	234–73–452291 or 610289	Ogbonna@unijos.edu.ng Ogbonna@skannet.com
43. Dr A'isha Usman Mahmood	Nigeria	Hon. Commissioner, Ministry of Women Affairs & Social Development, Bauchi	234–77–542695	
44. Dr Mamady Konte	Senegal	Laboratoire National d'Elevage et de Recherches Veterinaires (LNERV), BP 2057, Dakar-Hann, Senegal	221–8322710	Mkonte@sentoo.sn
45. Dr Marc Neyra	Senegal	Laboratoire de Microbiology IRD, BP 1386, Dakar, Senegal	221–849–3318	Marc.neyra@ird.sn
46. Dr Mamadou Gueye	Senegal	ISRA, BP 1386, Dakar, Senegal	221–849–3318	Mamadou.Gueye@ird.sn
47. Dr Paul T. Senghor	Senegal	Tissue Culture Lab. (URCI), ISRA/URCI, BP 8120, Dakar, Senegal	221–849–3333	Ptsenghor@isra.sn
48. Mr Prosper Houeto	Senegal	Ministre d' Enseignement Superieur et de la Recherche Scientifique, 23, Rue Calmette, Dakar, Senegal	221–821–32–60/ 822–51–39	Proshou@hotmail.com
49. Mrs Ndeye N. Diop	Senegal	CERAAS, BP 3320, Thies Escale, Senegal	221–951–49–94	Ceraas@telecomplus.sn

Annex 2. Personnel by gender with postgraduate training in core molecular biology—Ghana.

Institution	PhD		MSc		Nationality	
	Male	Female	Male	Female	Native	Foreign
CRIG	3	–	1	–	3	1
CSIR–CRI	–	–	1	1	2	–
CSIR–FRI	–	1	–	–	1	–
CSIR–SRI	1	–	–	–	1	–
CSIR–WRI	1	–	–	–	I	–
BNARI	4	1	2	1	8	–
MOFA–VSD	1	–	–	3	4	–
Total	10	2	4	5	20	1

Annex 3. Personnel by gender with postgraduate training in core molecular biology—Cameroon.

Institution	PhD		MSc		Nationality	
	Male	Female	Male	Female	Native	Foreign
Univ. Yaoundé–Biotech. Center	7	–	4	1	12	–
IRAD–JP Jonson Biotech. Lab. Ekona	1	–	–	3	4	–
IRAD–Animal Prod. & Fisheries	4	–	1	–	5	–
IRAD–CRBP, Njombe	1	–	–	–	1	–
Total	13	–	5	4	22	–

Annex 4. Personnel by gender with postgraduate training in core molecular biology—Côte d'Ivoire.

Institution	PhD		MSc		Nationality	
	Male	Female	Male	Female	Native	Foreign
CNRA–Biotech. Center	5	1	1	–	7	–
Univ. Abobo–IREN	–	–	–	–	–	–
Univ. Cocody–Biochem. Lab	–	–	–	–	–	–
Oceanography Research Center	1	–	–	–	1	–
Total	6	1	1	–	8	–

Annex 5. Personnel by gender with postgraduate training in core molecular biology—Senegal.

Institution	PhD		MSc		Nationality totals	
	Male	Female	Male	Female	Male	Female
ISRA–Biotech. Center/URCI	4	–	2	1	6	1
IRD–Microbiol. Lab.	11	2	10	3	17	9
CEERAS	–	–	–	1	1	–
ISRA–LNERV	2	–	–	2	4	–
Total	17	2	12	7	28	10

Annex 6. Personnel by gender with postgraduate training in core molecular biology—Nigeria.

Institution	PhD		MSc		Nationality	
	Male	Female	Male	Female	Native	Foreign
NAU	3	1	1	–	5	–
NIFOR	2	–	2	–	4	–
PQS	–	–	1	–	1	–
NRCRI	–	1	–	–	1	–
SHEDA (SSTC)	3	–	–	–	3	–
CRIN	4	–	8	3	15	–
NACGRAB	–	–	3	–	3	–
NIHORT	1	1	–	–	2	–
IAR&T	1	1	–	1	3	–
ABU (IAR)	2	1	–	–	3	–
UI	11	1	1	1	14	–
NVRI	1	–	–	–	1	–
FED.POLY. BAU.	–	–	–	–	–	–
UNN (MICROB)	–	1	2	–	3	–
UNN (BOT)	1	–	1	–	2	–
MOU	1	–	1	–	2	–
UNIJOS	1	–	3	–	4	–
Total	31	7	22	5	65	–

Annex 7. Ancillary field postgraduate degree holders by laboratory—Cameroon.

Ancillary field	Univ.Yaoundé Biotech.Center		IRAD–JPJ Biotech. Lab		IRAD–Animal Production		IRAD–CRBP		Total	
	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc
Breeding	–	–	–	2	1	–	–	–	1	2
Agronomy	–	–	1	3	–	–	–	–	–	3
Virology	–	–	–	1	–	–	–	–	–	1
Plant pathology	–	–	–	1	–	–	–	–	–	1
Total	–	–	1	7	1	–	–	–	–	7

Annex 8. Ancillary field postgraduate degree holders by laboratory—Côte d'Ivoire.

Ancillary field	CNRA–Biotech. Center		Univ. Abobo–IREN		Univ. Cocody Biotech. Lab		Oceanography Research Center		Total	
	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc
Agronomy	–	–	–	–	–	–	1	–	1	–
Entomology	1	–	–	–	–	–	–	–	1	–
Microbiology	–	–	1	–	1	–	1	–	3	–
Biochemistry	–	–	–	–	5	–	1	–	6	
Immunogenetics	–	–	–	–	–	–	1	–	1	–
Total	1	1	6		4		12			

Annex 9. Ancillary field postgraduate degree holders by laboratory—Ghana.

Ancillary field	CSIR–FRI		CRIG		CSIR–CRI		BNARI		CSIR–WRI		CSIR–SRI		MOFA–VSD		Total	
	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc
Breeding	–	–	1	–	2	1	–	–	–	–	–	–	–	–	3	1
Agronomy	–	–	–	–	1	–	1	–	–	–	–	4	–	–	2	4
Virology	–	–	–	–	2	–	–	–	–	–	–	–	–	2	2	2
Plant pathology	–	–	2	2	1	–	–	–	–	–	–	–	–	–	3	2
Microbiology	1	4	–	–	–	–	–	–	–	1	–	2	–	–	1	7
Entomology	1	–	–	–	–	–	–	–	1	1	–	–	–	–	2	1
Biochemistry	–	–	–	1	–	–	1	1	–	–	–	–	–	–	1	2
Parasitology	2	–	–	–	–	–	–	–	1	–	–	–	–	–	1	2
Immunogenetics	–	–	–	–	–	–	–	1	–	–	–	–	1	1	1	2
Seed technology	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–
Total	3		3	3	7	1	2	2	2	1	–	4	1	3	17	24

Appendix 10. Ancillary field postgraduate degree holders by laboratory—Nigeria.

Ancillary field	NAU		NIFOR		PQS		SSTC		CRIN		NACG–RAB		UNN (MIB)		UNN (BOT)		MOU	
	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc
Breeding	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Agronomy	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Virology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Plant pathology	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nematology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Entomology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Microbiology	1	8	–	–	–	2	–	–	–	–	–	–	9	6	–	–	–	4
Biochemistry	–	–	3	1	–	2	–	–	–	–	–	1	–	–	–	–	–	–
Parasitology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Immunogenetics	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cytogenetics	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mycolology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1

	UNIJOS		NRCRI		NIHORT		IAR&T		ABU–IAR		UI		NVRI		FEDPOLBAU		Total	
Breeding	2	–	1	1	1	1	–	–	7	1	–	–	–	–	–	–	11	3
Agronomy	1	–	–	–	2	–	–	–	2	–	–	–	–	–	–	–	5	2
Virology	1				2	–	1	–	1	–	6	2	1	4	–	–	12	6
Plant pathology	1	–	–	–	–	1	–	–	4	–	–	–	–	–	–	–	6	1
Nematology	1	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	3	–
Entomology	2	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	4	–
Microbiology	5	–	–	–	–	–	–	–	2	–	–	–	–	3	1	–	34	17
Biochemistry	3	–	–	–	–	–	–	–	1	1	1	–	–	2	–	–	11	6
Parasitology	3	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	6	–
Immunogenetics	2	–	–	–	1	–	–	–	1	–	2	–	–	–	–	–	5	–
Cytogenetics	2	–	–	–	1	–	–	–	–	–	–	–	1	2	–	–	4	2
Mycolology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1

Annex 11. Ancillary field postgraduate degree holders by laboratory—Senegal.

Ancillary field	ISRA–Biotech./URCI		IRD–Microbiology		CERAAS		ISRA–LNERV		Total	
	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc
Breeding	4	5	3	–	–	–	–	–	7	5
Virology	–	–	–	–	–	–	2	1	2	1
Microbiology	–	–	–	–	–	–	2	1	2	1
Biochemistry	–	–	–	–	1	–	1	–	2	–
Parasitology	–	–	–	–	–	–	3	–	3	–
Immunogenetics	–	–	–	–	–	–	2	–	2	–
Vaccine technology	–	–	–	–	–	–	3	1	3	1
Artificial insemination	–	–	–	–	–	–	2	–	2	–
Total	4	5	3	–	1	–	15	3	23	8

Annex 12. Sample data sheets

12a. Biotechnology data sheet 1—equipment

Country:

Institution:

Department/division:

Contact person:

Address:

Email:

Phone:

Item	Number
Tissue Culture	
Kitchen (media prep., cleaning, steril.)	
Laminar flow	
Various media[1]	
Assorted glassware[1]	
PH meter	
Autoclave	
Growth chamber/Culture rooms	
Balances	
Assorted refrigeration units	
Screenhouse	
Plant house for hardening	
Stable power supply[2]	
Inoculation/Transfer room	
Stereomicroscope	
Stirrer/Hotplate	
Rotary shaker	
Water still	
Water bath	
Dispenser	
Thermohydrograph	
ELISA reader	
Microcentrifuge	
Air conditioner	
Freezer	
Refrigerator	
Standby generator	
Assorted reagents	

Annex 12a. contd.

Fermentation	
Fermentors below 5 liter capacity	
Fermentors above 5 liter capacity	
Incubators	
Autoclave	
PH meter	
Assorted refrigeration units	
Centrifuges	
Assorted glassware[1]	
Water still for double distillation	
Balances	
Stable power supply[2]	
Container/Biosafety facilities	
Assorted reagents	
Molecular Biology	
PCR	
Laminar flow	
Electrophoresis equipment	
Assorted deep freezers (4°C to –80°C)	
Incubators	
Cold room	
Autoclave	
Film processing room	
Water still for double distillation/sterilization	
Assorted centrifuges	
DNA sequencer	
PH meter	
Balances	
Sample preparation room	
Assorted glassware[1]	
Assorted reagents1[1]	
Stable power supply[2]	
Container/Biosafety facilities	
UV light box	
Spectrophotometer	
Fluorometer	
Ice maker	
Water bath	
Heat block	
Shaker	
Stirrer	
Vortex	

[1]Indicate “some” or “many” [2]Indicate “Yes” or “No”

Annex 12b. Biotechnology data sheet—manpower.

Country:

Institution:

Department/division:

Contact person:

Address:

Email:

Phone:

Qualif.	Molecular biology and tissue culture specialists					
	Number		Nationality			
	Male	Female	Native	Foreign		
PhD						
MSc						
BSc						
Other						
(Specify)						

Other specialized staff with biotechnology exposure

Field	Number of staff by gender with qualification							
	PhD		MSc		BSc		Other	
	M	F	M	F	M	F	M	F
Breeding								
Agronomy								
Virology								
Plant Pathology								
Nematology								
Entomology								
Microbiology								
Biochemistry								
Parasitology								
Immunogenetics								
Other (Specify)								

Annex 12c. West and Central Africa biotechnology status survey additional response from the national research system

Background

1. Country:
2. Institution:
3. Contact person:
4. Designation of contact person:
5. Address:
6. Email:
7. Phone:
8. Date:
9. Key inputs requested:
10. Biotechnology tools in use (Please tick)

Tissue culture	rDNA/Transformation/GMO
DNA fingerprinting/gene mapping	Other (Specify)
DNA sequencing	

11. Biotechnology application areas (Please tick)

Planting material production	Vaccine production
Marker-assisted breeding	Diagnostics
Biofertilizer production	Other (Specify)
Monoclonal antibody production	

12. Specific commodity program (List project title)
13. Level of funding received from government
14. Level of funding received from donor sources
15. Nature of public–private sector linkage
16. Biotechnology outputs being commercialized
17. Plans to commercialize biotechnology outputs
18. List existing national biotechnology networks
19. List existing international biotechnology networks
20. Key constraints in biotechnology research
21. Ideas on a biotechnology subregional center of excellence
22. Ideas on a biotechnology national center of excellence
23. Future biotechnology development plans at the Institute

Many thanks for your cooperation

Please return to: Prof. W.S. Alhassan
Crop Improvement Division, IITA, Ibadan, Nigeria

Annex 12d. International agricultural research centers (IARCS) and international funding agencies (IFAS) operating in West and Central Africa—biotechnology focus

1. Date:
2. Name of IARC/IFA:
3. Subregional address:
4. Contact person (providing information):
5. Contact person's email:
6. Contact person's phone number:
7. Contact person's designation:
8. Institutional policy on biotechnology. Please include priority areas of support:
9. Existing biotechnology capacity (manpower, infrastructure, funding, etc.). For IFAs, indicate current biotechnology support budget:
10. Current institutional programs in the subregion using biotechnology:
11. Biotechnology linkages with NARS in the subregion:
12. Contribution to the biotechnology capacity building in the NARS of the subregion. For training, indicate level, number, and gender by year as well as country of trainees:
13. Views on regional centers of excellence:
14. Contribution to biopolicy formulation (e.g., establishment of biosafety guidelines):
15. Any other information relevant to subregional or regional biotechnology capacity building:

Kindly RETURN completed questionnaires on or before 30 September 2000 to:

Prof. W.S. Alhassan
Crop Improvement Division, IITA, Ibadan, Nigeria
E-mail: WAlhassan@cgiar.org or walteralhassan@hotmail.com

Many thanks for your cooperation

Annex 12e. West African biotechnology status survey Government ministries' response

Background

1. Country:
2. Ministry:
3. Contact person:
4. Designation of contact person:
5. Address:
6. Email:
7. Phone:
8. Date:
9. Key inputs requested
10. Ministry responsible for biotechnology research and development
11. Current level of funding for biotechnology projects
12. Importance government attaches to biotechnology research and development and application.
13. Current national biotechnology focus (Please tick)
    a. Biosafety guidelines
    b. Increased agricultural productivity
    c. Health diagnostics and cure
    d. Environmental cleansing—pollution, waste management, etc.
    e. Food processing
    f. Other (specify)
14. Current status of biosafety guidelines application

Enforcement ministry	Biosafety committees in place and functioning
Drafting committee appointed	Biosafety committees in place but not functional
Guidelines drafted	No Biosafety committee in place
Draft Bill in preparation	Stage of legislation
Legislated	Other stage (specify)

15. Willingness to harmonize biosafety guidelines for the subregion
16. Biotechnologies transferred to the private sector
17. Specific biotechnology projects funded by government
18. Potential areas of government support in biotechnology
19. Existing linkages with government ministries with biotechnology relevance
20. Plans to address public awareness in biotechnology issues
21. Constraints in promoting biotechnology
22. Laws to regulate exploitation of genetic resources available
23. If not available, indicate plans to address the above

Many thanks for your cooperation

Please return to: Prof. W.S. Alhassan
Crop Improvement Division, IITA, Ibadan, Nigeria

About IITA

The International Institute of Tropical Agriculture (IITA) was founded in 1967 as an international agricultural research institute with a mandate for improving food production in the humid tropics and to develop sustainable production systems. It became the first African link in the worldwide network of agricultural research centers known as the Consultative Group on International Agricultural Research (CGIAR), formed in 1971.

IITA is governed by an international board of trustees and is staffed by approximately 80 scientists and other professionals from over 30 countries, and approximately 1,300 support staff. Staff are located at the lbadan campus, and also at stations in other parts of Nigeria, and in Benin, Cameroon, Côte d'Ivoire, and Uganda. Others are located at work sites in several countries throughout sub-Saharan Africa. Funding for IITA comes from the CGIAR and bilaterally from national and private donor agencies.

IITA's mission is to enhance the food security, income, and well-being of resource-poor people primarily in the humid and sub-humid zones of sub-Saharan Africa by conducting research and related activities to increase agricultural production, improve food systems, and sustainably manage natural resources, in partnership with national and international stakeholders.

To this end, IITA conducts research, germplasm conservation, training, and information exchange activities in partnership with regional bodies and national programs including universities, NGOs, and the private sector. The research agenda addresses crop improvement, plant health, and resource and crop management within a food systems framework and targeted at the identified needs of four major agroecological zones: the dry savanna, the moist savanna, the humid forests, and the mid-altitude savanna. Research focuses on smallholder cropping and postharvest systems and on the following food crops: cassava, cowpea, maize, plantain and banana, soybean, and yam.

Cosponsored by the World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Development Programme (UNDP), the CGIAR is an informal association of over 40 governments and about 15 international organizations and private foundations. The CGIAR provides the main financial support for IITA and 15 other international centers around the world, whose collective goal is to improve food security, eradicate poverty, and protect the environment in developing countries.