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Agricultural Biotechnology Research Partnerships in sub-Saharan Africa

Achievements, Challenges and Policy Issues

Introduction

Much has been said, and disputed, about the promises of agricultural biotechnology in meeting the growing and urgent needs of developing countries. At the core of the controversy is the proprietary nature of most existing agricultural biotechnology products and tools, which are owned by research institutions and multinational private companies in developed countries. By concentrating biotechnology research in areas of interest to organisations in the North, it is likely that the needs of poorer countries will be by-passed. In view of this, it is argued that the promises of biotechnology can only be fulfilled if developing countries acquire the capacity to develop, manage, and use biotechnology to meet their own needs. This, however, is not easily done in many African countries as they lack adequate resources, technical and scientific capabilities, and are ill-prepared to deal with policy matters on the risks and benefits of agricultural biotechnology.

A widely accepted mechanism for providing developing countries with access to proprietary biotechnology products and tools is the formation of partnerships between Southern and Northern research institutions and multinational private companies. Fostering North-South partnerships in biotechnology has become an important item in the agenda of multilateral and bilateral development agencies over the past decade, resulting in an increasing number of projects. However, the nature and characteristics of the partnerships, the processes of technology transfer and development, the achievements, and the challenges ahead are largely unknown, despite the importance of such information for policy decision-making. This Technology Policy Brief contributes to filling this gap for three east sub-Saharan African countries, namely Kenya, Tanzania and Uganda. It is based on information collected and analysed in the framework of a comparative study carried out in the three aforementioned African countries, designed and co-ordinated by UNU-INTECH.

Léa Velho, the project leader, presents the main questions addressed by the study as well as the procedures followed. Of particular interest is the database on North-South partnerships in agricultural biotechnology. This database was designed to store the empirical information collected and allow for a combination of variables that are relevant to policy making. A second article by *Adriana Roa-Atkinson and Léa Velho* provides a description of the database, with examples of how it can be used. A preliminary version of the database is available. Interested users can contact Professor Velho at UNU-INTECH for more information.

The remainder of this Brief consists of three articles, each providing a synopsis of the nature, main features and achievements of North-South research partnerships in agricultural biotechnology in one of the above-mentioned African countries. Despite some cross-country differences, *Moses Ikiara* and *James Njogu (Kenya), Debora Melo* and *Emmarold Mneney (Tanzania) and Franklin Nsubuga-Muyonjo (Uganda)* emphasize the importance of Northern funding for biotechnology research. This support, however, needs to be better coordinated at the national level, as part of an overall biotechnology policy strategy developed in dialogue with local stakeholders. Among the latter, the private sector has yet to become a significant player in the process, a necessary requirement if agricultural biotechnology is to deliver its promises in Africa.

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North-South, Public-Private Partnerships in Biotechnology: Relevant Issues and Implications for Developing Countries

Research partnerships have become an increasingly important means of creating and diffusing technical and organisational knowledge. Over the past two decades, the formation of international technology alliances has grown considerably. This is particularly true in biotechnology-related activities, an occurrence that has generated a significant literature on biotechnology partnerships in industrialised countries.

The significance of these developments has been tracked by a number of initiatives, leading to the creation of dedicated databases in the US and Europe (e.g. the CORE database in the US and the CATI-MERIT database in the Netherlands).[1] There is consensus about the relevance of these databases for policy purposes, despite their recognised shortcomings. For instance, information on partnerships contained in the databases can be analysed according to several criteria, such as the national origin of partners.

These advances contrast sharply with the lack of systematic information and the fairly thin literature on biotechnology partnerships involving developing country research institutions and firms. There are some scattered references to existing capacity building initiatives, such as the implementation of joint projects by Southern and Northern researchers, training of Southern researchers, provision of research grants, and the transfer of biotechnologies to developing countries.[2] However, the dispersed nature of this information, and the fact that it is mostly based on case studies, renders it a very poor basis for decision making. Nevertheless, it is widely agreed that biotechnology can play an important role in fostering development in the South and that the necessary capability for this may be enhanced through North-South partnerships.

The UNU-INTECH study on North-South partnerships in agricultural biotechnology was formulated to contribute towards filling this gap. The main findings of the sub-regional study covering Kenya, Uganda and Tanzania are reported here, together with relevant policy issues derived from the analysis.

The objectives of the study were to:

1. Describe and examine the range and characteristics of North-South research partnerships in agricultural biotechnology in East Africa;

2. Build a picture of the different ways in which such partnerships enhance scientific and technological capacities in the South;

3. Examine the contribution of the partnerships to policy-making capabilities in the South, particularly in relation to biosafety guidelines and intellectual property rights;

4. Identify framework conditions for mutually beneficial North-South partnerships;

5. Analyse the influence of these partnerships in terms of the overall performance of each country's agricultural innovation system;

6. Assess the impacts of the partnerships in stimulating intra-regional (South-South) cooperation;

7. Investigate the extent to which the partnerships engage the participation and interests of a range of stakeholders, including technology user groups;

8. Draw up policy options to improve existing and future cooperation in this area to contribute to sustainable development objectives, and create and enhance links among the different agents of the agricultural innovation system in each country.

The methodology was extensively discussed with country researchers and followed three basic steps:

1. Mapping and description of the agricultural innovation system, identifying the existing capabilities at the sectoral level, including those of the key actors (universities, research institutes, firms, and support institutions) and the government policies and programmes that directly affect the innovation system in that sector.

2. Mapping of North-South partnerships in agricultural biotechnology. Since information on partnerships is not centralised in any institution, the mapping exercise drew on a variety sources including public agencies involved in international cooperation; interviews with key experts in S&T issues in agriculture; interviews with university officials responsible for international cooperation; secondary information from a variety of sources including academic journals and the public media, covering agricultural biotechnology activities in private and public organisations; direct interviews and short

questionnaires applied to a sample of pre-identified researchers, government officials and NGOs.

3. Selection of three North-South partnerships among those mapped for in-depth investigation as case studies. The criteria for selection included diversity in the national origin of partners, crops under investigation, techniques used, and types of capacity or skills aimed at. The case studies intended to identify: a) the motivations and roles of partners; b) the organisation and the management of the partnership; and c) the outcomes and impacts of the partnership.

Despite the common methodological approach, data collection and analysis in each country was shaped by the professional experience and views of the local research team as well as by the country's historical context. The similarities and differences between the country findings, their interpretations and, consequently, the policy issues highlighted by the authors are clear in the respective articles. This notwithstanding, information collection was standardised for all countries so that a general database could be designed. A description of the main features of the database and how it can be used are given in the following article.

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1 For general information on the databases, see chapter 4 of National Science Board, Science and Engineering Indicators 2002 (http://www.nsf.gov/sbe/srs/seind02/start.htm); Hagedoorn, J.; Link, A.N.; and Vonortas, N.S. (2000), Research Partnerships, Research Policy 29: 567-586.

2For example research networks, market mechanisms and those brokered by private companies in the business like the International Services for the Acquisition of Agri-biotech Applications - ISAAA), see http://www.isaaa.org/

North-South Partnerships in Agricultural Biotechnology

A Pilot Database

North-South partnerships in agricultural biotechnology are increasingly seen as an important mechanism for creating capacity in developing countries to generate, manage and use biotechnology to meet local needs. There is also growing academic and policy interest in understanding the characteristics of such partnerships as well as the circumstances under which they seem to work more effectively. Having a common need for a large data set on North-South partnership projects, four research teams[1] that are currently investigating the institutional impacts and knowledge and technology flows of partnership projects in agricultural biotechnology decided to join efforts in this direction. The agreement was to develop a pilot database that would meet the needs of all the projects involved and to test it with the information collected in the partnership mapping phase of the research project reported in this Brief.

The pilot database was designed to store key data about partnerships (projects and programmes) and the unity of analysis is in itself a project in partnership. For the purposes of the study, a partnership was defined as a research project that involves any type of resource - financial, human or physical - provided by another country besides the one under study.

The identification of some key categories and the standardisation of basic tables were agreed to by a core group of researchers working on the project.[2] To facilitate further comparisons with other databases in the future, international codes were incorporated, in particular ISO country and some organisation types from the Research Outputs Database, ROD.

The results obtained are relevant for policy making both within developing countries as well as among donors and research partners in the North. It is possible, for instance, to use the database to identify the level of research capacity in a particular country, the main crops under study and techniques mastered, the occurrence of knowledge gaps and needs, the overlapping of efforts and need to improve

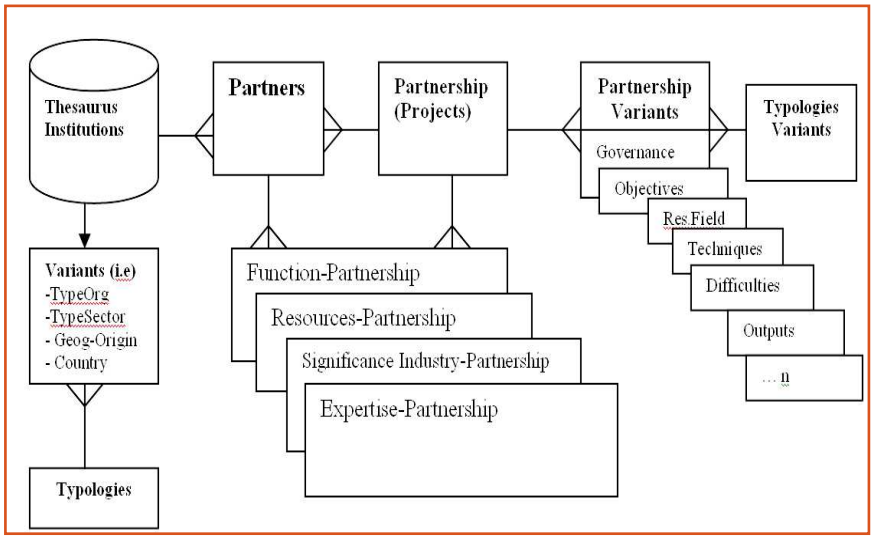

Fig. 1: Model entity-relationship structure

communication, the main outcomes of the partnerships in terms of training, equipping labs, publication, and creating links with users.

Database Design and Interface

The pilot database was designed as a relational database, to allow the integrity of data between different tables (entities) to be maintained. The software selected to implement this relational model was Access 2002 - Office XP. Figure 1 illustrates the entity-relationship structure. The main advantage of this structure is that new values of basic tables (typologies) can be added without affecting the general structure of programmes. This, however, imposes the restriction that records cannot be modified until the entities affected have also been updated. So reverse processes are controlled to ensure integrity of data. Key information was entered in the database once the project reports had been processed and analysed.

The interface for data entry covers three main options: i) to add or edit information, ii) to maintain typologies and a thesaurus of institutions; and iii) to produce queries or reports (see Fig. 2). The first part of the menu interface covers most of the options relating to the full data entry not just the partnership details, but also the list of partners and their role in the partnership. In the second part the interface provides easy access to calibrate and maintain the basic tables and the thesaurus of institutions. Finally, the interface allows the users to either enquire about information available or to create their own queries.

1. Adding or editing information

Once typologies have been calibrated, key information about partnerships can be stored in the database, selecting any of the submenus associated with partnership information or partners' details. The submenus included are:

Key Contacts: this option keeps the main contacts available to access, particularly for entry in their websites and e-mail connections.

Governance: this dialog box contains details about how the partnership has been initiated, the type of agreement involved, and the key decision-making structures.

Objectives: if applicable, there are options for breaking down objectives into categories according to the main targets or research questions covered by the partnership.

Subject and Technique: this tab deals with the options that help to describe the area or research field that the partnership relates to as well as what products are targeted. It enables users to select specific techniques (Table 1 provides a list of these techniques).

Research Methods: this submenu provides information on the nature of the participants in terms of their disciplinary approach (natural sciences, interdisciplinary, social sciences, or indigenous knowledge). This gives a picture of the scope of the research problem under investigation,

Outputs: this option allows the user to ask questions about capacity building processes facilitated by the partnership through training, dissemination, policy regulation, and product development. Basic details of economic performance can also be registered here.

Difficulties/problems: this submenu registers the problems encountered by partners and how they have affected the development and outcomes of the project. Basic typologies are provided (for example, late disbursement of funds or withdrawal of a research partner) but other problems can be calibrated according to the research or information needs.

List of Partners: under this option the user is allowed to select the names of partners from the thesaurus of institutions.

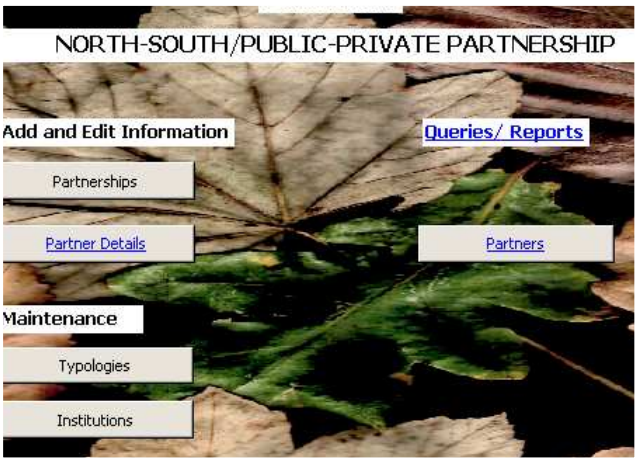

Fig.2: Main menu of the interface

Once the list of partners has been entered in the database, details of partners can be entered in the submenus according to the information available. Key details, such as expertise and professional experience, as well as resources and functions, must be registered in order to have a complete picture of the resources involved in building the partnership. For instance, it can help to find answers to what role is played by different partners.

2. Maintenance of typologies and the thesaurus of institutions

Codes and description of typologies in basic tables can be calibrated according to the research field, (such as agriculture, human health, animal health) being analysed. For instance, new values for techniques and products in the field can be tuned through the 'Maintenance' submenu, allowing the user to access it directly or interactively once a new value has been identified. The thesaurus of institutions guarantees the availability of basic information about institutions involved in projects. In order to continue entering information about partners in subsequent submenus, their institution-branches need to be entered in the thesaurus whatever their function in the partnership. Once the institution has been entered, it is accessible for other partnerships.

3. Data Retrieval (Queries/Reports)

The database can be searched by means of simple or advanced questions using SQL language (Standard language used by many database programmes). These queries can be saved using Access utilities to generate reports, which can be of matrix type (crossing variables), or general listings grouped by attributes. A matrix report contains information, for instance, on the funding source and institutions involved in research on tissue culture in a particular country. An example of a general listings report is provided in Table 1.

Information on a specific partner or partnership can be obtained by:

- Identifying part of the name of the partner or project;
- Identifying functions of the partner, such as: donor, research collaborator, manager, facilitator;
- Naming and grouping one or more attributes of the partners, such as: type of sector, type of organisation, country;
- Naming and grouping one or more attributes of the partnership, such as: technique, crops studied, research field, type of decision-making, agreement established, indigenous knowledge use and so on.

Table 1 below provides an example of a search result for biotechnology techniques adopted by research partnerships in the three countries. A number of conclusions can be drawn from this information. Tissue culture tops the list as the most common technique being used by agricultural biotechnology partnership projects in the three countries.

The low ranking of techniques such as genetic engineering and molecular diagnosis indicates that there is little capacity for advanced biotechnology research in the countries studied. This lack of capacity in turn inhibits technology transfer and in the realm

Techniques	Total
Tissue culture	36.54
Molecular Markers	21.15
Disease testing	3.85
Embryo culture	3.85
Fermentation	3.85
Genetic engineering	3.85
Industrial biotechnology	3.85
Microbiology technology	3.85
Molecular Diagnosis	3.85
Bio regulation	3.85
Breeding technique	1.92
Conservation	1.92
Diagnosis	1.92
Fortification	1.92
Micro propagation technologies	1.92
PRA techniques	1.92
Grand Total	**100.00**

Table 1: Techniques in Agricultural-biotechnology in Kenya, Tanzania and Uganda (%)

of policymaking, contributes to uninformed, and sometimes very ideological debates on issues related to these techniques, for instance on-going discussions on the pros and cons of genetically modified products.

Conclusion

The database is in a development phase and still has a number of limitations. There is need, for instance, to create more objective definitions for some categories (e.g. capacity building) and to develop systematic tracking of the incidence of the inputs and outputs associated with the various types of research partnership. Finally, maintenance and responsibility for this repository is necessary in order to: i) increase and refine the information on institutions available in the thesaurus, ii) advance the mapping process and arrive at a better understanding of agricultural biotechnology partnerships in the East African sub-region, and iii) create a base from which to conduct a similar analysis in other developing countries. This requires not only more funding (actions have been taken in this respect) but also potential user interest in testing the pilot template for specific information needs and suggesting improvements (to this end the database can be made available on request).

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[1] The teams and their respective research projects are: The Innovation and Genomics Centre (INNOGEN - see details in http://www.innogen.ac.uk/) is carrying out two related projects: "North-South Partnerships in Genomics and Biotechnology: Exploring Knowledge and Technology Flows in Latin America and Asia"; and North-South Partnerships in Genomics and Biotechnology: Exploring Knowledge and Technology Flows in Africa; another project is also associated with INNOGEN and funded by the ESRC Science in Society Programme and Open University (see details in http://www.innogen.ac.uk/and http://sbs.xnet.sbs.ox.ac.uk/scisoc/) and is entitled "Institutional Impacts of North-South Partnerships in Agricultural Biotechnology"; INTECH-UNU project, part of which is the basis of this TPB, "North-South, Public-Private Partnerships in biotechnology: relevant issues and impacts in the developing" For details see www.intech.unu.edu) .

[2] Typologies and the general structure are based on reports and questionnaires that have been discussed and analysed with the team of research fellows at the Open University (OU) as part of the collaboration with UNU-INTECH to define the pilot template of the database.

Agricultural Biotechnology Partnerships in Kenya

Biotechnology research in Kenya dates back to the 1960s when a Rinderpest vaccine was produced by the East African Veterinary Research Organisation (EAVRO). Proper awareness of biotechnology, however, is associated with the holding of the Third Conference of the International Plant Biotechnology Network (IPBNet) in Nairobi in May 1989. The Conference led to the establishment of the African Plant Biotechnology Network (APBNet). A year later, the National Biotechnology Advisory Committee was established under the Ministry of Research, Science and Technology, with the task of advising the Minister on biotechnology policy and institutional issues.

During another conference on plant and animal biotechnology held in Nairobi in 1990, priorities were set for agricultural biotechnology in the country. These included: development of tissue culture procedures for use in propagation and pathogen elimination; utilisation of non-conventional methods in selecting desirable traits such as high productivity and adaptation to different agro-ecological zones; development of diagnostic methods for detecting disease-causing agents; development of novel vaccines; conservation and distribution of germplasm; development of molecular markers in plant breeding and selection; transfer of useful genes into plants to develop pest and disease resistance; development of methods of bio-control for insect pests and diseases; and development of bio-fertilizers. Enhancement of biotechnology research and development capacity through training, instrumentation, and infrastructure development, and through the development and improvement of tissue culture protocols for use by the private sector is also a key part of the agenda.

With the support of the US-sponsored Agricultural Biotechnology Support Project (ABSP), Kenya instituted the National Bio-safety Committee in 1996, which subsequently formulated the *National Regulations and Guidelines for Safety in Biotechnology*. In addition, the Kenyan Plant Breeders' Rights office was established in 1997; the Kenya Agricultural Biotechnology Platform (KABP) was established in 1999 to formulate bio-safety guidelines, coordinate agricultural biotechnology research, and offer short-term training courses for

scientists and technicians; and the Seeds and Plant Varieties Act of 1972 was amended in 2002 to accommodate biotechnology.

Achievements

Kenya has made fairly significant strides in agricultural biotechnology over the years, in spite of a deteriorating economic environment and rising poverty.

The adoption of tissue culture technology in the 1980s led to a three fold rise in the farm productivity of pyrethrum. Tissue culture bananas are very popular with farmers as they are more productive, resistant to diseases and pests, and mature in two, instead of three, years. The production of tissue culture potato, moreover, is widespread in many parts of the country. The mastering of this technique and its economic applications involved significant collaborative efforts between local universities (particularly Jomo Kenyatta University of Agriculture and Technology-JKUAT) and research institutes (Kenya Agriculture Research Institute - KARI) with support from a number of multilateral agencies (UNESCO and World Bank) as well as Northern donors (Dutch Ministry of Development Cooperation and Rockefeller Foundation).

Molecular marker technology, adopted in 1995, mainly to shorten the breeding time and to reduce the cost of screening procedures, is being used to develop maize varieties and lines that are resistant to insects (particularly stem borers), diseases (specifically maize steak virus), and drought. KARI has developed significant capability in this technique and has an ultra modern lab at its Katumani research station, for which support from the Rockefeller Foundation was crucial.

The Kenya Agricultural Research Institute (KARI) pioneered genetic engineering in 1991, with the transformation and regeneration of sweet potato. Although there is no commercial GM variety of sweet potato as yet, KARI has developed capacity in the technique. This was achieved through a partnership between KARI and Monsanto, mediated by ISAAA.

Features of North-South Partnerships

In the course of this study, 60 North-South research partnerships were identified. The analysis of these partnerships revealed that:

1. North-South agricultural biotechnology partnerships in Kenya are predominantly carried out by public research institutes and universities. KARI, which operates 17 research centres, is involved in the majority of these partnerships. Other significant players are: Institute Trypanosomiasis Research Institue (KETRI), Kenya Forestry Research Institute (KEFRI), and Kenya Marine Fisheries Research Institute (KEMFRI), University of Nairobi, JKUAT, and Moi University.

2. Within these partnerships a wide array of stakeholders - international, regional and national, public and private, networks and local farmers - are involved. International partners primarily supply funding and capacity building support, but also provide research material, including donation of technology. Collaboration in research projects between Northern and Kenyan researchers is less common. Key donors include the Government of The Netherlands; Rockefeller Foundation; UNESCO; the International Maize and Wheat Improvement Centre (CIMMYT); and the United State Agency for International Development (USAID). Other leading players include facilitating agencies (ISAAA; A-Harvest, and Biotechnology Trust Africa), private companies such as Monsanto and Genetic Technologies Limited (GTL), and networks such as the African Biotechnology Stakeholders Forum (ABSF) and Kenya Agricultural Biotechnology Platform (KABP).

3. Most of the partnerships involve tissue culture techniques although a significant number of projects have begun work on newer biotechnology techniques such as molecular markers.

4. There is minimal diversity in the form of North-South partnerships. The local partners, in collaboration with researchers from the North, prepare proposals that are funded by Northern donors. Decisions over the technical work are left to the research collaborators. There are a few cases of technology transfer from the Northern partners, however.

5. Most of the partnerships do utilise local indigenous knowledge and involve the intended beneficiaries in projects. Local partners contribute to the design of projects, including needs identification and priority setting.

Policy Recommendations

Kenya has not tapped the full potential of agricultural biotechnology because of several constraints. First, the Kenyan Science and Technology Act does not make provisions for agricultural biotechnology, which then lacks clear prioritisation. Second, mirroring the situation in the rest of Africa where more than 85% of biotechnology R&D is within the public sector, participation of the Kenyan private sector is minimal.

This has been partly attributed to a lack of effective Intellectual Property Rights (IPRs), a major shortage of IPR experts, the lack of favourable policies and institutional frameworks, poor political and economic governance, meagre resource allocation to research by government, lack of a critical mass of biotechnology capacities (scientists and infrastructure), and lack of corporate trust between the private and public sectors. Third, the lack of flexibility is also a weakness of partnership agreements, with donors preferring to fund very specific areas, which may not be the country's priority. Other problems include the tendency by some donor agencies to pull out before project completion, inadequate funding, and disbursement delays. Fourth, arrangements or capacity for technology dissemination are inadequate.

The following measures are proposed to address these challenges:

1. Improving economic and other forms of governance, and the general business environment, in order to attract partnerships - particularly involving the private sector;
2. Developing a proactive national aid policy, with a clear programme for building capacity in aid negotiation capacity, to enable the country to maximise its net benefits from aid;
3. Making available public funds to develop agricultural biotechnology infrastructure and other capacity to draw the maximum benefits from technology transfer;
4. Strengthening capacity in the national system of agricultural research and technology extension, distribution, diffusion, and feedback;
5. Ensuring effective and efficient coordination of the national system of agricultural research in view of diverse collaborators and stakeholders, including farmers;
6. Maintaining strong regulatory instruments and institutions to manage risks related to genetic engineering.

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Agricultural Biotechnology Partnerships in Tanzania

Biotechnology research involving first generation techniques (selection of biological organisms for fermentation and tissue culture) is well established in Tanzania. The pioneer institutions include the University of Dar es Salaam, where research has explored the use of microorganisms in fermentation; Sokoine University of Agriculture (SUA), which has a successful record in the development of NITROSUA, a bio-fertilizer (Rhizobium inoculum); and the Mikocheni Agricultural Research Institute (MARI), long active in tissue culture and micro-propagation systems.

Many important food crops in Tanzania are vegetatively propagated. Tissue culture is an important technique for seed distribution and production of disease-free planting material. The first micro-propagation facility in the country was a lab developing coconut tissue. The laboratory was set up in 1992/93 under a partnership between MARI and the German Government, through the German development agency, GTZ. Building on this experience researchers at MARI have gone on to develop efficient micropropagation systems for a number of other crops, including cassava, banana, sweet potato pineapple and cashew. SUA established a similar lab that became operational in 2000 and has more recently begun work on banana plantlets.

Research in molecular techniques (second generation biotechnologies) was first reported at MARI in 1993, following the establishment of a Molecular Biology Laboratory under a partnership with the European Union. The lab has used molecular markers to identify and screen diseases in coconut and to assess the genetic diversity among coconut varieties. Pathogen specific DNA probes and PCR primers have been developed that are now used for routine diagnosis of infections in palms. The results obtained are being applied to the characterisation of coconut, cashew, cassava, sweet potato and coffee germplasm, with funding from several Northern partners, including the Rockefeller Foundation and the Swedish SAREC through the BIO-EARN programme. SUA constructed a USAID/GTZ-funded molecular lab, which also became fully operational in 2000. Diagnosis techniques have been applied to beans, cowpeas, fruits and vegetables. Other

research institutes of the Ministry of Agriculture and Food that opened tissue culture labs in 2000 include Horti-Tengeru, Mlingano Agricultural Research Institute and the Kizimbani Agricultural Research Station, Zanzibar. They are involved in personnel training and establishing the necessary infrastructure.

Other biotechnology institutions include: the Faculty of Agriculture, Sokoine University of Agriculture, which is involved in research and training on tissue culture and molecular biology; SUA, using biotechnology techniques to analyse genetic diversity in livestock and wildlife species and the application of molecular diagnostic techniques for animal diseases; the Tanzania Food and Nutrition Centre, on food processing techniques (cereal and cassava fermentation), including microbial biotechnologies; the Animal Disease Research Institute (ADRI) that develops sero-diagnosis of animal diseases; and the Applied Molecular Unit at the University of Dar es Salaam where analysis on mushroom cultivation techniques; food microbiology and wastewater treatment is underway.

In summary, the bulk of biotechnology research activities in Tanzania takes place in public research institutes and universities. Essentially, there are only two organisations active in agricultural biotechnology, one of which has only recently established a well-equipped research facility. No private companies or producers associations have developed biotechnology capacity to date, but there is a lot of interest among these organisations in using modern biotechnology techniques to improve cultivars and seed dissemination systems for a variety of crops, including pyrethrum, sugarcane and tea.

Features of North-South Partnerships

The study identified 16 partnership projects at MARI and SUA, which exhibit a number of common features:

1. Most projects are funded by Northern donors, such as GTZ, European Union, SIDA/SAREC, DANIDA, DFID, Rockefeller Foundation, and USAID.

2. The typical partnership involves a local research organisation and a Northern funding organisation. The direct involvement of Northern partners in the implementation of research projects is rare. Only seldom do partnerships include other local and Northern collaborators, as is the case with EU-funded projects. On such occasions, the networks mainly serve as channels for exchanging material, while the Northern research partner retains control over the project.

4. Most partnerships focus on training and capacity building. Training is mostly conducted through a 'sandwich' model, where local researchers spend some time at Northern universities.

5. From their initial work on tissue culture, a number of projects have incorporated second generation techniques, such as molecular markers. However, third generation techniques (those involving genetic manipulation) are yet to be introduced.

6. Projects tend to be confined to local research institutes and universities. Linkages with other actors in the country are being explored in a few projects, as in the case of the SAREC funded BIO-EARN, which involves various agricultural research institutes (ARIs).

7. Public-private partnership are extremely rare, the exceptions being cashew and sisal. Increasingly though, the 'privatised' producer associations that are taking over the running of public research institutes and establishing new organisations (for instance the Tanzania Coffee Research Institute - TACRI) are potential collaborators in biotechnology research.

8. Collaboration with neighbouring countries is still rare - among the isolated examples is ongoing work between MARI and Makerere University, in Uganda, and SUA and KARI, in Kenya.

9. Many partnerships have succcessfully used participatory methods to incorporate the needs of beneficiaries in their research. On the whole, however, other stakeholders have largely been excluded in the implementation and monitoring of biotechnology research activities. Hence conventional 'top-down' project implementation structures are still the norm in Tanzania's biotechnology sector today.

Constraints to Biotechnology Development in Tanzania

a) Funding for biotechnology research remains a serious constraint in Tanzania. The bulk of funding comes from Northern donors and public-private partnerships have not been explored. Exceptions are government resources channeled through TARPII, the cashew levy, and one case of collaboration with private companies;

b) The lack of skilled personnel is a serious bottleneck in building capacity in this area. It is exacerbated by brain drain of the best staff due to poor remuneration and unfavourable working conditions including poor infrastructure (water, power, telecommunications), a shortage of tools

and scientific equipment and inadequate capacity to maintain available equipment and facilities.

c) Biosafety regulations and ethical guidelines relating to newer technologies are poorly developed and there is a general lack of awareness and commitment by policy makers and the general public on both the potential and risks of biotechnology research;

d) There has been little international interest in the agricultural products and plant species that are important for Tanzania and other sub-Saharan African countries - for instance pigeon peas, millet, cassava and sweet potato. The work being done by local research centres is therefore crucial, despite the limitations mentioned above.

Policy Recommendations

1. The Tanzania Commission for Science and Technology (COSTECH) should play a greater coordinating role in identification of research priorities, developing biopolicy and overseeing partnership projects to ensure that they meet the country's needs.

2. While Tanzania is yet to develop third generation biotechnology research, important issues such as biosafety (for instance work being done by the BIO-EARN project) and patents should be addressed now. There is need for closer involvement of the Patent Office and relevant organisations in drawing up guidelines.

3. North-South partnerships should facilitate greater dialogue and involvement of end users and non-experts not only in agenda setting but also at all stages of product development.

4. In order to build truly equal partnerships in biotechnology research, there is a need to build structured mutual assessment and feedback procedures in order to facilitate reflection and learning from experience among project partners. Such mechanisms should not be limited to funding but should include technical, structural, and organisational issues as well. Local researchers and policy makers should play a more active role in demanding equity in these partnerships.

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Agricultural Biotechnology Partnerships in Uganda

The Plan for Modernisation of Agriculture of the government of Uganda, one of the main national strategies under the Poverty Eradication Action Plan of 1997, explicitly recognises the potential of biotechnology in national development. In this framework, a draft biotechnology and biosafety policy was submitted in October 2003 for endorsement by the Cabinet.

While various traditional forms of biotechnology have been used since time immemorial, the development and growth of modern biotechnology in Uganda is still in its infancy. The limited application that exists is mainly in the agricultural sector where the technology is generally being used in breeding.

The Main Players in Agricultural Biotechnology

Agricultural biotechnology activities are mostly carried out on a collaborative basis between local institutions and foreign partners, facilitated by substantial donor funding. Tissue culture is the most intensive biotechnology activity for purposes of plant germplasm conservation and improvement, as well as in the production of pathogen-free planting materials. Other techniques being used fall in the broad areas of molecular biology and diagnostics, spectrophotometry, marker identification, and marker assisted selection as well as immunological methods.

The main centres of biotechnology research in Uganda are the National Agricultural Research Organisation (NARO) and Makerere University - both of which are public sector institutions. Under NARO, Kawanda Agricultural Research Institute (KARI) is the hub of research, with the National Agricultural Biotechnology Centre (NABC) as the main facility equipped and mandated to conduct studies on broad issues and crops. The NABC is mainly funded by the Rockefeller Foundation, Belgium, USAID, and DFID. At the moment, it has modern tissue culture and molecular biology laboratories. The facility is relatively well equipped but has not yet reached its full capacity due to a shortage of qualified technical staff.

One of the largest programmes at KARI is the National Banana Research Programme (NBRP), mainly funded by the Rockefeller Foundation. Banana is a high priority food and cash crop in Uganda, but its growth and production is associated with several constraints (mainly pests and diseases) that cannot be addressed using conventional means. Research activities on this programme include embryo rescue, tissue culture, and genetic engineering.

Other NARO institutes engaged in crop biotechnology include Namulonge Agricultural and Animal Production Research Institute (NAARI), the Coffee Research Institute (CORI), and Serere Agricultural and Animal Production Research Institute (SAARI).

Agricultural biotechnology research at Makerere University is carried out at the Faculty of Agriculture. Training and research is concentrated in the main areas of marker-assisted breeding, tissue culture, and genetic diversity studies, with a molecular and cell biology laboratory at the main campus and a tissue and cell culture lab at the Kabanyolo campus. The labs were established with support from DANIDA, SAREC through the BIO-EARN Programme, the EU and the Rockefeller Foundation.

At the Department of Crop Science (DCS), biotechnology research includes the development of protocols for the mass propagation of indigenous cash and food crops. Banana research funded by the Rockefeller Foundation and BIO-EARN is one of the main programmes whereby DCS works collaboratively with local and international partners like the Swedish University of Agricultural Sciences, Uppsala, the Uppsala Genetic Centre, and the Agricultural University of Norway.

There are currently only two non-public biotechnology research institutions, Med-Biotech Laboratories (MBL) and Agro-genetic Technologies (AGT). MBL is a non-commercial establishment dealing almost exclusively with medical biotechnology. However some limited attention is also given to crop biotechnology (cassava) with support from BIO-EARN. AGT, on the other hand, is an independent, profit-motivated biotechnology firm. It uses tissue culture mainly for the micro-propagation of bananas on a commercial basis. AGT work is demand-driven (or even seasonal) depending on what the farmers and other stakeholders want at any particular time. Its activities, however, have attracted minimal donor interest. Where this has happened, AGT has only managed to attract short-term collaborative projects indirectly from public R&D institutions.

Complementing the public and private sector efforts are the International Agricultural Research Centres (IARCs) that are hosted in Uganda. These include IITA and CIAT and are undertaking collaborative research with institutions in the local NARS.

Features of North-South Partnerships

The Ugandan government has been very supportive of these initiatives and has at times made financial contributions (the government contributes to KARI's operational funds through the CGIAR, for instance, although the amount has been dwindling over the years). In addition, the government, with the support of its development partners, has made efforts to create a conducive policy and legal environment. However, there is a clearly discernible preference on the part of external partners to link up with government institutions, leaving the private sector quite weak, undercapitalised and generally sidelined in policy development. Of the 23 North-South collaborative projects identified in this study, only one involved a local partner from the private sector (AGT) for the micro-propagation of crops (mainly banana) on a commercial basis.

There has been an increase in research collaboration involving countries of the South, but this is still not very significant. A notable exception is a partnership between DCS and the University of Pretoria, South Africa as well as with the Mikocheni Agricultural Research Institute in Tanzania. Similarly, NARO and Makerere University collaborate with Latin American partners through such institutions as the International Potato Centre.

All partnerships focus on the training of local scientists and joint research ventures. This is broadly defined, however, to include the purchase of equipment and building new and/or strengthening existing facilities in order to build research competence, provide access to international research funds, and to effect technology transfer. The primary role of donors has been to provide funding, offer technical advice and participate in monitoring and evaluation.

In addition, donor-funded programmes have contributed to knowledge dissemination by supporting publishing in international journals. At the UNCST, the National Biotechnology and Biosafety Policy has been developed with donor support, especially from SAREC-funded BIO-EARN, USAID and UNEP/GEF.

An immediate benefit of such programmes has been a steady rise in the number and quality of scientists

specialising in various aspects of biotechnology and molecular biology - a notable improvement from the situation just ten years ago. This boost to individual and institutional capacity has given the country the potential to undertake biotechnology research and knowledge transfer through, for instance, the work of Ugandan scientists outside the country.

Ugandan farmers too are beginning to reap the benefits of biotechnology research through increased access to disease-free planting materials at some NARO institutes. Many people interviewed during the study argued that these products of local biotech research have a huge potential to contribute to government efforts to alleviate poverty, by helping reduce farm costs and increase yields.

Areas for Policy Intervention

1. Despite the growth in the number and quality of scientists specialising in biotechnology and molecular biology, there is still need for growth in human resources to build the critical mass needed for modern biotechnology research. More opportunities need to be created through post-doctoral training and similar schemes. Furthermore, the scope of training needs to be widened to include not only academics but also technicians and other personnel in the sector.

2. The government will continue to rely on international support for biotechnology research. However, there is need to broaden the funding base by providing incentives for scientists in the private sector who have taken the initiative to undertake biotechnology research. Donors should also encourage public-private partnerships in biotechnology. The government has an important role to play in coordinating ongoing research to build synergies, reduce duplication of activities, and maximize the output of existing facilities.

3. The country lacks a coherent policy on biotechnology and biosafety (although a draft was submitted to Cabinet in 2003). Pertinent legislation is also lacking. There is need to raise public awareness with respect to the techniques, basic applications, opportunities, utility, and safety of new and emerging technologies.

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FUTURE TECHNOLOGY POLICY BRIEFS

The next UNU-INTECH Technology Policy Brief will focus on interlinkages between the TRIPS agreement and the Convention on Biological Diversity

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