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SHORT COMMUNICATION

Inventory of agricultural biotechnology research capacity in Uganda

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Abstract

Strengthening research capacity in agricultural biotechnology is seen as a necessary and worthwhile investment to efficiently addressing the concerns of farmers and the agribusiness sector. In order to identify the intervention points for building biotechnology capacity, a survey was conducted among the laboratories involved in agricultural biotechnology research. This paper presents the major findings of the survey. The existing institutional capacity in the country, current research activities as well as the available infrastructure, human and financial resources are described. Fourteen laboratories were included in the survey, 12 are in public sector institutions whereas one each is found in an international organisation and the private (non-profit) sector. The equipment and infrastructure vary widely, with a substantial number of laboratories considered to be deficient. Due to low staffing, many operate below capacity. Biotechnology research is predominantly funded by international donors. This arises concerns regarding the sustainability of funding and the commitment of the government. Contrary to observations made in other African countries, the available resources in Uganda do not seem to be spread over a too wide range of target crops. But resources may be spread too thinly over the physical infrastructure. There is a much higher percentage of livestock biotechnology research in Uganda than in other commodities.

Key words: Biotechnology capacity, research indicators, survey, research planning

Introduction

The economies of most African countries depend largely on agriculture. The improvement of the agricultural performance is therefore fundamental to boost economic growth. Efforts to advance the application of modern biotechnology is seen as means to speed up and increase the efficiency of the research process whereever possible, and to enhance the exploration of new opportunities. Juma (2000) emphasises the importance to build strategic alliances with industrialised countries to acquire agricultural biotechnology and enable African contries to add value to their rich biogical resources. A recent report for the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) focuses on the transfer of technology from advanced laboratories (Johanson, 2000). Still, the uptake of biotechnology in Africa has been slow. While many factors contribute to this, the limited national research capacity has been identified as one of the major hurdles for the exploitation of biotechnology's potential (Komen, *et al.*, 2000; Bhagavan, 1997; Brenner, 1996). In addition, the available resources for agricultural biotechnology research appear to be spread over a wide range of research activities and target crops,according to a recent survey of 50 national institutes in Africa (ISNAR/ IITA, 1999).

The need to build research capacity in the area of agricultural biotechnology has also been recognised by Uganda as evidence in several recent policy documents (NARO, 2000, GoU, 2000). Establishing biosafety regulations is recognised as vital for progress in biotechnology. This country has already formulated a "Uganda biosafety framework", which defines the parameters within which the various institutions and agencies involved in biotechnology may operate. This framework point out that Uganda faces shortage of manpower for the application of biotechnology to solve its social economic problems. At a national level the areas that have been identified to be critical for capacity building in agricultural biotechnology include: disease and quality diagnostics, molecular biology techniques including transformation and regeneration of transgenic organisms, vaccine production and environmental biotechnology (UNCST, 2000). An important step towards a concerted effort for strengthening agricultural biotechnology research is to obtain a clear picture of the existing capacity in the country. The study commissioned by the Rockefeller Foundation

(ISNAR/IITA, 1999) had the purpose to "assess the needs and opportunities for greater investment in biotechnology research in African Crops". Accordingly, Uganda was one of 10 countries included in the study. In Uganda, the survey focused on six staple crops and was mainly interested in biotechnology capacity with respect to these crops. The study reported data from only three research institutes.

A country-specific study carried out by a committee set up by NARO (1998) provided more detailed data on the existing research capacity in agricultural biotechnology with a focus on NARO institutes. It looked mainly at opportunities for biotechnology applications, proposed research areas, and started outlining the need for an institutional framework. The inventory reported in this paper aims to update and complement the findings of that study.

Background

The National Agricultural Research Organisation of Uganda (NARO) and the International Service for National Agricultural Research (ISNAR) have jointly developed a research project on "Priority setting for Strengthening Biotechnology Research capacity in Uganda". The project aims to develop a strategy for strengthening agricultural biotechnology capacity and in a way that allows NARO and other organisations involved in agricultural research to be in touch with the frontiers of science while efficiently addressing the concerns of farmers and the agribusiness sector.

In order to identify the intervention points on how this could be done, a survey on the existing capacity in agricultural biotechnology research was carried out. The survey was used to define which type of biotechnology capacity should be strengthened and what could be the preferred institutional framework. In particular, the outcome of the survey helped the project core team to define the biotechnology tools to be strengthened, the need to train scientists, the required the physical infrastructure and equipment, and the financial implications.

Survey Methodology

The survey was carried out by the project core team in the first half of the year 2000. A structured questionnaires developed by ISNAR to analyse and compare the development of agricultural biotechnology research capacity in different developing countries was modified to better serve the specific purposes of the survey. Apart form a general section on the institute and its biotechnology activities, the questionnaire included detailed sections on the physical, human, and financial resources, as well as present and future research focus.

The questionnaire was completed by the head of the laboratory, sometimes assisted by a core team member and in a few cases by a core team member. The completed questionnaires were examined for any important data that were missing. In a core team meeting, the members completed an incomplete part of the questionnaire of the laboratory. The data obtained were summarised and observations that might be considered din setting up a strategy for strengthening biotechnology research capacity in the country made.

Institutional Capacity

Fourteen laboratories with significant agricultural biotechnology research activities were captured by the survey. Laboratories with microbiological activities such as nitrogen fixation, biocontrol agents, and fermentation were not included. Similarly, embryo transfer and artificial insemination in livestock research were considered as rather traditional biotechnology and thus excluded from the survey. On the other hand, the laboratory of the Institute of Environment and Natural Resources (MU) was included although their activities are at present mainly related to wildlife. The type of laboratory and its institutional affiliation are presented in Table 1.

The bulk of biotechnology research takes place in the public sector with six of the surveyed laboratories belonging to

Table 1. Type and institutional affiliation of biotechnology laboratories

Type of laboratory	Unit	Institution
Tissue Culture	M.U. Agriculture Research Institute	Makerere University
Molecular Biogy	Faculty of Agriculture	Makerere Univeristy
Tissue Culture	Department of Veterinary Medicine	Makerere university
Molecular Biology/Immunology	Department of Parasitology and Microbiology	Makerere Uniersity
Molecular Biology	Institute of Environment and Natural Resources	Makerere University
Tissue Culture	Livesock Health Research Institute	NARO
Biochemistry	Livesock Health Research Institute	NARO
Veterinary Immunology	Livesock Health Research Institute	NARO
Tissue Culture	Namulonge Agricultural and Animal Production Research Institute	NARO
Tissue Culture	Kawanda Agricultural Research Institute	NARO
Disease Diagnosis	Kawanda Agricultural Research Institute	NARO
Disease diagnosis/Virology	IITA – Uganda (at NAARI)	CGIAR, (IITA)
Molecular Biology	Med Biotechnology Laboratories (MBL)	Private Sector

Makerere University and another six to NARO, the two main actors in agricultural research. One laboratory belongs to an international organisation and another or to the private (non-profit) sector. Makerere has only 2 culture labs and 4 laboratories in the group of higher end biotechnology (molecular biology). In the case of NARO, the ratio is exactly opposite. This appears to be a rational division of labour in terms of strategic and applied research. The same applies for the international organisation, which works more on advanced techniques. The engagement of a small private company in advanced techniques might be best explained by its non-commercial activity. It is also worth noting that a greater percentage of the laboratories focus on animal research. To get a better idea of the real capacity of individual institutions, the physical infrastructure as well as the human and financial resources
have to be considered, rather than just the number of laboratories.

Physical Infrastructure

The size and other characteristics of ht surveyed laboratories are presented in Table 2. Almost 30% of the laboratories (4 out of 14) were considered as deficient due to lack of important equipment or on account of size. One laboratory is not yet equipped and it may still take some time until it is fully operational. There are considerable differences between individual laboratories, which may not come out of the table. For instance, the tissue culture laboratory at NAARI has a very limited space and just the basic equipment for moderate biotechnology work. The one at KARI, on the other hand is spacious – has media preparation room, one washing room, two transfer rooms, 3 growth rooms and is modern and equipped with the latest technology. The molecular biotechnology laboratory of MBL probably has the most advanced facilities for DNA research in the country.

Human Resources

There are 38 researchers working in agricultural biotechnology. In addition, 31 technicians and other support staff are attached to the laboratories. The number does not include most of the researchers at MBL since all but one work in malaria research. Table 3 gives an overview of the human resources and their qualification in terms of degree and years of experience. A total of 15 professionals engaged in agricultural biotechnology hold PhDs, 17 MScs and 6 BSc degrees. Their experience in biotechnology research is, respectively, 7.5, 5 and 3.5 years on average.

The average ratio of technicians to researchers in the surveyed laboratories is only 0.6:1. This is much below the recommended ratio of 2:1 for genetic engineering and tissue culture research and may effect research outputs (Falconi, 1999).

Table 3. Number and qualification of human resources

	PhD	MSc	BSc.	Techn-icians	Support Staff
Number	15	17	6	22	9
Average years of experience	7.5	5	3.5	n/a	n/a

Table 2. Characteristic of the biotechnology laboratories

Type of laboratories	Infrastructure and equipment	Size of the laboratory	Major needs
Tissue Culture	adequate	10 x 25 m	-Automation -Stand by generator
Molecular Biology	adequate (equipment will soon be acquired)	8 x 11 m	-
Tissue Culture	adequate	4 x 4 m	-autoclave -Ordinary incubator
Molecular Biology/Immunology	deficient	3 x 4 m	thermocycler
Molecular Biology	adequate	10 x 25 m	-automation -CO_2 incubator
Molecular Biology	deficient	10x25 m	-Automation -DNA sequencer
Tissue Culture	adequate	6x8 m	-
Biochemistry	adequate	6x8 m	-
Veterinary/immunology	deficient	6x8 m	-
Tissue Culture	adequate for now, but small	5x9m	-
Tissue Culture	adequate	15 x 17 m	-
Disease Diagnosis	deficient	3x3 m	bigger PCR tanks more centrifuges
Viorology	adequate	5x5 m	-
Molecular Biology	adequate	5x8 and 2	-

On average, each laboratory works with less than 3 professionals. The full time equivalent (fte) gives a more realistic notion on the time spent for biotechnology research by the researchers and the survey revealed that the aggregated fte for the 14 laboratories was only 18.5. This points to the fact that many laboratories operate below capacity. However, some laboratories are involved in training activities and thus they may be occupied by students (Lubega, 2000).

The professionals belong to a wide range of disciplines ranging from one to three scientists per specialisation considering both PhD and MSc levels. On the crop side the disciplines include plant breeding and genetics; molecular biology, physiology, pathology, nematology and tissue culture. The disciplines on the animal side include molecular immunology, microbiology, parasitology, zoology, veterinary medicine, vector entomology, conservation genetics and biochemistry.

Financial Resources

The total expenditure for agricultural biotechnology research was estimated US $ 400,000. On average 50% was spent on personnel, 37% operating cost and the remaining 13% on capital cost. A reason for concern was the analysis of the sources of funding. Nine of the 14 laboratories were 100% donor funded (including the international and the private laboratories), two receive 90% and 85% donor funding, respectively, and the remaining three were 100% government funded. In all three cases, however, government funding covered salaries but not operational and capital cost. However, the figures might have underestimate the contributions of the government because the budgets reported in the questionnaires did not consistently include salaries of permanent staff overhead cost.

Table 4 shows the percentage and the absolute amount of total expenditure by category. For the private sector institute, only expenditures related to research in agricultural biotechnology is included which accounts for about 10% of the total research budget. Out of the US$ 243.000 spent at the university for agricultural biotechnology research, US $ 200.000 or more than 80% were consumed by only two laboratories at the Department of Parasitology and Microbiology and the Institute of environment and Natural Resources.

Table 4. Biology research expenditure by category

Category	Amount in US$	% of total expenditure
Public Research Institute	67,000	16.75
University	243,000	60.75
International organizations	70,000	17.5
Private Sector	20,000	5
Total	400,000	100

Research Activities

The major target crops in current research activities are banana/plantain and cassava. Various tissue culture techniques are used for mass propagation and for indexing of these crops against viruses. Tissue culture is also used in other crop commodities such as coffee, potato and sweet potato and has tried with limited successes in passion fruits and citrus . Molecular disease diagnostic tools, PCR-based, and ELISA techniques are used for detection of pathogens, studies on pathogen variability as well as for cleaning and indexing work in many crops. DNA sequencing and cell culture technologies have been started in order to determine genetic diversity of the African high land Bananas and prepare for transformation work respectively.

In animal research, the focus is on livestock health with the objective to develop diagnostic tool kits and vaccines. Cell culture and PCR based techniques are in use.

DNA analysis is also being used at the Institute of Environment and natural resources to evaluate the genetic diversity of various animal wild species.

So far, no laboratory uses genetic engineering techniques. But there are plans for research activities for future transformation of banana and cassava . There are plans to enhance use of molecular disease identification and pathogen characterization tools, tagging quality and resistance traits and maker assisted breeding. In livestock, future research activates intend to use recombinant DNA technology for development of vaccines and to identify useful traints for increased production and disease resistance in animals.

Conclusion

The most striking conclusion concerns the heavy dependence on donor funding for agricultural biotechnology research. This is consistent with results from similar surveys for other African counties. It posses serious questions for sustainable financing of biotechnology research. A broader funding basis and a stronger commitment by the Uganda government is required for proper planning and better use of existing infrastructure.

This leads to the second conclusion. Many laboratories do not seem to operate at full capacity. The reason being lack of operational funds. Most of the on-going biotechnology projects were started through personal other than institutional driven investments and this may affect long-term funding perspectives.

Contrary to observations made in other African countries, findings of this survey do nt confirm that available resources are spread over a wide range of target crops. But resources may be spread too thinly over the physical infrastructure.

Major crop biotechnology research is focused on tissue culture techniques followed by disease diagnostics. On the other hand, the high percentage of livestock biotechnology research is note worthy. Finally, the complete absence of the commercial private sector is an issue that needs attention. The overall results of this survey indicate that the resources in biotechnology research are not only low but are spread

across institutions. There is lack of an institutional framework to promote efforts sharing of physical resources and cross consultations which would improve efficiency, capacity and rate of advancement in this field.

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