Linking Biotechnology and Agricultural Biodiversity Resources in Holistic Strategy in West Africa

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Abstract

Modern economic activities are heavily dependent on using diversity of biological resources. Africa has a wealth of biodiversity resources which, with the appropriate application of biotechnological tools for conservation and use, can serve as sources of wealth creation. Proper harnessing of the linkages between biotechnology and the diversity of biological resources is required to meet challenges of food security, health, poverty and wealth creation in West African countries. The paper explores some of the key applications of biotechnology for conservation of agricultural biodiversity resources, and considers the potential threat of biotechnology to diversity of genetic resources. It also explores complex issues that inform current policy debates. It concludes that Government support is required for the conservation and breeding of farmers' varieties, or landraces by public breeding programmes, and the design of private and public mechanisms to ensure that the pursuit of biotechnology does not compromise the diversity in biological resources. It would be strategic for West African countries to establish and explore beneficial linkages between the sub-regional genetic resources conservation initiative and biotechnology programmes. Some pertinent questions are raised on how to best manage the strategic interplay between biotechnology and diversity in agricultural biodiversity resources. The provision of adequate information is highlighted to inform decisions and choices based on the real value and potential risks of biotechnology.

Introduction

Biological diversity has contributed in many ways to the development of human culture, and mankind has in turn influenced biological diversity (FAO, 1999). In today's modern economy, agriculture, pharmaceuticals, traditional medicine, forestry, fisheries and tourism are heavily dependent on using a diversity of biological resources. AU/NEPAD High-Level Panel on Biotech-nology (2006) rightly recognized that one of the critical capabilities that exist in Africa is the wealth of biodiversity that can potentially serve as a resource for wealth creation with the aid of biotechnological tools. But how these resources are managed, particularly how they are conserved and used, has a profound effect, for better or for worse, on available diversity and the ecological services that sustain life. For example, destruction of habitats as a result of competing human needs has often resulted in the loss of numerous plant and animal species and the services they help provide. On the other hand, proper harnessing of the linkages between biotechnology and the diversity of the biological resources provides a good platform for conservation of the diversity required to meet challenges of food security, health, poverty, wealth creation and the furtherance of overall developmental goals of West African countries.

FAO (1993) defines agricultural biodiversity as the variety and variability of animals, plants and micro-organisms that are important to food and agriculture which result from the interaction between the environment, genetic resources and the management systems and practices used by people. Mulvany (1998) describes agricultural biodiversity as a vital subset of biodiversity comprising of varieties, breeds, species and agro-ecosystems that underpin universal food security and provide the genetic material needed for industry, agriculture and biotechnology. In agriculture, biotechnology has a potential role in enhancing agricultural productivity, food security and promoting the conservation, scientific characterization and use of genetic resources to improve human well-being. Therefore, as an integral part of the focus on developing a holistic biotechnology strategy for West African countries, the need to explore and incorporate the beneficial interplay between biotechnology and agricultural biodiversity resources cannot be overemphasized.

Exploring the benefits of biotechnology for biodiversity

Africa's wealth in its diversity of biological resources, generally, and agricultural biodiversity, in particular, is rapidly being lost in many ways, for instance, through genetic erosion. The continued loss of diversity in genetic materials needed for the improvement of yields or productivity, as well as for enhancing capacity to deal with diseases, pests and the vagaries of the weather cannot be ignored. Therefore, it is imperative that, in formulating a biotechnology strategy and plan of action, West African countries explore how to effectively use modern agricultural biotechnology tools to help stem the rapid loss of diversity in agriculturally useful materials.

Examples of biotechnological tools that are relevant to the conservation of genetic resources include *in-vitro* techniques, such as slow growth tissue culture, and cryopreservation (for long term conserva-tion). Cryopreservation of plant material represents a safe and cost-effective option for long-term conservation of germplasm of non-orthodox seed species, vegetatively-propagated species, and biotechnology products (Englemann, 2004). For example, cryopreservation of shoot-tips is the method of choice for the collection, safe movement and long-term conservation of seedless and, thus, vegetatively-propagated crops like banana (*Musa* spp.). Large scale cryopre-servation of embryogenic cultures has been found to be essential for advanced forestry breeding programmes (Panis *et al.,* 2004). Cryopreservation has been shown to improve the frequency of virus elimination – specifically cucumber mosaic virus and banana streak virus (Helliot *et al.,* 2002).

A simple cryopreservation method is available for proliferating meristem cultures of banana (*Musa* spp.). The miniaturization of explants reduces space requirements and, consequently, labour costs for maintenance and transporting germplasm collections. Tissue culture systems allow the propagation of virus-free plant material with high multiplication rates using meristem culture in combination with thermotherapy. Biotechnology also has an important role or value through the use of molecular markers for prioritizing populations for conservation and for characterizing populations (e.g. fish stocks). The use of molecular marker techniques for characterization work and genetic mapping could enhance the growing of crops and other plants at the gene level.

The Consultative Group on International Agricultural Research (CGIAR) is investing heavily in biotechnological methods, through the Generation Challenge Programme, to use advances in molecular biology to harness the rich global heritage of plant genetic resources, and create a new generation of crops that meet the needs of resource-poor people. Better-performing crops improve rural livelihoods by increasing food security and income. For example, the International Rice Research Institute (IRRI) uses applications of biotechnology, *in vitro* culture of seedlings and the study of genetic diversity using a range of molecular markers. Understanding of the genome of one crop, like rice, can yield useful clues about others, such as wheat, barley and maize because there is a great similarity among the genomes of species in the same family. In such situations, isolating the desired gene in one plant for a particular key trait, such as plant height, offers valuable clues to the same trait in all the others in the same family (Devos & Gale, 2002).

Effective use of agricultural biodiversity resources requires fundamental activities such as acquisition of good knowledge of species and genes through collection, characterization and documentation of the resources and their associated indigenous knowledge, and conservation and under-standing of the value of the genetic materials for use in applications that will improve the well-being of the human population. The relevant activities and the associated information to be generated are fundamental to a productive application of biotechnology to plants/species (both introduced and underutilized indigenous plants) to resolve biotic and abiotic constraints, and/or increase productivity in the West African countries.

Is biotechnology a threat to diversity?

Discourse regarding the nature of the threats presented by modern biotechnologies is almost as complex as the technologies themselves. It would not be possible to cover all the perceived threats in this paper. However, a few illustrative cases are discussed. Biotechnology is sometimes seen as a tool encouraging privatization of resources. Fears are often expressed that biotechnology will reduce crop biodiversity and that the increasing privatization of crop genetics will hurt poor farmers and exacerbate hunger among the world's poor. Some controversies have revolved around property rights of private companies that will be motivated by the pursuit of biotechnology to invest in hitherto neglected food crops and the potential limitation to farmers' ability to save and use their own seed. In particular, the 'technology protection system' or the 'terminator technology' has provided a lightening rod for controversy and fears about the potential impacts of patents on society at the level of food production (Cox, 1988).

Widespread adoption of varieties carrying the 'technology protection system' will undermine the culture of farmer seed selection and conservation for planting or later exchange, and lead to crop uniformity and potential future vulnerability to biotic and abiotic stresses. Furthermore, biosafety concerns have been raised about sterility traits escaping beyond the boundaries of fields planted to protected varieties and infecting neighbouring fields of the same crop and their wild relatives through pollen produced by plants carrying the technology protection system. Doubts have been raised about the seriousness of these biosafety concerns because the natural out-crossing of some self-pollinated crops is only up to 5% (Cox, 1988). The issue is that if a conventional farmer's variety is planted next to variety with a technology protection system, they must be in close proximity and there must be a similarity of flowering dates. Moreover, the likelihood of a trait being passed to another species is even lower because normally foreign pollen is unable to fertilize an unrelated species (Cox, 1988).

Environmental threats, through potential reduction in genetic diversity with potential long-term effects on food security, have also been highlighted. Instead of negating the use of biotechnology for seed production, there is rather an argument for strengthening local seed systems to counterbalance seed production through the use of biotechnology. Also, there is some doubt that the mere availability of new varieties using the technology protection system will limit farmers' ability and willingness to select, conserve and use their own seeds or develop their own locally-adapted varieties. In the light of all the above arguments, are there real negative outcomes that are the inevitable consequences of using biotech-nology? It may be the case that private sector pursuit of biotechnology, driven mainly by profitability and proprietary reasons, may move in the direction of narrowing diversity in agricultural biodi-versity resources. In this case, the public research system has a critical and valuable function to undertake in encouraging the conservation of local agricultural biodiversity resources for use in research or for direct use by farmers. This translates into govern-ment support for the conservation and breeding of farmers' usual varieties or landraces by public breeding programmes. At the ECOWAS level, the question should be what model private and public mechanisms (institutional, legal, policy, advocacy) can be devised and agreed on regionally to ensure that the pursuit of biotechnology does not compromise the diversity in the biological resources on which our people depend for food and agriculture.

Policy issues

Biotechnology policy is a complex field that, more accurately, refers to a range of policy issues of relevance to a family of, often only loosely related, technologies. For example, the issues that may arise in relation to the introduction of genetically modified organisms are unlikely to be similar to those involved with the release of the products of micropropagation. As a result, the first step in any policy formulation process is to ensure that one is quite clear about what is being discussed and that there is a framework for these discussions that is flexible enough to accommodate multiple approaches for multiple technologies. Closely related to accurately defining the subject matter of discussions is the question of clearly stating the objectives of any policy. The relative weighting of factors involved with, and desired outcomes from, risk and benefit assessment in different fields is of fundamental importance in moulding any policy. Even after having established the basic parameters of any policy debate, biotechnology remains a complex field. For example, biosafety policy revolves around the classic regulatory balance of safety (of the environment, of livelihoods and of commercial options as the three most obvious factors) *versus* freedom of action but involves a scenario where there are multiple opinions, and considerable uncertainty, regarding almost all of the factors.

At a strategic level, this may involve consideration of the appropriate level of burden to place upon the providers and users of particular technologies relative to the range of perceived risks and benefits, actual and potential, involved with their activities. These burdens can be imposed upfront, in terms of authorisation requirements and procedures, or they can be downstream, focusing on liability and redress, or involve some combination of the two. It is important to note that both risks and benefits are vital to any accurate assessment. For example, in the area of risks, even a technology that is considered safe in environmental or human health terms may be more complex from the perspective of international trade and commerce.

Similarly, in the area of benefits, liberal biosafety regimes will promote the development of a base of scientific skills that can independently inform risk assessment as well as actually conduct applied research. As a result, in some areas of biotechnology policy, one may actually need to focus on incentives more than burdens. Quite apart from scientific complexity, biotechnology policy is surrounded by a sometimes bewildering array of connected fields and their associated regulatory frameworks. For example, parties to the Cartagena Protocol are, almost invariably, also parties to the World Trade Organisation's Agreement on Sanitary and Phytosanitary Standards and should, therefore, seek to reflect an appropriate blend of these different commitments in their policies.

The relationship between agrobiodiversity and modern biotechnologies is typical of the complexities described above. There is enormous potential for synergies, with the diversity of plant, animal and microbial life providing the most effective source of building blocks for modern biotechnologies, and these technologies, in turn, significantly broadening the options for the conservation of agrobiodiversity. However, agrobio-diversity may also be placed at risk by poor management of the environmental or commercial implications of some techno-logies. The development of long-term sustainable biotechnology strategies should be directly linked with the expression of coherent policies and supporting regulatory structures that genuinely reflect political objectives and realities.

Conclusion

Most West African countries individually have limited capacities and face enormous constraints in genetic resources collection, conservation and deployment for use in promoting human well-being. Until these fundamental constraints are resolved, efforts to make the best use of biotechnology to promote agriculture in West Africa will be severely hampered by ongoing loss of genetic materials and lack of knowledge of the potential of available biological resources. On the other hand, biotechnology tools offer opportunities for conserving genetic resources. West African countries have individually attempted to set up genetic resources conservation units without much success due to human, infrastructural and maintenance constraints. The conference of West and Central Africa Research Directors (WECARD/CORAF), as a regional research arm of the West African Economic Community (ECOWAS), is promoting the development of selected functional conservation infrastructure sites and their personnel as Nodal Centres of Excellence to serve the West and Central Africa region in the conservation and use of genetic resources. It would be strategic for ECOWAS to establish and explore beneficial linkages between the WECARD/CORAF initiative and biotechnology programmes within the sub-region.

In exploring how best to manage the strategic interplay between biotechnology and diversity in agricultural biodiversity resources, there is need to address a few pertinent questions. How can biotechnology be used to enhance access to or management (conservation and use) of genetic resources? Which biotechnology tools are relevant to each country's situations? What alternatives to bio-technology are available to effectively achieve similar ends? What are the resource implications (human, equipment, operating expenses) of sustaining a biotechnology programme *vis-à-vis* the alternative methods for conservation of agricultural biological resources? What is there to lose if biotech-nology investment for the conservation of genetic resources is not made?

Investment in developing and maintaining functional biotechnology capabilities (human, material, etc.) is very expensive. It would not be strategic for each ECOWAS member country to invest scarce resources in setting up the full range of biotechnology capabilities. Developing and maintaining a few existing biotechnology centres to provide regional services, within the ECOWAS framework, could be an attractive alternative. There is need to decide how to mobilize political will to face the common problems that can be solved using biotechnology. It is important to provide adequate information at all levels (political, extension, farmers, etc.) to inform decisions and choices based on the real value and potential risks of biotechnology.

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