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Agricultural biotechnologies in developing countries: Options and opportunities in crops, forestry, livestock, fisheries and agro-industry to face the challenges of food insecurity and climate change (ABDC-10)

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Synthesis: Current status and options for crop biotechnologies in developing countries

Introduction

In developing countries, there is a need for continued focus on the optimization of agricultural output, in conjunction with the conservation of the natural resources base, via improved crops and crop management systems. The implications of climate change make it necessary to integrate considerations regarding adaptation, uncertainty, vulnerability and resilience into agricultural research strategies and programmes. The various biotechnologies available have the potential to play a significant role in this process. Over the past two decades, there has been some progress in making new crop technologies more widely available in developing countries, but several removable constraints still impede the full development and deployment of advanced crop breeding and management practices by developing countries.

Confronting biotechnology sector-specific problems can be complicated by a lack of clarity among experts and policymakers about the definition of the term itself. For the purposes of this document and the other FAO documents prepared for ABDC-10, the Convention on Biological Diversity definition is used: i.e., "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use". Crop biotechnology therefore encompasses a wide range of technologies applicable to crop production, from the less complex, such as micropropagation, to the more sophisticated, such as applications of genomics and other "omics" to plant improvement. A distinction is sometimes made between "traditional" and "modern" biotechnologies or between non-transgenic and transgenic approaches, also called genetic engineering or genetic modification. While a sharp category differentiation may be somewhat contrived, and may not be recognized by all crop scientists, it nevertheless is quite real in terms of legislation and the perception of many policymakers and consumers.

This paper synthesizes the key elements of document ABDC-10/3.1, which discusses the status of application of biotechnologies in the crop sector in developing countries, and the reasons for their success or failure; examines emerging challenges and options from crop biotechnologies to

address food insecurity in developing countries, particularly in the context of deepening economic and environmental uncertainty; and considers the possible role of the international community, including FAO and other intergovernmental agencies, NGOs and donors.

Stocktaking – Lessons from the Past

Crop biotechnologies have developed incrementally over the past century, but progress has accelerated greatly over the last two decades, leading to many important scientific achievements and impressive technological advances. Many crop biotechnologies are available, and they can be roughly classified according to their main purpose: i.e., the creation of new genetic variation; the screening and selection of favourable variants; or the improvement of the production/management systems for crops or their derivatives. Some biotechnologies are increasingly used in developing countries, especially tissue-culture-based techniques (such as micropropagation), mutagenesis, interspecific or intergeneric hybridization, genetic modification, marker-assisted selection (MAS), disease diagnostics and bioprotection, and biofertilization.

As with other maturing technologies, there have been mixed experiences with crop biotechnologies in developing countries. Genetic modification has had limited but real success in modifying a few simple input traits in a small number of commercial commodity crops, adopted also in some developing countries. The wider application of genetic modification has been slowed down by severe limitations on the kinds of traits available, complex intellectual property rights (IPR) regimes and regulatory issues, and the often negative perception of the public. While there have been significant successes in the adoption by farmers of a few first-generation transgenic varieties, there have also been unexpected market setbacks as farmers sought to avoid high seed costs and other restrictions.

The major breeding and crop management applications to date have come from non-transgenic biotechnologies encompassing the full range of agronomic traits and practices relevant to developing countries' farmers. For example, mutagenesis is widely used in developing countries and more than 2 200 mutation-derived crop varieties have been obtained worldwide in the last sixty years, mainly in developing countries. Interspecific hybridization allows the combination of favourable traits from different species and has been used successfully in, for instance, the development of interspecific disease-resistant Asian rice and New Rice for Africa (NERICA) varieties. However, interspecific hybridization programmes can be slow and require a great deal of scientific expertise and skilled labour. MAS is still at a relatively early stage in its application for key subsistence crops in many developing countries, although it has begun to produce some significant results, such as the development of a pearl millet hybrid with resistance to downy mildew disease in India. The costs and technical sophistication required for MAS, however, remain major challenges for developing countries. Micropropagation is used for the mass clonal propagation of elite lines or disease-free planting material. Many developing countries have significant crop micropropagation programmes and are applying it to a wide range of subsistence crops. Biotechnology also offers important tools for the diagnosis of plant diseases of both viral and bacterial origin, and immuno-diagnostic techniques as well as DNA-based methods are commercially applied for this purpose in many developing countries. Biofertilizers are also being used in developing countries both to augment the nutritional status of crops and as alternatives to chemical supplements. Biotechnologies such as cryopreservation, artificial seed production, somatic embryogenesis, and other forms of *in vitro* cell or tissue culture, are also extensively used for the conservation of genetic resources for food and agriculture in developing countries.

Biotechnology programmes have been effective where they complemented well-structured conventional plant breeding and agronomy R&D programmes. Key factors in the successful development of crop biotechnologies in developing countries have been: appropriate policy development, strengthened research and extension institutions, and enhanced capacities for researchers and technicians. The establishment of cross-sectoral regulatory measures has also been important.

The uptake of biotechnologies in developing countries is improving gradually but remains patchy. Many biotechnological advances were made in industrialized countries in the private sector,

leading to development of proprietary technologies that are often unavailable to scientists in developing countries. Farmers in developing countries, especially small farmers, cultivate crops and face problems that are particular to their cultural and environmental conditions, and have often limited purchasing power to access proprietary technologies. The spillover of research results obtained in industrialized countries by the private sector has therefore had only a limited impact on the livelihoods of subsistence farmers in developing countries. In fact, the most enduring successes to date have come from indigenous public-sector crop research programmes addressing farmer-relevant problems.

Even when there has been strong development of biotechnologies within the public sector in developing countries, they have not always been directed towards – or made available for – improving smallholder livelihoods. In fact, an inclusive process of decision-making about the allocation of resources for the development of appropriate crop biotechnologies was rarely adopted, undermining the successful development of crop biotechnologies. In some cases, even though the technology was sound and the products were potentially beneficial to farmers, there was limited or no adoption due to often-predictable infrastructure or market deficiencies. A promising approach to address such problems is farmer participatory research, but this must be coupled with measures to address a wide range of cross-sectoral issues from extension services to seed multiplication programmes.

Information relating to the application and impact of crop biotechnologies in developing countries is very scant and often inconsistent. Studies of the impact of crop biotechnologies are frequently limited to the analysis of the production equation and fail to pay due attention to their socio-economic effects, especially their impact on rural livelihoods. Assessing the value of biotechnologies for rural development is therefore rather difficult, with the result that the decision-making process is not always supported by an appropriate information base.

Looking Forward – Preparing for the Future

In looking to the future, we can identify a wide range of existing and emerging problems related to food security where crop biotechnologies, in combination with other technologies, might be of assistance. The problems include biotic stresses (pests, diseases and weeds), abiotic stresses (such as salinity and drought tolerance), the need to improve crop yields and nutritional quality as well as the need to broaden the genetic basis of crop production and ensure that crop production is sustainable and environmentally friendly. Some of these problems are likely to be exacerbated in the future due to climate change.

These issues and the analysis of the lessons learned in the past are helpful for identifying a number of specific options for developing countries to help them make informed decisions regarding adoption of biotechnologies. In addition, the stocktaking exercise indicates the Priorities of Action that the international community should adopt for their technical and political assistance programmes.

It is of crucial importance that developing countries develop the expertise enabling them to make sovereign decisions about adopting biotechnologies and carry out their own independent, broad-based cost/benefit analyses before implementing them. International organizations have a role to play in informing decision-makers and society at large about the potential of all crop improvement/management biotechnologies for food security and to facilitate informed decision-taking processes. To this end, the documentation and analysis of the adoption and socio-economic impacts of crop biotechnologies should be undertaken at the national level, and systematized and analysed at the international level.

An analysis of the past shows that appropriate biotechnologies, when properly directed and complemented by enabling measures, have contributed to enhancing crop production. They have also significant potential to assist in tackling a wide range of existing and emerging problems related to food security and climate change. Developing countries should therefore build up or strengthen indigenous public-sector R&D programmes, ensuring adequate, consistent, and sustained investments. Donors and international funding agencies are encouraged to dedicate an

appropriate share of their assistance projects to promoting and strengthening public biotechnology R&D. Regional collaboration on shared problems can leverage synergies and improve the cost efficiency of research programmes.

Smallholders are responsible for an important share of developing countries' food production and can play a key role in poverty reduction. It is therefore of paramount importance that crop research activities are prioritized to address the needs of smallholders through appropriate policy development. With this in mind, it is necessary to ensure the adequate involvement of the relevant stakeholders in decisions about the allocation of resources for the development of crop biotechnologies. National public sector organizations should engage and communicate more effectively with society at large about the role of crop improvement/management biotechnologies for food security to empower the public to participate in decision-making processes. The international community should also provide assistance to developing countries to strengthen their capacities for the involvement of relevant stakeholders in decision-making processes.

To enable crop biotechnologies to realize their potential, developing countries should develop the biotechnology capacities of their National Agricultural Research Systems, including policy development, institutional set-up and human capacities. The international community should assist developing countries in this effort. Research in crop biotechnologies should be effectively integrated with well resourced and structured R&D programmes in crop breeding and management. Investments in biotechnology R&D should not be made at the expense of current expenditure in other research fields.

Countries should be encouraged to establish consistent and transparent, evidence-based decision-making processes to regulate crop biotechnology R&D, and its application. FAO and other international agencies should assist developing countries in building adequate institutional capacities for the establishment and enforcement of robust and consistent national regulatory frameworks in areas such as biosafety, food safety, plant health protection, IPR and traditional knowledge. For this purpose, the adoption of the *Biosecurity* approach (i.e. a cross-sectoral national approach to the management of biological risks associated with food and agriculture) in a holistic and integrated framework can offer significant advantages. While it is essential that decisions about adopting biotechnologies ultimately be based on verifiable scientific evidence, such processes should take public participation into account where appropriate. Regulatory procedures should be internationally harmonized in order to facilitate international trade and scientific collaboration. Intergovernmental organizations should continue to offer member nations a meeting place for international discussions regarding these and other issues relating to biotechnologies.

The development of crop biotechnologies should be strongly linked with strategies for their widespread dissemination. Stronger, pluralistic, decentralized extension services, with expertise in modern agronomy and linked with participatory crop improvement and management programmes, should be an integral part of national agricultural support structures. Biotechnology knowledge and expertise should be made available within extension, educational, and advisory services to facilitate farmer uptake of crop biotechnologies. Enhanced seed production and distribution systems should be developed and development agencies should assist developing countries in this effort.

Biotechnology research requires substantial investments and sometimes has to deal with IPR issues. The establishment of effective and equitable mechanisms for partnerships between the public and private sectors can therefore, in some instances, be very helpful for the efficient use of scarce resources and for ensuring access to proprietary technologies. International development agencies should assist in establishing appropriate mechanisms for the dissemination of biotechnologies developed in industrialized countries to developing countries (North-South collaboration, public-private partnerships).

Developing countries should consider, where appropriate, sharing technologies, skills and knowledge with other developing countries by establishing South-South collaboration platforms or mechanisms. The international community should facilitate effective mechanisms for South-

South collaboration including: the training of scientists and technicians; joint research projects (pooling complementary resources to work on project of common interest); the sharing of technologies, techniques, protocols and materials; and the sharing of information relevant to the development and adoption of biotechnologies.