OECD DEVELOPMENT CENTRE

POLICY BRIEF No. 14

Biotechnology Policy for Developing Country Agriculture

by

Carliene Brenner

- Biotechnology offers the potential for more environmentally-friendly agriculture but the conditions for developing countries to take advantage of that potential should be created.
- Policy intervention is needed to ensure that biotechnology responds to the priorities set for agriculture.
- Decisions are urgently needed in two policy areas specific to biotechnology: biosafety and intellectual property rights.
- Public funding restrictions demand innovative approaches and public/ private partnerships.
- Flexibility and long-term commitment are essential if donor-supported biotechnology initiatives are to succeed.

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In its research activities, the Development Centre aims to identify and analyse problems whose implications will be of concern in the near future to both Member and non-Member countries of the OECD. The conclusions represent a contribution to the search for policies to deal with the issues involved.

The *Policy Briefs* deliver the research findings in a concise and accessible way. This series, with its wide, targeted and rapid distribution, is specifically intended for policy and decision makers in the fields concerned.

A growing number of developing countries are investing in agricultural biotechnology, which offers an environmentally-friendly alternative to the chemical-intensive model of agricultural production. However, its potential will be realised only if certain policy and other conditions are met. This Policy Brief is based on a number of country studies (Colombia, India, Kenya, Mexico, Thailand and Zimbabwe) as well as analysis of donor-funded biotechnology projects and programmes. It suggests that the elaboration of a coherent national biotechnology strategy may involve difficult policy choices and trade-offs, of which countries need to be aware. It also points to a range of options for donor agencies in supporting biotechnology initiatives for developing country agriculture.

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Acronyms

ABSP	Agricultural Biotechnology for Sustainable Productivity
B.t.	Bacillus thuringiensis
CGIAR	Co-ordinating Group on International Agricultural Research
CIT	Centre for Innovation and Technology (Mexico)
CORPOBIOT	Colombian Corporation for the Industrial Development of Biotechnology
DGIS	Special Programme on Biotechnology and Development Co-operation (Netherlands)
IARCs	International Agricultural Research Centres
IBS	Intermediary Biotechnology Service
IICA	Inter-American Institute for Cooperation in Agriculture
ISAAA	International Service for the Acquisition of Agri-Biotech Applications
IPR	Intellectual Property Rights
NARs	National Agricultural Research Systems
NGOs	Non-governmental organisations
NSI	National System of Innovation
TRIPs	Trade-related Intellectual Property Rights
UNAM	National Autonomous University of Mexico

Introduction

Despite the extravagant claims made in the mass media in recent years that biotechnology[1] would revolutionise agriculture and food production, the first wave of genetically-engineered biotechnology crop products is only now entering the market in OECD countries. Spearheaded by the Flavr Savr tomato which was commercialised in the United States in June 1994, marketing approval has now been obtained in Australia, Canada, the European Union, Japan and the United States for the following transgenic crops: cotton, maize, potato, rape seed and soybean. The long-term impacts of these new technologies, in terms of competitive advantage, productivity or sustainability are therefore still unclear.

Biotechnology offers new methods for agricultural diagnostics, plant virus and insect resistance, novel biocontrol agents, as well as genetic marker and mapping techniques as an aid to conventional plant breeding. By offering not only the prospect of enhanced resistance to pests, disease and stress, but also less dependence on agro-chemicals, biotechnology also offers the potential for more sustainable methods of plant production and protection. As a growing number of developing countries are investing scarce human and financial resources in biotechnology research, it is important to create the conditions which would enable them to take full advantage of this potential.

One important aspect of those conditions is the need to confront policy issues so that biotechnology will be integrated with, or complement, other priorities and concerns related to agriculture. This Policy Brief, which draws on lessons learnt from recent Development Centre research (Brenner, 1996), is intended to point to possible policy options and trade-offs for developing countries. It also discusses the role of donors.

The Changing Context for Agricultural Research, Technology Development and Diffusion

The national and international environment in which biotechnology is being developed and diffused is very different from that which inspired the earlier "Green Revolution" of high-yielding crop varieties. Furthermore, concern has been expressed that this changed environment may be less conducive to facilitating technology transfer from industrialised to developing countries.

At the forefront of preoccupations is the need to maintain adequate food production levels in the light of continuing high rates of population growth. Another major preoccupation affecting food supply is that of environmental degradation, which has two essential causes. One is the use, with increased population growth, of increasingly marginal lands for agricultural production. The other is the chemical-intensive (but high-productivity) model of agricultural production adopted in industrialised countries which has, increasingly, been adopted — and encouraged — in developing countries.

There is thus universal interest in seeking an alternative model of agricultural production which would depend less on agro-chemicals and be based more on indigenous plant genetic resources and local agro-ecological production conditions.

Another important aspect of the changed configuration is that the roles played by the public and private sectors, and the balance between the two, are evolving. Estimates of expenditure on agricultural biotechnology research vary widely and are available for very few countries. For the United States, a recent report (Caswell, Fuglie, and Klotz, 1994), provided a figure of $234.2 million for total Federal funding of agricultural biotechnology in 1994. An industry source, Standard & Poor's Compustat Services estimated the R&D spending of 15 leading United States agricultural biotechnology companies (**not** including pesticide and seeds companies) at $68.5 million in 1992. For all International Agricultural Research Centres (IARCs) combined, in 1993 an estimated $23.6 million was devoted to biotechnology research (see Brenner and Komen, 1994).

The "Green Revolution" technologies were essentially the prerogative of public research institutions and philanthropic foundations. Undoubtedly, commercial agricultural input suppliers profited from the increased demand for their products, but the key elements of the technology package — the high-yielding varieties of wheat and rice — were developed in the IARCs and within the National Agricultural Research Systems (NARs). In contrast, the development of agro-biotechnology is being led by multinational agro-chemicals and seeds companies, which have invested heavily in setting up in-house research facilities, commissioning research undertaken by new biotechnology firms, or entering into contractual arrangements with public research institutions or universities. The role of the private sector in biotechnology research, both basic and applied, has thus been considerably expanded.

At a time when very large sums are being invested in biotechnology research in industrialised countries, and when increased financial resources are required if developing countries are to master the increasingly science-based new technologies, investment in agricultural research is stagnating (or even declining) in many developing countries. In some countries, the NARs — together with public extension services — are under stress as a result of structural adjustment and privatisation. At the same time, development assistance funds destined to supplement national efforts are being drastically reduced by some donor countries, while there is a widespread sentiment of "aid fatigue". Moreover, future support for the international agricultural research system (the Co-ordinating Group on International Agricultural Research, or CGIAR), which played such an important role in the transfer of Green Revolution technologies, is no longer assured.

Another significant change in the environment in which biotechnology is being developed is that the "public good" aspect of earlier biological techniques is being eroded with the strengthening and extension of intellectual property rights (IPR) protection related to agriculture in general, and biotechnology in particular. A further step in the direction of stronger IPR protection has been taken following the Uruguay Round agreement, under what is termed the TRIPs (trade-related intellectual property rights) agreement which binds all signatories to introducing IPR on micro-organisms, plant genetic material and techniques for the genetic manipulation of plants.

Against the background of this new configuration, the factors which in the past have inhibited or facilitated the widespread diffusion of new technologies in developing country agriculture are still poorly understood. More important, these factors have generally been overlooked by developing countries in their expectations for biotechnology. It is therefore crucial to better understand the research, technology development and diffusion process as a whole if the full potential of biotechnology is to be realised.

Integrating Biotechnology in a Country Context: Towards a Conceptual Framework

Clarifying the Concept of Technology Transfer

The term "technology transfer" is used frequently, often indiscriminately, to convey different meanings in different contexts. At its most fundamental, *technology* implies knowledge, both theoretical and practical, of techniques. The tangible and obvious aspects of technology are embodied in products and machines. However, there are also intangible aspects of technology which are embodied in the minds and memories of people, in organisational structures and in behavioural patterns. *Technological change* refers to **any** improvement in technique and includes minor, incremental modifications as well as major breakthroughs, which are referred to as *innovations.*

Technology transfer takes place, in a variety of forms, among individuals as well as organisations, both public and private. Technology may be transferred through learning (education and training) or through the introduction of new processes and products. It may also be transferred through non-commercial channels (for example, through public extension systems) or through market transactions (purchase, licensing, joint ventures).

In international technology transfers between countries of widely-differing levels of economic and scientific and technological development, two important caveats should be kept in mind. Firstly, due to the intangible aspects of technology already referred to, in all technology transfer transactions (whether knowledge is exchanged or communicated in the form of products, equipment, methods or skills), there is an element of uncertainty regarding what is actually transferred. Inevitably, the supplier possesses more knowledge about the nature, use and eccentricities of a technology than can be conveyed to the recipient in blueprints, documentation or training. An added complication in the case of biological technologies in agriculture is their location-specific character and consequent need for adaptation to particular climatic, soil and other production conditions prevailing in different geographic locations. Thus, even the most successful technology transfer has inherent limitations.

Secondly, the relative success or failure of technology transfer transactions from one country to another will depend on the level of technological capability in the country to which the technology is transferred. Technological capability, or the ability to make effective use of technological knowledge (Pack and Westphal, 1986), is essential in order to: generate technology appropriate to a particular economic and socio-cultural environment; identify, select and diffuse relevant technologies; and to adapt, assimilate and make the most efficient use of imported technologies. National technological capability will to a large extent determine what elements of technology can be absorbed and assimilated through international technology transfer. Thus, while technology acquired from external sources may be an essential input to technological change and innovation, it can only **complement** local scientific and technological efforts. It cannot be a **substitute** for the consolidation of national capacities through local knowledge, education and training, or learning-by-doing.

Finally, the term *technology diffusion* conveys a meaning which differs from that of technology transfer. Technology diffusion refers to the transfer of technology, in the form of a final product, and its widespread distribution or dissemination to agricultural producers or other final consumers.

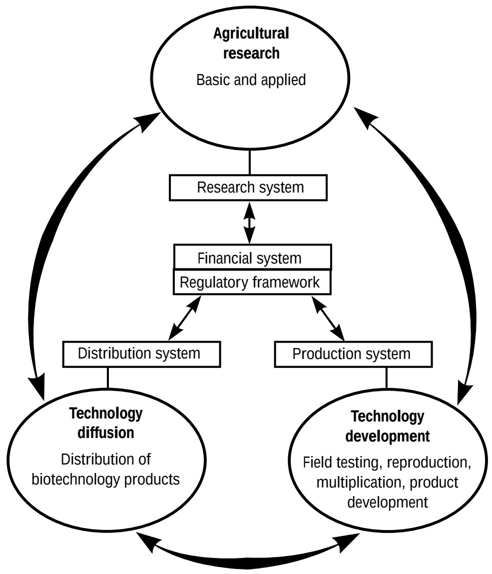
Biotechnology in the Context of a National System of Innovation (NSI)

Biotechnology has generally been considered in isolation from the specific national context which, to a large extent, will determine success or failure in taking advantage of what the new technology has to offer. The intrinsic capacity of a country to stimulate technological change and innovation — and, hence, to integrate biotechnology in that process — has rarely been taken into account in formulating biotechnology policies and strategies. The NSI approach provides a useful framework for elucidating the national context in which biotechnology should be integrated[2]. It is also useful in highlighting the complexities of the process of technological innovation and diffusion.

Figure 1 provides a simplified framework for biotechnology research, technology development and diffusion based on the concept of a NSI. The framework encompasses a network of units, systems and sub-systems which interact to generate, exchange and distribute knowledge. The effective functioning of the system depends in part on the capabilities and characteristics of its individual units. It also depends on the nature, frequency and intensity of linkages and flows of technology and information among the different units and sub-systems within the system. For our purposes, the terms linkages or flows are synonymous with that of technology transfer.

In Figure 1, agricultural **research**, technology **development** and **diffusion** are linked through research, production and distribution systems. **Agricultural research** may include basic, applied and adaptive research. Adaptive research can be important in agriculture, as elements of "transferred" or imported technology (for example, germplasm or a new seed variety) may require a lengthy period of adaptation to different agro-ecological and production conditions. Ideally, biotechnology research should be closely integrated with national science and technology objectives, with the priorities set for the agriculture sector, and with national agricultural research.

Figure 1. **Biotechnology in a National System of Innovation**



In principle , close interaction is necessary between the research and farming communities, and among research, farming and industry, both in identifying the major production or other problem areas to which research should give priority, and in providing feedback on the acceptability or appropriateness of technology products generated by the research community and industry.

Development encompasses the activities which translate the results of successful laboratory research into a tangible technology product, such as a genetically-modified seed or disease-free planting material. These may include small and large-scale field testing, seeds multiplication, or setting up a pilot plant. Product development may involve both public and private actors: commodity boards, parastatals, individual farmers, producer organisations, industrial firms. Again, as in research, interaction with and feedback from farmers is an important aspect of technology development.

Technology transfer may take place — as both commercial and non-commercial transactions — in all phases of the research, technology development and diffusion process indicated in Figure 1. In biotechnology, the forms of technology transfer encompass: education and training; the acquisition of research techniques, material and equipment; the acquisition of biotechnology products such as biopesticides, genetically engineered organisms or plant varieties, etc. In an effective NSI, feedback would occur between the final users and the research system, and between final users and the production system.

Many different public and private actors and institutions interact between the research phase, the product development phase, and the ultimate **diffusion** of new technology to final users. These may include, in the public sector: ministries of agriculture, education, science and technology, etc.; national research councils and institutes; universities; parastatals (seeds, feed, animal health); national extension systems. In the private sector, they may include: commercial biotechnology, seeds and agricultural input and veterinary supply companies; producer associations and co-operatives; and commercial agricultural services. They may also include non-profit foundations and non-governmental organisations (NGOs).

In contrast with mechanical and chemical technologies which, in industrialised countries, have been developed by private companies, biological techniques have traditionally had a strong "public good" aspect. While in the United States and other industrialised countries, seeds industries have been in private hands for some time, public agricultural research institutions (such as the Land Grant Universities in the United States) have played a key role in R&D. In many developing countries, private seeds sectors are still in their infancy and public institutions continue to play the predominant role not only in R&D but also in technology transfer and diffusion. Under structural adjustment policies, that key role is likely to be diminished

The different units, systems, and sub-systems shown in Figure 1 function within the confines of particular policy, financial and regulatory **environments**. Elements of that environment which are of particular importance for biotechnology include: macro-economic policies (and, in particular, structural adjustment and liberalisation) and their impact at the micro-level; levels of investment, both domestic and foreign; science and technology policies; environmental policies; agricultural policies, including agricultural research; and last, but not least, the regulatory framework (particularly for biosafety and intellectual property rights).

An important feature of the agricultural innovation system is its increasing openness. Elements of technology or information may be acquired from a diversity of sources, at several different levels. Interaction and feedback in the research, technology development and diffusion process thus occur not only at micro-level, between units forming part of the system, or at national level, but also at regional and international levels.

Lessons from Country Experiences

This section draws on developments with respect to biotechnology for plant production and protection in six countries: India and Thailand in Asia; Colombia and Mexico in Latin America; and Kenya and Zimbabwe in Africa (see bibliography). In addition to an analysis of the nature and scope of research effort, effort was made to examine the policies, practices and mechanisms in place which would facilitate or impede the development of biotechnology-based products and their diffusion in the farmer's field. Country studies thus were concerned not only with the "state of the art" with respect to biotechnology research, but also with the different phases in the whole process from basic research to the marketing and widespread diffusion of a biotechnology product.

Biotechnology Policies, Institutions and Priorities

Although biotechnology is still in its infancy in the countries we have studied, it is nevertheless perceived as being of strategic importance, four of the six countries (Colombia, India, Thailand and Zimbabwe) have created special institutions to promote biotechnology research and its applications. Despite the creation of these specialised institutions, none of the countries we have studied has a clearly-defined policy for agricultural biotechnology.

Nor have all countries clearly defined and implemented national policy with respect to two pressing issues specific to biotechnology in agriculture: biosafety and intellectual property rights (IPRs). Only three countries (India, Mexico and Thailand) have biosafety procedures in place, and in most countries, IPRs related to plants are still under discussion or negotiation. The formulation of policies in these areas implies costs, but it also implies the need for particular kinds of capacities and expertise. Whether policies are incorporated in new or existing laws, countries also need to make choices with respect to the agency(ies) most competent to administer and, even more important, to enforce legislation.

Decisions regarding biotechnology policy have generally been taken outside the decision-making process for agricultural research which, in some countries, is well-established. Initiatives for setting up biotechnology institutions, research programmes and projects have come more from the scientific community and from government bodies concerned with science and technology policy than from the traditional agricultural research community. Developments in biotechnology have, as a result of "science-push", to a large extent been divorced from the priorities set for national agricultural research and agriculture generally. Thus, from the outset, the linkages between biotechnology initiatives and agricultural research have not been firmly and uniformly established and little effort has been made to link the new biotechnology institutions, formally or informally, to the traditional agricultural research and extension community.

In some countries, attempts have been made either by the scientific community or in donor-sponsored programmes, to set priorities for agricultural biotechnology. These have not, however, benefited from the support of key decision-makers in the countries concerned.

Efforts to bring together the different "stakeholders" likely to be affected by or interested in developments in agro-biotechnology have been made in some countries, sometimes initiated by government, sometimes by donors. In Kenya and Zimbabwe, this has resulted in the creation of informal biotechnology "platforms". These informal groupings could be instrumental in forging regular interaction among the different public and private entities involved, and in highlighting the need for biotechnology policies which are, indeed, better integrated with agricultural and other policy considerations.

Biotechnology Research, Technology Development and Diffusion: Incentives and Constraints

The potential of biotechnology to contribute to enhanced productivity, quality, or to resistance to pests, disease, or abiotic stress, acts as a powerful incentive to "get into the act". Most countries, however, have a number of obstacles to overcome in order to be able to take full advantage of what biotechnology has to offer.

One of the important lessons to be learnt from country experiences is that little economic information is available, whether on the costs of biotechnology research, the comparative cost of final biotechnology products or on changes in production costs associated with their introduction in the farmer's field. Even more important, very little evidence is available on the actual or potential cost-benefits of biotechnology products to farmers which will, in the long run, determine their success or failure. The fragmentary evidence generated by the country studies indicates a pressing need for more in-depth analysis of short and long-term economic and social costs and benefits of biotechnology.

This is not to suggest, of course, that economic criteria should be the only ones taken into consideration in embarking on biotechnology research. Decisions may be based on broader social or environmental concerns. However, whatever the criteria for initiating activities in biotechnology, the scarcity of financial resources means that economic considerations cannot be ignored.

The "distance" between research, product development and commercialisation — or from the laboratory to the farmer's field — depends on a number of crucial links and interaction among public and private actors, both national and international, and between government policies and market forces. In most countries, the linkages among the key actors are weak or tenuous. Private markets for technology remain undeveloped but at the same time, under structural adjustment, the structures and mechanisms set up by the public sector as a means of facilitating technology transfer and diffusion are being privatised, or even dismantled.

Research

Except in the case of commodity-oriented research initiated by producer groups (in Colombia, for example), the biotechnology research reported on in the country studies suffers from a lack of clear priorities and focus and has not been firmly integrated with the priorities and problems confronting agriculture. In addition, linkages between scientists and farmers, between biotechnologists and the agricultural research and plant breeding communities, between the research community and private industry and, indeed among institutions working on similar problems, which could help provide clear signals for establishing research priorities, facilitate technology development and transfer are weak. An added difficulty is that public research institutions often compete for scarce funds.

All countries are tempted to enter the field, but country studies suggest a much greater preoccupation with "supply-side" than with "demand-side" issues. Country studies yielded little comparable data on the numbers of institutions and scientists involved in biotechnology research, on public and private expenditure on biotechnology research, on the share of biotechnology in the total research effort. Figures for India and Thailand gave estimated public expenditure at approximately $19 and $20 million respectively for 1994, representing 7.4 and 10 per cent respectively of total R&D expenditures.

All countries cite the lack of human and financial resources as an obstacle to the development of agricultural biotechnology, but without a sense of what would be an appropriate level of resources to be diverted to biotechnology rather than to other, perhaps equally or more important, problems. Similarly, in the absence of clear objectives and priorities, it is difficult to determine what would be a "critical mass" of scientists in biotechnology disciplines.

Individual research projects are often undertaken in isolation with external funding support but without *ex-ante* assessment of the scientific, economic, social or environmental viability of the project, or of its prospects for success. In this situation the element of accountability (which would be essential in a large commercial company) is missing, along with the equally important aspect of reward (in financial or other terms).

Given that research programmes have often been undertaken without an assessment of the effective demand for the technology which could result from the research, in general, the process of development — and even less the questions of technology transfer and diffusion — has not been taken into account in research programme design.

Technology Development

The crucial area of "development" thus emerges as a major obstacle in most country studies, for a number of reasons. These include: lack of effective demand for the biotechnology product being developed; lack of interaction and feedback between public research institutes and agricultural producers or between the public sector (including universities) and industry; inadequate provision or lack of provision in research budgets for product development, large-scale testing and up-scaling.

In all six countries with the exception of Mexico, the public sector provides the major share of investment in agricultural research in general, and biotechnology research in particular. Investment in biotechnology research by commercial firms remains very limited, although private-sector organisations such as producer groups play a significant role for specific crops in Colombia, Kenya and Zimbabwe. Given the difficulties of governments to maintain current low levels of investment in research, it will therefore be necessary to provide incentives to firms to encourage participation in biotechnology research, or in public/private sector research collaboration. The alternative would appear to be greater effort on the part of public research institutes towards "finished" products, closer to potential commercialisation, which would imply additional development costs.

Efforts are being initiated in some countries to encourage private sector participation in the development of biotechnology and a diversity of policy measures have been taken. These include, in Thailand, different forms of tax incentive to companies and soft loans for public-private research projects. They also include innovative institutional arrangements, such as university institutions set up specifically to explore commercial possibilities and partnerships, as in the case of the Centre for Innovation and Technology — CIT — at UNAM in Mexico, or the public/private corporation CORPOBIOT in Colombia, set up specifically to strengthen links between research centres and industry in biotechnology product development and the up-scaling of related bio-processing, or to provide advisory services and training to companies interested in developing biotechnology innovations. In some countries there are also growing pressures on public research institutions to generate income and this is likely to lead to closer interaction with the private sector.

Another possible constraint to the development and diffusion of biotechnologies is that of inadequate national capacity in the complementary or underpinning technologies and capacities which are necessary to ensure the transition from laboratory to the field. For example, growing demand for biopesticides would require more efficient, large-scale bio-processing capacity. Similarly, strong plant breeding capacity and a seeds industry which incorporates not only production but also quality control and certification, will be needed for the diffusion of biotechnologies embedded in seed. In the six countries, the seeds industry is well developed for the major commercial crops, with private local and foreign firms supplying and selling seed. For other crops — and in particular for food crops grown by low-income farmers — the seeds sector is less developed. Indeed, for some crops, seed is not commercially produced but is mainly reproduced, saved and exchanged among farmers. Not all countries have strong plant-breeding capacity for all their major crops and not all countries have the capacity to ensure quality control and the varietal certification of seeds.

Technology Transfer and Diffusion

With respect to technology transfer and diffusion, it is important to keep in mind that biotechnology may be considered both as a set of tools or enabling techniques, usually complementary to other techniques, as well as an end-product. The use of genetic markers in plant breeding is an illustration of the use of biotechnology as an enabling technique, while a transgenic plant variety would illustrate an end-product. And indeed, in the short term, biotechnology may be much more important for developing countries as a tool in the research process than as a means of developing new products. Already, a growing number of countries are incorporating biotechnology methods — particularly genetic marker techniques — in traditional plant-breeding programmes, or using molecular-based diagnostic tests for identifying different types of diseases in crops. The introduction of these more effective, rapid, and accurate methods will be an important factor both in improving the research process and in building domestic capabilities.

Constraints are also likely to be encountered when it comes to the diffusion of biotechnology products, or to the final step in "moving from the lab to the farmer". Most of the biotechnology products already being commercialised in developing countries are the products of tissue culture and micro-propagation. Disease-free planting material is now available for a growing number of crops and is supplied by a growing number of local, private firms. Other biotechnology products such as biopesticides, which may have important long-term socio-economic and/or environmental benefits, have met with less commercial success at a time when public extension services which, in the past, have facilitated the diffusion of new technology at the farm level, are constrained by lack of funds and retrenchment.

Commercial technical services are generally considered to be more efficient than public extension systems in transferring technology and in communicating the information necessary to ensure its optimal use and to encourage feedback from producers. However, private sector distribution and sales networks are directed towards producers and regions where market prospects are most promising. This then highlights the difficulties of devising ways in which governments could at one and the same time keep short-term costs to a minimum, support the development of "public-good" biotechnologies, and create conditions for their production and diffusion by commercial companies in the longer term.

To overcome these difficulties, effort would need to be directed towards creating or strengthening collaboration between the public and private sectors and, at the same time, to stimulating demand (or creating markets) for new biotechnologies. This may mean, in the former case, that the government would need to provide market guarantees through the purchase of a share of production, although it should be clear that government procurement would be limited in time. In the latter case, there would probably be a need for pilot projects in order to demonstrate the advantages to farmers — particularly the poorest, most "risk-averse" — of the new technology compared to technologies already in use, as well as training (for example, in integrated pest management techniques or environmental education). At the same time, it would be necessary either to provide credit facilities for farmers to purchase the new technology or to ensure subsidised distribution, which would necessarily imply public-sector costs.

In certain situations where markets are not yet created and where private firms may be reluctant to invest in the transfer and diffusion of technology, experienced NGOs or international "intermediaries" such as the International Service for the Acquisition of Agri-Biotech Applications (ISAAA) may facilitate technology transfer and diffusion.

Access to technology in the form of the training of developing country scientists in the laboratories of industrialised country institutions and companies is a crucial aspect of technology transfer and of biotechnology capacity-building for developing countries. Many opportunities for training abroad are provided or financed by donor agencies, but it is important that these efforts should be co-ordinated in order to ensure that training encompasses the key disciplines and to avoid unnecessary duplication.

Importing Biotechnology versus Local Development

One issue which was not adequately addressed in the country studies is assessment of the comparative costs/benefits of importing or purchasing biotechnology techniques and/or products versus local development. Clearly, this is not an "either-or" issue, as importing biotechnology requires, at the least, the capacity to identify technologies suitable for transfer or purchase. In an increasingly open world, no single country is "self-reliant" in science and technology and information and technology are likely to be obtained from a diversity of different sources: local, national, regional and international. However the question of the extent to which developing countries should conduct their own research and develop their own biotechnology applications is one which needs to be considered.

In certain situations, it may make eminent good sense in both scientific and economic terms to purchase, license, or import particular elements of technology rather than "reinventing the wheel", and there are certain undeniable advantages in being a follower or latecomer rather than attempting to lead the field or to "catch up" with a moving target: the technology which is acquired has been tried, tested and assessed for, and can probably be obtained at a lower price. If a country attaches considerable importance to the development of a particular biotechnology, there are also ways in which it can reduce the costs of research efforts by sharing those costs with others who have an interest in developing similar technology. The Colombia study highlights the example of biotechnology research on sugar, where the research centre set up by the sugar producers' association in Colombia has joined a research consortium composed of research institutes from Australia, Brazil, South Africa, the United States and others to contract research from leading United States universities (California Institute of Technology, Cornell, and others).

Many of the biotechnology products being developed in industrialised countries may not be the most appropriate for resolving the particular problems confronting agriculture in developing countries and, in particular, in the countries included in our research. Herbicide-tolerance, for example, is unlikely to be a property sought after in low-input agriculture. In the same way that Green Revolution technology involved a "technology package" of improved seed, chemical inputs and adequate water supply, new biotechnologies are also likely to complement, but not necessarily supersede technologies already in use. For example, biopesticides are generally not used alone, but as one element in an integrated pest management "package" and the education of farmers in pest management and control methods, as suggested by successful programmes in Indonesia and elsewhere, has required major investment. Similarly, as suggested by the recent experience in the United States with Monsanto's B.t. cotton[3], the production of transgenic crops with resistance to specific pests may require management skills and a level of education on the part of farmers which may be incompatible with the conditions prevailing in many of the production systems of developing countries.

In the final analysis, the question of the extent to which a country undertakes its own biotechnology research and the extent to which priority is given to biotechnology over other research methods should be linked, first and foremost, to country priorities and objectives in agriculture and in agricultural research, as well as to environmental concerns. It must also be linked realistically to the scientific and technological capacities and level of agricultural development of the country concerned. Our research suggests a continuum or hierarchy of capacities with respect to biotechnology: from tissue culture (disease-free planting material and rapid propagation) to anther culture and the use of genetic markers; to transgenic plants (transformation and regeneration and gene constructs). This would correspond to a block-building, cumulative learning process compatible with the concept of a NSI.

Experiences with Regional and International Collaboration

Regional Collaboration

The building of national institutions and capabilities is crucial in biotechnology research, technology development, and diffusion. However, linkages with external sources of information, technology and possibly capital, are perhaps equally important, particularly in today's world of globalisation.

Country experiences suggest that regional collaboration in biotechnology has been most successful thus far in the policy arena. Workshops on biosafety and on IPR, organised by IICA, DGIS, ISAAA or by the Agricultural Biotechnology for Sustainable Productivity (ABSP) programme, have been evaluated as extremely useful in supplying impartial information and guidance. Perhaps more importantly, they have provided sufficient momentum for countries within a given region to organise follow-up activities.

The efforts of the Intermediary Biotechnology Service (IBS) to assist in biotechnology policy formulation and research-programme management through the organisation of a series of regional seminars are also worthy of note[4]. An important feature of these regional seminars is that, to the extent possible, country delegations are composed of representatives of the key public and private organisations which should be instrumental in decision-making with respect to biotechnology. Delegations thus include policy makers from agriculture, science and technology, and finance, research managers from public and private institutions, and representatives of NGOs and farmers' groups. The seminars also provide a rare opportunity for countries within a given region to compare experiences.

Regional collaboration in biotechnology research should in principle permit the sharing or pooling of scarce resources. It is tempting to suggest that, as many agricultural production problems are indeed regional in scope, it should be possible to propose regional research priorities, with different countries in a given region working on specific aspects of the problem, according to their particular research strengths. In reality, experience has shown that it is extremely difficult to agree on priorities and to agree on the allocation of research tasks.

Also, while it may be feasible to envisage regional collaboration in research on food crops, increased economic and trade liberalisation means that countries within a single region are likely to be competing against each other in the same crops in export markets. Research collaboration then becomes more problematic.

Strengths and Limitations of Donor-supported International Initiatives in Agricultural Biotechnology

A growing number of developing countries benefit from international biotechnology initiatives funded by bilateral or multilateral donor agencies as well as foundations such as the Rockefeller Foundation.

A survey of expenditures on international biotechnology initiatives (see Brenner and Komen, 1994) estimated that between 1985 and 1993, a total of $400 million had been invested by bilateral and multilateral aid agencies, international organisations, national agricultural research institutions, universities and private foundations. According to the survey, developed countries received 43.2 per cent, developing countries 40.4 per cent, IARCs 14.3 and "other" 2.1 per cent of those expenditures. Given that a majority of the IARCs are located in developing countries, more than half the total financial commitment to international initiatives in biotechnology is actually spent in developing countries.

While the number of countries taking part in international biotechnology initiatives is quite high — over 60 — developing countries have not been closely involved in their planning and design. The most notable exception to this rule is the DGIS biotechnology programme, which is not confined solely to research and has been active in priority-setting. This programme is funded by the Netherlands Government.

While international biotechnology initiatives are more or less evenly spread among the different geographic regions, efforts are nevertheless concentrated in a small number of countries within each geographic region: Kenya, Zimbabwe, Egypt and Côte d'Ivoire in Africa; Indonesia, Thailand and India in Asia; and Costa Rica, Mexico and Brazil in Latin America. For some countries these — and other — donor-funded efforts constitute a major share of their total research effort in agriculture. This has been the case, notably, in Kenya and Indonesia.

Few instances where developing countries contribute matching funds to international programmes were recorded in the survey of international initiatives in biotechnology referred to above. The most substantial contributions by participating national institutions emerged in the Rockefeller Foundation's International Rice Biotechnology Program, in which China, India, Indonesia, Korea and Thailand participate. This situation is likely to evolve in the future, as development assistance budgets are reduced and as aid agencies become more insistent that recipient countries contribute a share of project costs.

A majority of the programmes referred to concern biotechnology research and scientific collaboration and many of the research programmes provide training opportunities for developing country scientists in the disciplines and methods of biotechnology. In most cases, the programmes have not been designed as a function of developing country priorities, capabilities and needs. Similarly, few of the programmes are explicitly concerned with **local** capacity and institution-building.

Some projects are now approaching the field-testing or product development stage and it is not at all clear that product development and technology transfer (in the sense of a product in the farmer's field) have been taken into consideration either in project design or with respect to costs. Nor is it clear that development has been allowed for in the time-frame set for projects.

At a time when developing countries are attempting to reduce government expenditure and when bilateral aid budgets are also under stress, the need to ensure the effectiveness of aid is clear. There is thus a need for the effective co-ordination of aid, both on the part of recipient countries and on the part of donors. From the point of individual recipient countries — particularly those receiving assistance from several different sources — there is a need for co-ordination in order to exploit complementarities among the various initiatives underway, to avoid wasteful duplication of effort and to ensure maximum impact.

From the point of view of donors, co-ordination would essentially concern exchange of information among the different agencies (foundations, bilateral and multilateral agencies). Meetings of the kind organised by IBS in November 1993[5], when the preliminary results of the survey of international initiatives in biotechnology were presented, may be particularly useful in this respect. Given that most programmes/projects have now been underway for a few years, the time might also be ripe for assessing progress achieved and problems which might have arisen unexpectedly. At the same time it would be important to assess the compatibility between national programmes and priorities in biotechnology and international initiatives and to seek ways of ensuring closer complementarity.

From *ad hoc* to Strategic Policy Approaches

Conclusions

Confronted with acknowledgement of the key role of technology and innovation in stimulating economic growth and in enhancing competitiveness, developing countries are anxious to avoid any widening of the technological gap with industrialised countries. For this reason, biotechnology is considered to be of strategic importance. At the same time, biotechnology offers enhanced possibilities in the diagnostics of plant and soil pathogens and in the diagnosis of plant diseases and, through genetic engineering, the possibility of greater tolerance to stress, and pest and disease resistance in plants. It thus has the potential of being more environmentally-friendly than the earlier chemicals-intensive technologies.

The changing configuration in which agricultural biotechnology is being developed and diffused has major implications both for the generation and application of the new technologies in developing countries, and for international technology transfer. The essential differences between the current configuration and that which resulted in the diffusion of the earlier Green Revolution technologies include: within developing countries, budget stringency under structural adjustment and liberalisation accompanied by stagnating investment in agricultural research; changes in the roles played by the public and private sectors and in the balance between the two; a less prominent role played by the international agricultural research system (CGIAR), due not only to uncertainty about future financial support for the system, but also because the IARCs may not be at the forefront of developments in biotechnology; the strengthening of IPR protection and a consequent weakening of the "public good" aspect of biotechnology research.

Perhaps the most obvious conclusion emerging from country experiences is that biotechnology has, indeed, acquired a certain momentum but to a large extent has been embarked upon in isolation from the overall national context in which it is being developed. This can lead to unrealistic expectations with respect to the pace and extent of its development and application in developing-country situations. Given the potential of biotechnology to contribute to more sustainable methods of plant production and protection, it is important to create the conditions which would enable developing countries to take full advantage of that potential.

The NSI framework outlined above is shown to be useful in moving towards better understanding how technological change occurs within a given country context, of where the units and linkages within the system are weakest and where the bottlenecks and constraints are most likely to occur in the innovative process. It is important to enhance understanding of how biotechnology will be incorporated within that system because, inevitably, biotechnology products will be subjected to the same constraints as those encountered in the transfer and diffusion of conventional technologies. This crucial point is often overlooked.

Whether countries import biotechnology products or seek to develop their own — and usually it will be a combination of both — does not cast doubt on the wisdom of developing local capacities and institutions. The biotechnologies which are being generated are increasingly costly, requiring high levels of scientific capability and skill, and increasingly sophisticated and expensive equipment. Their application may also require high levels of management capability on the part of farmers. It will not be possible to master biotechnology methods **or** products without developing national scientific and technological capabilities at the same time. This will require, at the minimum, trained people (scientists, technicians, plant-breeders and others), appropriate institutions and facilities (laboratories, equipment and the maintenance of equipment) and financial resources. New biotechnology methods provide a powerful set of tools which will complement but not supersede other techniques. It may therefore be important to strengthen capacities in the techniques required to underpin biotechnology (such as plant-breeding, fermentation) before diverting a major share of scarce resources to biotechnology research.

Given the scarcity of both human and financial resources, attempts should be made to create conditions whereby research effort is not wasted and to improve the chances that successful research will lead to the diffusion of a biotechnology product. This would require concentration on a few, selected problem areas rather than a proliferation of research projects and dispersal — or even duplication — of research effort as is the case at present. It would also require that the constraints to technology transfer and diffusion — whether regulatory procedures, at the production level, inadequacies in the seeds sector, or problems of acceptance by farmers — be taken into account. Finally, it would require strengthening the links and interaction among biotechnology research projects, among the relevant research institutions, between the biotechnology and agricultural research communities, and between public research institutions and the private sector.

The economic advantages of biotechnology are neither clear nor straightforward. It is therefore important that more effort should be made to determine the comparative advantage of biotechnologies over other technologies and to assess the effective demand for the new technologies. It is also important that more effort should be devoted to **ex ante** technology assessment and to improving methodologies available for this purpose.

Many of the decisions already taken to undertake biotechnology research have not been grounded in an objective assessment of the costs of the research, the chances of success, or the time-frame for tangible results. Decisions to embark on the biotechnology path have also often been taken without consideration of whether the particular biotechnology product(s) to be generated would have a comparative cost advantage over alternative technologies.

One conclusion which concerns developing countries and donors alike is the importance of bringing the interested parties together in terms of shared commitment which, increasingly, will imply shared funding. More and more often, with financial assistance declining, donor agencies require counterpart funding in projects and programmes. This is viewed, however, not simply as a financial requirement, but as a sign of commitment on the part of the developing country, from whose point of view, there is no doubt that counterpart funding provides leverage in negotiations. Much more influence can be wielded in the design of a project or programme if one is a partner in the financing.

Another conclusion concerns primarily donor agencies and the ways in which they can best facilitate capacity-building **in** developing countries. As we have argued, developing countries will not be able to take advantage of biotechnology — whether the technology is transferred from industrialised to developing countries, or whether it is generated in developing countries — without at the same time developing the scientific and institutional capacities required to master and apply the technology.

If aid-funded international initiatives in biotechnology are to be effective in both financial and scientific terms, it is important that donor agencies should have a clearer idea of the situation in the countries in which they are planning to support biotechnology initiatives. A crucial part of that situation is not only the capacity which exists (or does not exist) in the biotechnology disciplines for research, but also the technology development, transfer and diffusion mechanisms which are already in place (or not in place).

Strategic Policy Approaches

National Policy Options

Clearly there can be no single policy blueprint for agricultural biotechnology. Each country will need to formulate its own strategy or policy for the development of biotechnology for use in agriculture. However, if countries want to avoid the risks inherent in the science-driven, *ad hoc* approach and to ensure that biotechnology research is at the service of agriculture and agricultural producers, policy intervention will be required. At the same time, a certain number of conditions will need to be fulfilled.

Firstly, biotechnology policies and programmes should be integrated within a sectoral context, within the framework of the problems confronting agriculture and agricultural research and with a clear sense of the specific problem areas to which biotechnology could best contribute. Biotechnology in itself will contribute little to agricultural improvement unless due attention is paid to the array of policies (including appropriate price policies) and institutions needed for sustainable agricultural development.

In making decisions regarding the allocation of scarce resources to biotechnology, more attention should be devoted to assessing the effective demand for new biotechnology products, particularly at the level of agricultural producers or particular commodities. This would facilitate determination of the roles to be assigned to the public and private sectors, both with respect to coherent policies for investment in biotechnology and to testing, monitoring and disseminating biotechnology products. It would also enable governments to have a clearer indication of those technologies which would require changes in management practices at the farm level, or for which there is no ready market.

Biotechnology does have the potential for contributing towards more sustainable methods of plant production and protection which could have major long-term environmental, economic and social benefits. It has to be acknowledged, however, that in the short to medium-term, the economic costs not only of developing these “environmentally-friendly” technologies, but also of ensuring public channels for technology transfer and diffusion and/or subsidising their utilisation by poor farmers, could be considerable. Furthermore, the burden would need to be met by public funding.

Efforts to involve the private sector, preferably early in the research, development and diffusion process, and to create new public/private partnerships and mechanisms — in which producer associations, small and medium-sized local (or foreign) firms and NGOs would play a more prominent role — should be intensified.

A further condition is the strengthening of linkages and networks among those concerned with developing and distributing biotechnology products, as well as those interested in developing and disseminating information about biotechnology. These linkages should be encouraged at all levels, whether formal or informal. Effort should be made at the outset to involve the appropriate public and private decision-makers (including farmers) and the scientific community in the determination of a coherent national strategy.

As suggested by the NSI framework, this is important not only at the level of individual institutions and within a national context, but also at regional and international levels. Networks are especially important at this stage of the development of agricultural biotechnology as so many research and policy groups are on a “learning curve” in dealing with the many different facets of the problems of biotechnology. Economies of scale from networking can be substantial, as are the gains from personal contacts among scientists, especially those from developing countries visiting advanced institutes. In this regard, IBS and other institutions have played an important role as facilitators and in bringing together and sharing information among policy-makers, scientists and others involved in the development of biotechnology for sustainable agricultural development. Clearly, these institutions have an important role to play as governments continue to grope towards formulating appropriate policies.

A final, essential condition to be met is that of national capacity-building, whether in terms of human resources, financing or institutional development. Whatever policy decisions are taken with respect to biotechnology, all countries will need to pay due attention to the universal aspects of biosafety and IPR. Whether for biotechnology processes and products which are imported, or for those generated by local research, procedures for risk assessment will need to be in place. Similarly, for all those countries which are signatories of the final agreement of the Uruguay Round and which have therefore undertaken to strengthen IPR protection, decisions will need to be taken regarding which kind of system to adopt with respect to agriculture in general, and to biotechnology in particular.

All governments will need to strengthen their capacity to address these issues. In some instances this will require marginal changes in patent laws, health regulations, testing procedures and the like, while in other instances it may be necessary to create new structures to deal with these problems. Relevant guidelines or legislation for biosafety and IPR will also require implementation, monitoring and enforcement and, consequently, financial resources as well as technical and legal expertise. It is important that progress be made in this area as the lack of adequate institutions continues to be a barrier to investment and progress towards the introduction and spread of genetically altered materials.

Regional and/or international collaboration in these two policy areas has already proven fruitful and a number of institutions, such as OECD, UNIDO, the Biotechnology Advisory Center at the Stockholm Environment Institute (for risk assessment), ABSP, and IBS, are available to provide impartial advice or training. These efforts should receive continued support.

The Role of Donors

Our research points to a wide range of options for donor agencies in supporting biotechnology initiatives in developing country agriculture. These range from the approach of the World Bank where a biotechnology component may be included in agricultural development programmes, through the "participatory bottom-up" approach of The Netherlands, to the public-private sector approach of the USAID-funded ABSP programme, to much more narrowly-targeted approaches. These might include, for example, small sums for meeting recurrent costs, purchasing particular items of equipment, or for maintaining them, which can be a major difficulty in developing country institutions. Alternatively, they might include meeting development costs, or contributing a share of development costs when these are shared between the public and private sectors.

What is important is that there should be continued support, once research programmes *per se* are close to achieving scientific objectives, for further development and for technology transfer and diffusion. Flexibility is therefore needed, in terms of the duration of a project or programme, in terms of providing "catalytic" funding and in the point of intervention.

Given the limited financial and human resources available for biotechnology, developing countries will continue to need support, particularly for capacity and institution-building. It is also becoming abundantly clear that if biotechnology projects and programmes are to be brought to fruition — particularly if that implies the ultimate diffusion of a biotechnology product in the farmer's field — long-term financial support and commitment will be required. Unfortunately, the need both for flexibility in financing and for long-term financing run counter to current trends, particularly in the bilateral donor community.

The Problem of "Public Good" Technologies

Last but not least, one of the key policy implications which emerges is that, in those situations where public sector systems are no longer fulfilling their earlier role and where technology markets are not yet developed, alternative technology transfer and diffusion mechanisms for "public good" technologies in developing country agriculture may be needed. These would need to involve a diversity of public and private partners. This is a matter which will require reflection on the part of developing countries, relevant NGOs, the donor community and the international agricultural research community as a whole.

Notes

1. The OECD has retained the following definition: "The application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services". Appendix 1 of Bull, Holt and Lilly (1982) lists 11 definitions.

2. This section draws on Lundvall (1992), Nelson (1993), Niosi Saviotti, Bellon and Crow (1993) as well as ongoing work at OECD.

3. See Jocelyn Kaiser, *Pests Overwhelm B.t. Cotton Crop* in the News and Comment Section of *Science*, Vol. 273, 26 July 1996 and Letters to the Editor in the 20 September edition of the same journal.

4. The first, in Singapore in September 1994, brought together representatives from Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam. Participants from Ethiopia, Kenya, Mauritius, South Africa, Uganda, Tanzania and Zimbabwe attended the second seminar in South Africa in April 1995 (see Komen, *et al.*, 1995 and Komen, *et al.*, 1996). A third seminar took place in Lima in October 1996, bringing together participants from Chile, Colombia, Costa Rica Mexico and Peru.

5. IBS Seminar on "International Agricultural Biotechnology Programme: Providing Opportunities for National Participation", ISNAR, The Hague, 9-11 November, 1993.

Bibliography

AGRICULTURAL BIOTECHNOLOGY (1990), *Opportunities for International Development*, ed. G. J. Persley, C.A.B. International.

ALAM, G. (1994), "Biotechnology and Sustainable Agriculture: Lessons from India", Technical Paper No. 103, OECD Development Centre, December.

BHUMIRATANA, S., S. SRIWATANAPONGSE, and M. TANTICHAROEN, "Biotechnology and Sustainable Agriculture: The Case of Thailand", OECD Development Centre, mimeo.

BRENNER, C. (1996), *Integrating Biotechnology in Agriculture: Incentives, Constraints and Country Experiences*, OECD Development Centre, Paris.

BRENNER, C. and J. KOMEN (1994), "International Initiatives in Biotechnology for Developing Country Agriculture: Promises and Problems", Technical Paper No. 100, OECD Development Centre, October.

BULL, A. T., G. HOLT, and M. D. LILLY (1982), Biotechnology: International Trends and Perspectives, OECD, Paris.

BUNDERS, J. *et al.*, (1990), *Biotechnology for Small-Scale Farmers in Developing Countries: Analysis and assessment procedures*, VU University Press, Amsterdam.

CASWELL, M. F., K. O. FUGLIE, C. A. KLOTZ (1994), *Agricultural Biotechnology: An Economic Perspective*, Agricultural Economic Report No. 657, USDA, FRS, Washington, May.

DAVID, P. A. and D. FORAY (1995), "Assessing and Expanding the Science and Technology Knowledge Base", in *STI Review*, No. 16, OECD, Paris.

GITU, K. W. (1995) "Biotechnology and Sustainable Agriculture: A Case Study of Kenya", OECD Development Centre, mimeo.

IBS (1994), *International Initiatives in Agricultural Biotechnology*, The Hague, May.

KOMEN, J., J.I. COHEN and S.K. LEE, eds. (1995), *Turning Priorities into Feasible Programs: Proceedings of a Regional Seminar on Planning, Priorities and Policies for Agricultural Biotechnology in Southeast Asia*. Singapore, 25-29 September, 1994. The Hague / Singapore: Intermediary Biotechnology Service / Nanyang Technological University.

KOMEN, J., J.I. COHEN and Z. OFIR, eds. (1996), *Turning Priorities into Feasible Programs: Proceedings of a Seminar on Planning, Priorities and Policies for Agricultural Biotechnology*. South Africa, 23-28 April, 1995. The Hague / Pretoria: Intermediary Biotechnology Service / Foundation for Research Development.

LUNDVALL, B.-A. ed. (1992), *National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning*, Pinter Publishers, London.

NELSON, R. (1993), *National Innovation Systems: a Comparative Analysis*, Oxford University Press.

NIOSI, J., P. SAVIOTTI., B. BELLON and M. CROW (1993), "National Systems of Innovation: In Search of a Workable Concept", in *Technology in Society*, Vol. 15.

PACK, H. and L. E. WESTPHAL, "Industrial Strategy and Technological Change: Theory versus Reality", in *Journal of Development Economics*, Vol. 22, No. 1, June 1986.

SANINT, L. R. (1994), "Crop Biotechnology and Sustainability: a Case Study of Colombia", Technical Paper No. 104, OECD Development Centre, December.

SOLLEIRO REBOLLEDO, J.L. (1994), "Biotechnology and Sustainable Agriculture: Country Study of Mexico", Technical Paper No. 105, OECD Development Centre, December.

WOODEND, J. (1995), "Biotechnology and Sustainable Crop Production in Zimbabwe", Technical Paper No. 109, OECD Development Centre, December.

WORLD BANK (1991), "Agricultural Biotechnology: the Next 'Green Revolution'?" Technical Paper No. 133, Washington, D.C.

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