SUSTAINABLE AGRICULTURAL DEVELOPMENT: THE ROLE OF INTERNATIONAL COOPERATION

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wide variety of species with a high degree of confidence as to the maintenance of correct expression in the heterologous recipient plant species.

Our knowledge of promoter (control) elements has progresed to a stage where we are now able to join them in different combinations to provide entirely new controls influencing the patterns and levels of expression of genes. We can tailor our production plants to fit new requirements.

WHAT WILL WE BE ABLE TO ACHIEVE IN THE FUTURE?

Our skills in genetic engineering will enable us to make small, precise and significant changes to the genetic make-up of our production plants, changes which will improve the capability of plants to cope with the prevailing climatic and soil conditions. We will change the architecture of plants, their proportional structuring, to make them fit better as complementary partners in production systems, so that intensive double-cropping may be achieved with a number of alternative crop species.

Apart from tailoring plants to our agricultural environments, we will make precise changes to the products we derive from these plants. We will change the chemical and biochemical make-up of the products so that they fit market requirements. This will be of great importance to the food-processing industry. Not only will we make changes to existing plant products, we will introduce entirely new products to plants. We can expect to use plants as factories for biochemicals of value in pharmaceutical uses and for enzymes for industrial purposes.

The marriage of biotechnology to agriculture is a powerful and critical development. The plant-based food and commodity production industry will never be the same again.

DISCUSSION OPENING: A COMMENT FROM THE PERSPECTIVE OF THE LESS DEVELOPED COUNTRIES – C.H. HANUMANTHA RAO*

The relevance of biotechnology to the agriculture of less developed countries is a subject about which hard information usable by economists is yet to be generated. Yet the promise and potential of biotechnology are so glaring that economists cannot shy away from analysis, however speculative and conjectural it might be, if they are to contribute to the setting up of correct priorities in research and the framing of socio-economic policies for deriving full benefit from, and adjusting to, these new developments.

Dr Peacock highlights the enormous potential of modern biotechnology for the future of agriculture and provides insights sufficient to stimulate speculative thinking on its possible socio-economic consequences. The experience of

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green revolution technology, based on hard data, provides the necessary building-blocks for such exercises to become constructive and useful.

The main techniques of genetic engineering enable improvements to be achieved in the nutritive value of existing products, or the introduction of entirely new products of higher nutritive value. The suitability of legume seeds or of leaf material for animal feeds can also be substantially enhanced. Apart from quality improvement there is also scope for increasing physical yields. Although the achievements so far are limited to cereals such as wheat and barley, methods have recently been developed which show promise in the case of rice and maize, which are particularly important in poorer parts of the world.

Genetic manipulation of plants will close the gap between actual and potential yields by providing more robust resistance to pests and diseases. In addition, changes in genetic characteristics will result in plants able to cope with abiotic stress from adverse soil and climate conditions. It is thus possible to modify the physiological responses of plants to environmental stresses and to modify their architecture so as to promote their use as complementary partners in production systems involving intensive double-cropping. The biochemical constitution of products can also be changed to fit the requirements of storage, marketing and processing. For example, anti-sense technology has already been used in modifying tomato genetics to improve storage and ripening qualities.

In view of the significant potential of biotechnology the introduction of genetically engineered plants in agriculture now depends more on legislation and social and economic acceptability than on limitations in science itself. Perhaps the most important feature of biotechnology which distinguishes it from the 'seed fertilizer' green revolution package is the possible saving which it might bring in chemical inputs, including pesticides. Dr Peacock did not deal with the potential of bio-fertilizers and biological fixation of nitrogen, though my own view is that genetic engineering could be important in replacing the 'chemicalization' associated with the green revolution. 'Seed' becomes central to biotechnology.

Through new plants having better capability to withstand biotic and abiotic stress, biotechnology will impart stability to crop yields, close the gap between actual and potential yields by reducing crop losses, and enable wider geographical coverage to occur when compared to green revolution technology which is often suited only to agro-climatically favoured areas. Because there is likely to be time saving in the engineering of new seeds when compared with the evolution of strains through traditional plant-breeding methods, the rate of technological advance is likely to be quite fast. Usually when technical change is rapid the rate of obsolescence is also likely to be high in quite a few cases. Hence biotechnology will be knowledge- and skill-intensive, necessitating greater investments in research and a need to improve the capabilities of farmers. There are a number of potentially important socio-economic consequences stemming from the new developments.

Food security

Ceilings on yields have been reached in most of the favourable areas affected by the green revolution, and prospects for further growth have become bleak except where heavy investment has been provided in infrastructure in new areas. Given high rates of growth in population in many less developed countries, the threat of their becoming heavy importers of foodgrains in the near future looms large. The new tools of biotechnology offer significant possibilities for breaking these yield barriers and overcoming food and population imbalance. A significant decline in the relative price of foodgrains, given greater food security, would be a most important outcome. However, there is one difficulty. It may not be possible to ensure access to food through the generation of employment and purchasing power for a growing agricultural labour force. Some recent evidence suggests that, although the absolute income of labour may rise, its relative share may decline steeply on account of much higher increases in returns to fixed resources such as land (Ahmed, 1989). The experience of the green revolution also cautions us against expecting higher labour absorption within agriculture in the wake of the bio-revolution. Therefore maintaining access to food through general employment generation has to become a major concern of overall development strategy.

Stability

Owing to its need for controlled irrigation and its vulnerability to pests and diseases, seed-fertilizer technology resulted in higher yield variability, particularly in the case of crops grown in less favourable agro-climatic conditions. By imparting stability to crop yields biotechnologies can be expected to raise the investment incentives for small farmers who are deficient in resources and risk-averse. Farm labour would experience more stable incomes because of the reduction in annual variability in farm employment. More stable yields would also reduce costs of storage and distribution and thus strengthen national food management systems.

Productivity

There will be significant savings of conventional resource inputs of land, labour and capital. However, these gains will depend crucially on access to knowledge and skills. Therefore investment in basic and applied research, and in farm extension work and education, will be required.

Equity

Biotechnology could have a pro-poor bias arising from scale neutrality at the farm level, saving on chemical inputs, stability in yields, and improved prospects for crops grown in less favoured areas. However, the realization of pro-poor potential depends on research priorities. Biotechnology presents a wide range of options which could be slanted to suit entrenched interests rather than favouring the poor. The classic example is the choice between pest-resistant versus pesticide-resistant types of seed. The former can be pro-poor as well as environmentally sound because of savings in pesticide costs, whereas the latter can promote the interests of multinationals supplying pesticides (Ruivenkamp, 1988). The advanced research capacities of the developed countries could also be harnessed to developing import substitutes, displacing the products of less developed countries (Panchamukhi and Kumar, 1988).

Sustainability

In many of the less developed countries, at their present stage of development, damage to the environment arises not so much out of the extent to which chemicals are used in farming as from the extension of cultivation to marginal lands, and the prevalence of widespread poverty which causes undue pressure for the poor to clear forests to augment their incomes (Rao, 1990). Biotechnology could contribute immensely to sustainability through the protection and regeneration of the environment, partly from reduction in chemical inputs, but more significantly by raising yields and thus releasing marginal lands from cultivation. Large-scale afforestation could also be facilitated through using tissue culture techniques.

Realization of gains depends on research and policy orientation. Here there are three points to consider.

Research

The high flexibility of biotechnology enhances the importance of choice in research strategy. The role of governments of developing countries in framing priorities appears to be even more essential than in the case of green revolution technology. Since so much of the area under crops is located in unfavourable environments, it may be desirable, from the point of view of growth as well as of equity, to invest in techniques suited to them. There is likely to be a high return to such investment since the gap between actual and potential yields is quite high in unfavourable areas (Widawsky and O'Toole, 1990).

Policy

The distribution of gains will depend on access to new inputs and new knowledge, particularly among smaller farmers and in lagging regions. Public intervention to strengthen the capabilities of disadvantaged groups and to provide critical inputs and services will be essential for the equitable sharing of benefits. It will also be necessary to safeguard the interest of private sector entrepreneurs, among other things by formulating norms regarding access, sharing and utilization of germ-plasms for crop improvement by participants.

The role of economists

Because of the wide range of options opened up by biotechnologies there is great room for economists and social scientists to contribute to the evolution of appropriate techniques. Economists have so far been engaged mainly in *ex post* analysis relating to the consequences of adoption of seed-fertilizer technology, and their contributions towards the evolution of appropriate methods, in collaboration with agricultural scientists, at the policy-making level have been rather limited. It is therefore necessary to initiate collaborative ventures to bring agricultural economists and agricultural scientists together in shaping technology policy.

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DISCUSSION OPENING : A COMMENT FROM THE PERSPECTIVE OF DEVELOPED COUNTRIES – CORNELIS L.J.VAN DER MEER*

Introduction

Modern biotechnology makes headlines.[1] It occupies a significant share of the columns of journals and magazines. It receives huge research budgets from governments and private business. It is regularly on the agenda of politicians, research administrators, interest groups and professional organizations. It arouses heated debates about its possible benefits, its risks, its impact on economy and society, and its ethical aspects. Some people see it as a likely bonanza, others as an alchemist's dream and some fear it is Pandora's box. Some have great expectations of the spread of benefits of biotechnology,

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others fear that it will enhance dictatorship by technocrats and monopolistic power of multinational corporations. Biotechnology may provide great opportunities for agriculture, though sceptics expect it to result in agriculture becoming a dependent part of big agro-chemical, pharmaceutical and food-processing companies. Obviously such issues make headlines. This comment examines the potential impact of biotechnology on the structure of agriculture and related sectors in the next 10 to 20 years.

Assessing the impact of biotechnology on structural change

Agricultural sectors in developed economies have experienced tremendous structural change over the past century, in particular in the period since the Second World War. Many factors have contributed to that change and there is no reason to expect that trends will alter drastically in the next 10 to 20 years, even without biotechnology. The question of impact concerns the extent to which it will affect the process of change. This requires an assessment of alternative scenarios.

The concept of the 'structure of agriculture' refers to such issues as the relation of factors of production within farms, the size distribution of farms, their characteristics of production and productivity, and their relations with supplying and processing sectors. Alterations in structure are the outcome of many factors such as technical change, social and institutional development and the effects of shifts in the price structure. Productivity is also closely related to changes in structure. Trends in agriculture over the past decades can be characterized as follows.[2] Since the Second World War, labour productivity in the agricultural sectors of developed countries, with the notable exception of Japan, has increased more rapidly than in industry and services (Van der Meer and Yamada, 1990). In general this has also been true of net factor productivity. Since demand for agricultural products grew only slowly the agricultural sector exhibited a persistent tendency towards excess capacity and excess production, and faced pressure on prices and income. In many cases, price support given by governments to mitigate the depressing effect on incomes resulted in over-production. The major factor contributing to total productivity growth was the rapid decline of labour input. Although agricultural research is mainly devoted to achieving yield increases and biological efficiency, the effect of these improvements on total productivity is usually much less than that of the decline in volume of labour. Despite its rapid development, the agricultural sector still largely consists of small independent farms, operated by a farm family working alone or at most employing only a few paid labourers. Farm sizes have increased, but only the biggest 10–20 per cent of farms achieve economies of scale. Although farms are small, and are often engaged in some form of contract farming, they still have a great deal of freedom in their choices.

An assessment of the impact of biotechnology on these characteristics and trends is difficult to give. There are often conflicting expectations and speculations about technical possibilities, and assessment of the likely economic and structural impact is even more complex. It is, after all, the producer and the consumer who will decide. Economists are better at explaining the past than at predicting the future. So what can economists contribute to all the claims about biotechnology? One useful contribution can be to discuss biotechnology in the light of experiences with technological change, growth of output and productivity and structural change in agriculture, and to make conditional statements about the possible impact on present trends. Attention should also be paid not only to direct effects on the structure of agriculture by applications of biotechnology in the sector itself, but also to indirect effects which can result from applications within research and development programmes and within input-supplying and product-processing industries.

Impact of biotechnology in research and development

Biotechnology is a generic term, which means that it has a large number of possible applications in many fields. When genetic codes were deciphered and techniques for modifying genetic properties developed it was very useful to bring this kind of research together in special programmes, but gradually applications have become integrated within other research activities. This implies, for example, that knowledge of genetic codes accelerates and enhances effectiveness of traditional breeding programmes. Similarly, it may help all kinds of research by developing better detection methods. In other words, a new set of tools has been added to those already available to researchers. On the other hand, by its very nature, research and development in the field of biotechnology requires a fairly advanced general research infrastructure. If such a broad base is not available, research in biotechnology is probably rather ineffective and inefficient.

All this has two implications. First, it means that biotechnology is not an appropriate technology for countries that have not yet built up a good research system. Second, since it can only properly function jointly with other research, the estimation of the return to investment in biotechnology as such is difficult to isolate and in most cases therefore over-stated by its proponents.

Impact of applications within agriculture

How should the techniques that together form biotechnology be characterized from the point of view of agriculture? In the literature of agricultural development a distinction is usually made between land- and labour-saving technologies. The former consist largely of biological and chemical techniques and the latter mainly of mechanical techniques. Although in practice a clear-cut distinction is not always possible, since some techniques exhibit characteristics of both, the distinction is important for conceptual reasons. Green revolution technologies, involving use of high-yielding varieties, fertilizers and water control, are typically land-saving. Tractorization is an example of labour-saving innovation. Comparative research shows that land-saving technologies are most important in situations of land scarcity and at a lower level of economic development, whereas labour-saving technologies are important in land-abundant and labour-scarce situations and in advanced economies (Hayami and Ruttan,1985). In general, land-saving technologies are scale-neutral, whereas labour-saving technologies are characterized by economies of scale. Both types of techniques are to some extent embodied in purchased inputs, but they usually require farmers' knowledge for successful application. This knowledge can be obtained from other farmers, extension workers or from education.

Biotechnology that can sooner or later be applied in agriculture seems to be a typical example of biological and chemical techniques; modified properties of products, resistance against diseases and better technical input–output relations. They are not likely to generate significant economies of scale. From this perspective, therefore, no change in the pattern of agricultural development is likely. However, the possible impact of biotechnology does not only depend on the characteristics of the technologies but also on the pace and the intensity with which they are becoming available.

Although biotechnology applications are likely to become more important in the next 20 years it seems unlikely that they will exert a strong effect on the pace of technical change. There are several reasons for this. First, the commercially viable bio-techniques are emerging slowly because of technical and financial obstacles. For most products it may take quite some time before genetically modified and commercially attractive varieties become available. This is a general experience with generic technologies, from the development of electricity to the beginnings of information technology (OECD, 1989, ch. III). The diffusion of genetically modified varieties in agriculture is likely to take quite some time as well. Genetic modification of micro-organisms is technically easiest and therefore likely to result in significant applications first, though these will be made mainly in industry, not in agriculture. Genetically modified plants will have more impact on agriculture but developments in this field are slower because of technical difficulties. Applications of biotechnology on animals are still more complicated than on plants.

Second, in several cases biotechnology applications may be technically possible but still less cost-effective than traditional breeding techniques. Third, if the present GATT negotiations result in liberalization of markets and decoupled income support, then in most of the developed countries prices will decline. This will make yield-increasing technologies less attractive and probably slow down the pace of land-saving technological change in countries that have at present relatively high price levels. Fourth, there are risks and uncertainties about safety of applications for health and environment, which can probably be dealt with, but which will initially increase costs and result in lengthy and sometimes complicated procedures for admission.

Fifth, opposition to biotechnology seems firmly rooted in different groups. There are ethical questions about its applications, in particular for animals. Among some fundamental Christian groups, the ethical belief is widespread that genetic manipulation is perhaps not within the range of acceptable activities involving nature and life. Among ecologists and environmental groups, many see biotechnology as a dangerous and undesirable set of tools which should not be used. Among political activist groups on the left, there is also opposition, which can perhaps best be understood as a continuation of an ageold movement against capitalist development and the role of technology in a capitalist world.[3] Since the industrial revolution there have been continuous objections against new techniques. In most cases in recent history, however, ethical and political objections gradually disappeared or were overruled. This may also turn out to be the case with biotechnology, but it is also possible that strong opposition will remain. In this respect there are likely to be significant differences between countries, such as is already the case between countries in south and north-west Europe.

Sixth, consumer acceptance, which is partly related to the two previous points, is still far from certain. The attitude of consumers towards food has changed significantly during the past decades. If, for example, products have to be labelled, some of them may receive discounted prices, which would partly offset potential productivity benefits for producers.

Many uncertainties are evident and may result in significant setbacks in the rate of adoption of biotechnology. Even if everything is going smoothly the rate of application of biotechnology within agriculture may still be slow in the next 10 to 20 years. The net benefit of applications is the difference between value added in the with and without cases. In practice benefits seem often to be much over-estimated. Claims by biotechnology lobbies are sometimes exaggerated in the sense that they suggest high market shares for biotechnological products and incorrectly equate the net benefits to the share in value of production. Moreover, as argued already, increases in total productivity are more dependent on decreases in labour input than on biological efficiency. So, from an economic point of view, it seems realistic to have only moderate expectations about the net economic benefits of biotechnology in agriculture in the next two decades.

Impact of applications in input-supplying industries

Agriculture obtains considerable amounts of input from supplying industries. In developed countries this often amounts to more than 50 per cent of total value of production. The quality and price of inputs are crucial factors for international competitiveness of the agricultural sector. However, biotechnology is mainly applied in pharmaceutics, plant breeding and propagation and animal breeding,[4] and it follows that the relevant inputs account for only a modest share of the total input in farming. Nevertheless, there is much concern that agriculture will become increasingly dependent on a few multinational corporations in this field, because of the increasing role of concentration, patents and plant breeders' rights. It is true that, since the middle of the 1970s, there have been many mergers among seed companies. This development was related to the increasing economies of scale in this activity as well as to the fact that the oil crises in the 1970s stimulated interest in utilizing renewable resources, not least among oil companies. However, the prospects for producing bio-energy and developing non-food applications are now much reduced and returns have been below expectations. In one recent case in the Netherlands, an oil company sold a seed company to an agricultural cooperative and informed sources claim that this is not an isolated case.

Still there is a persistent strong concern among farmers, and in particular among Third World activists and radical groups on the left, that farmers and Third World countries are becoming dependent on breeders' rights and patents and that they may be exploited by multinational companies. These groups have little confidence in the role of competition or in countervailing power. There is certainly over-sensitivity with respect to seed companies. The argument is not advanced by pointing to the fact that the world market for chicken supply for production of layers and broilers is served by scarcely a dozen companies, that four-wheel tractors are supplied by even fewer, and that there are also few pharmaceutical companies left. The present sentiments about dependence on seed companies seem to be a continuation of those voiced by similar groups with respect to the green revolution. Not rarely in debates they still refer to 'the failure of the green revolution' when talking about the possible adverse effects for farmers of applications of biotechnology by seed companies.

Impact of applications in processing industries

In the processing industry, biotechnology is likely to be applied on a significant scale, both in food production and in non-food applications. In processing of agricultural products two developments that are already taking place could be accelerated by biotechnology. First, there is a trend for farmers to be encouraged to produce certain products under carefully specified conditions. This has resulted in various forms of sub-contracting. Diversification in consumer markets partly results in diversification of demand for raw materials. Some people, and in particular those critical groups mentioned above, believe that such developments will make farmers more and more dependent on big companies and that the application of biotechnology will strengthen this trend. Second, industries are continuously looking for possibilities to substitute cheap for expensive raw materials and they have been successful in doing so. It is assumed that biotechnology will enhance this process. This is often marked down as a negative impact of biotechnology, since it forces agriculture to compete with synthetics and also introduces competition among groups of farmers who previously produced for separate markets. It is believed that, as a conseqence, total value added will decrease. Artificial sweeteners and substitutes of vegetable origin for dairy products are the most common examples.

Although changes in the processing industries induced by applications of biotechnology can have adverse effects for particular groups, there are offsetting positive effects, hence the view which stresses negative effects only is rather superficial and biased. It ignores the consumers' interests, it fails to see the relation between substitution and protection in the sugar and dairy markets and it narrowly focuses on some selected effects of some processes without considering the wider impact of processes of technological change and economic development. One particular future contribution of biotechnology to the competitiveness of agriculture could be that plants and animals become new, or more attractive, sources of special chemicals, or that their products are better processed. Such developments could enhance the competitiveness of some branches of a more differentiated agriculture.

The dependence of farmers cannot be properly understood unless the dependence of processing industries is taken into consideration as well. Once processing industries have invested in specific products they require a reliable supply of raw materials of good quality. So there is usually a mutual dependence of farmers and processors, which is likely to become of increasing importance for the competitiveness of agriculture. Indeed, it is very probable that traditional bulk-producing farmers are more dependent on powerful outsiders than well-educated and properly organized groups of modern farmers.

NOTES

[1]Some definitions of biotechnology are very broad and include all traditional uses of biological processes. In this paper a more narrow definition is applied. Here 'biotechnology' refers to the collection of techniques which use knowledge of genetic codes and genetic modification, in particular by recombinant DNA techniques and cell fusion.

[2]For a detailed discussion of growth and development in agriculture see Van der Meer and Yamada (1990) and Van der Meer (1983 and 1989).

[3]From an economic point of view an interesting review is found in Kitching (1982). Van der Pot (1985) has given a broad overview of schools of thought from a philosophical perspective.

[4]To some extent it is applied in the feed industry as well. In the Netherlands, additives are used to reduce the phosphate content in compound feed in order to reduce environmental problems in areas with intensive livestock raising.

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DISCUSSION OPENING : A COMMENT FROM THE PERSPECTIVE OF INTERNATIONAL AGRICULTURAL RESEARCH CENTRES – RANDOLPH BARKER*

I have been asked to comment on the paper by Dr Peacock from the perspective of the International Agricultural Research Centres (IARCs). As a current member of the Board of Trustees of the International Institute of Tropical Agriculture (IITA) in Nigeria and a former Head of Economics at the International Rice Research Institute (IRRI) in the Philippines, I have had occasion to be concerned about priorities in research, particularly between biotechnology and other activities.

The organization of the Conference programme has allowed us to consider some of the invited paper material before our plenary session. Yesterday we heard an invited paper by Collinson and Wright on 'Biotechnology and the International Agricultural Research Centres of the CGIAR' and the very interesting discussion which followed by Dr Evenson and others. My comments will attempt to provide continuity between today's presentation and yesterday's discussion.

The key issue raised by Dr Evenson is why, given the potentially high payoff of investment in biotechnology described in Dr Peacock's paper, the Consultative Group on International Agricultural Research (CGIAR) had committed so few resources to biotechnology research. As Collinson and Wright indicated, research priorities at the IARCs are demand-driven. But I believe that research priorities (or demand) are primarily determined by the donors to the CGIAR. Collinson and Wright suggest that the CGIAR wants to strengthen research capacity in resource management and environment. However, the budgets for the IARCs have been steady or declining in the past several years. Thus the new priorities of the CGIAR can only be achieved by a reduction of capacity in traditional agricultural sciences. This has a direct bearing on the capacity to transfer biotechnology to developing countries. Without strong programmes in traditional agricultural sciences such as plant breeding, this capacity will be greatly reduced. Meanwhile, at the national level, the donors to the developing countries are busy transferring external resources for research from ministries of agriculture to ministries of environment or natural resources, again reflecting the priorities of the developed, not the developing, countries.

At IITA we are beginning to develop an applied biotechnology capacity. We have a link with Purdue University for biotechnology on cowpeas and with George Washington University (and indirectly Monsanto Chemical Company) for research on the cassava mosaic virus. We are also receiving financial and technical support from the Italian government for our biotechnology programme. We have one of the handful of laboratories in Africa capable of training scientists in applied biotechnology research, not the capacity to do recombinant DNA that Dr Peacock suggests, but simpler techniques such as tissue culture, embryo rescue and use of gene markers. Work on DNA transfer must be done in the advanced laboratories in the developed countries. Mean-

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while, with these simple techniques, progress has been made at IITA in identifying varieties resistant to one of the most serious fungus diseases in plantain, black sigatoga.

The IARCs current involvement with biotechnology will expand in the future. A recent evaluation of international biotechnology efforts recommended that the IARCs consider undertaking the following initiatives (Plucknett *et al.*, 1989; Barker and Plucknett, 1991):

(1) Identify and transfer high-priority technologies to developing countries. This would involve the centres in helping to determine the needs and abilities of their national programme partners and to ensure the transfer of high-priority technologies.

(2) Explore opportunities for establishing commercial relations with private industry. This could operate in a way similar to that used by universities for the receipts of royalty payments. It could generate an additional source of core funding to the centres. It should be emphasized, however, that the first responsibility of the public funded IARCs is to ensure widespread access to the technology. Formal links with the private sector that establish priority rights to the technology may be in conflict with these goals.

(3) Establish institutional biosafety committees (IBCs) to coordinate the safe use and development of technologies in international research. Each IBC could coordinate testing with host-country approved mechanisms, as well as with current regulatory standards adopted by the developed countries.

(4) Establish a standing group of experts to deal with the role of biotechnology in world agriculture. While each centre is capable of determining its own course, active dialogue with the group of experts should help each institution make better decisions. The IARCs do not now have the capacity to undertake all of the above activities. At IITA, for example, there are only two scientists dedicated full-time to biotechnology research. The pace of growth in research capacity in biotechnology at IARCs will be determined in large measure by the price of the major foodgrains and by the demonstrated capacity of biotechnology to raise agricultural productivity. With foodgrain prices at low levels, the donors to the CGIAR will continue to give priority to research on the environment and management of natural resources, as opposed to research designed to raise agricultural productivity. Whether or not this proves to be short-sighted only time will tell.

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