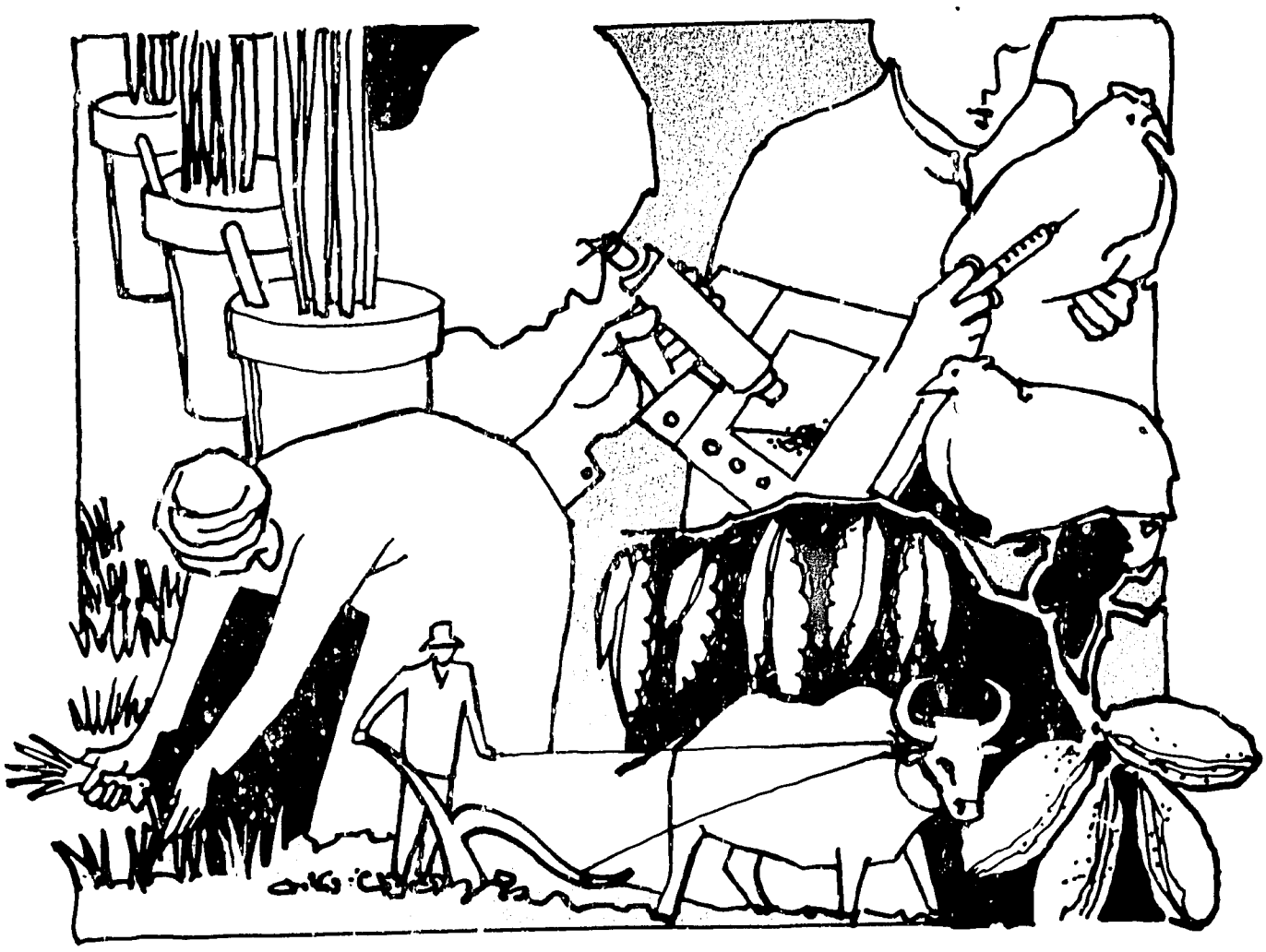
Consultative Group on International Agricultural Research

Study Paper Number 24

Partners in Research

The CGIAR in Latin America

Grant M. Scobie



Partners in Research

CGIAR Study Papers

No. 1 Technological Innovation in Agriculture: The Political Economy of Its Rate and Bias

No. 2 Modern Varieties, International Agricultural Research, and the Poor

No. 3 Plant Genetic Resources: The Impact of the International Agricultural Research Centers

No. 4 Costa Rica and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 5 Guatemala and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 6 Zimbabwe and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 7 Nepal and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 8 Bangladesh and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 9 Brazil and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 10 Indonesia and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 11 Ecuador and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 12 Peru and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 13 Syria and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 14 Cuba and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 15 Philippines and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 16 Thailand and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 17 Gender-Related Impacts and the Work of the International Agricultural Research Centers

No. 18 India and the International Crops Research Institute for the Semi-Arid Tropics: A Study of Their Collaboration in Agricultural Research

No. 19 Burma and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 20 Chile and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

No. 21 The Impact of Agricultural Research in Tropical Africa: A Study of the Collaboration between the International and National Research Systems

No. 22 The International Agricultural Research Centers: Their Impact on Spending for National Agricultural Research and Extension

No. 23 Burkina Faso and the CGIAR Centers: A Study of Their Collaboration in Agricultural Research

Also of related interest

Warren C. Baum, *Partners against Hunger: The Consultative Group on International Agricultural Research*

Jock R. Anderson, Robert W. Herdt, and Grant M. Scobie, *Science and Food: The CGIAR and Its Partners (forthcoming winter 1987–88)*

1985 Annual Report of the Consultative Group on International Agricultural Research

111

Consultative Group on International Agricultural Research

CGIAR

Study Paper Number 24

Partners in Research

The CGIAR in Latin America

Grant M. Scobie

The World Bank
Washington, D.C.

At its annual meeting in November 1983 the Consultative Group on International Agricultural Research (CGIAR) commissioned a wide-ranging impact study of the results of the activities of the international agricultural research organizations under its sponsorship. An Advisory Committee was appointed to oversee the study and to present the principal findings at the annual meeetings of the CGIAR in October 1985. The impact study director was given responsibility for preparing the main report and commissioning a series of papers on particular research issues and on the work of the centers in selected countries. This paper is one of that series.

The judgments expressed herein are those of the author(s). They do not necessarily reflect the views of the World Bank, of affiliated organizations, including the CGIAR Secretariat, of the international agricultural research centers supported by the CGIAR, of the donors to the CGIAR, or of any individual acting on their behalf. Staff of many national and international organizations provided valued information, but neither they nor their institutions are responsible for the views expressed in this paper. Neither are the views necessarily consistent with those expressed in the main and summary reports, and they should not be attributed to the Advisory Committee or the study director.

This paper has been prepared and published informally in order to share the information with the least possible delay.

Grant M. Scobie is the director of Scobie Economic Research, a private consulting company based in Hamilton, New Zealand.

Library of Congress Cataloging-in-Publication Data

Scobie, Grant McDonald.
Partners in research.

(CGIAR study paper, ISSN 0257-3148 ; no. 24)
Bibliography: p.
1. Agriculture--Economic aspects--Research--Latin America. 2. Consultative Group on International Agricultural Research. I. Title. II. Series: Study paper (Consultative Group on International Agricultural Research) ; no. 24.
HD1410.6.L29S36 1987 338.1'098 87-34658
ISBN 0-8213-0991-9

ABSTRACT

After decades of neglect, the agricultural sector in many countries of Latin America is receiving renewed attention. Trade and exchange rate policies, which have traditionally taxed the sector, are being recast to encourage growth, raise levels of employment, and increase export earnings. In addition, public research expenditures doubled between 1970 and 1980, although the economic pressures of the 1980s have slowed that progress. Private funding has played an increasingly important role as well. The establishment and consolidation in Latin America of three international centers funded through the Consultative Group on International Agricultural Research (CGIAR) account for a small but significant part of the growth in agricultural research. The importance of the centers lies not in the additional funding they bring, but rather in their collaboration with national research programs. There is increasing evidence that these centers have helped to expand the capacity of many national programs, especially in the numerous smaller countries. Their sustained funding, apolitical nature, and international scientific linkages have added an important dimension to the region's own enhanced capacity for agricultural research. The accelerated growth in the yields and output of staple foods in Latin America achieved over the past decade is striking testimony to the strengthened national research programs which are receiving, testing, adapting, and releasing technologies developed through their collaboration with international centers.

CONTENTS

1 INTRODUCTION

After decades of being relegated to a secondary role in the economic development of many countries in Latin America and the Caribbean, the agricultural sector is now being viewed in a new light. It is increasingly recognized that the trade and exchange rate regimes which have been pursued have implicitly placed a heavy tax on agriculture. The slow growth of employment, the uneven and hesitant improvement in agricultural productivity, the demands on domestic food supplies of an expanding population, and the pressure on both internal and external balances of food subsidies and rising imports have all served to focus renewed attention on the tradable goods sector in general, and agriculture in particular.

Together with some shift in policies toward those less discriminatory to the agricultural sector, has come a greater awareness of the role of research as an investment whose return comes through enhanced agricultural productivity. A direct consequence of this has been a marked increase in the overall level of investment in research in Latin America. This increase has come from private funding, from national programs, and from foreign grants and loans, multilateral as well as bilateral. A small but important part of this growth has been the establishment of an international network of research institutes funded through the Consultative Group on International Agricultural Research (CGIAR); three of the longest established of these centers are based in Latin America (CIMMYT, CIAT, and CIP).

The importance of these centers lies not in the additional funds they bring to the total agricultural research effort of the region; in fact their combined core budgets are a small share of that total. Rather their contribution stems from their unique structure, funding and global perspective. While it will be shown that these unique features have resulted in a significant strengthening of the entire global research system, many of the contributions of the centers are both novel and not necessarily readily apparent.

An appreciation of their nature and purpose, together with continual monitoring of their performance is needed if sustained support for the centers is to be forthcoming from a wide range of donors. Almost all these donors must answer to their political constituencies and be prepared to demonstrate that the value of the funds assigned to the CGIAR is at least equal to the benefits that direct bilateral funding of national research programs could generate. The continued growth and complexity of the international centers has made this a far from trivial task. It is perhaps for this reason that the system has been repeatedly scrutinised and is subject to more planning, reviews and reporting per dollar of research effort than any other national or international research system.

The pivotal feature of the international centers is their collaborative links with the national research programs in the individual countries. The objective of this paper is to review the role, relationships and results of that collaboration in Latin America based on recently completed reviews that sought to assess the progress of this collaborative arrangement (Homen de Melo 1985, Martin del Campo 1985, Muchnik 1985, Posada 1986, Sanchez and Scobie 1986, Stewart 1985a, 1985b, Venezian 1986). The paper is in three parts. In the first I elaborate on the policy setting and the evolution of the agricultural sector in Latin America, and provide a broad statement of the place of the CGIAR in the overall agricultural research effort of Latin America. In the second part I address the results, the strengths and the limitations of the collaboration of national programs in Latin America with the CGIAR. In attempting this assessment I will endeavour to synthesize information from a number of sources, not solely the CGIAR review. The concluding section focuses on some issues for the future.

2 THE SETTING

2.1 Agricultural Research and Economic Development

The development policies adopted in many countries in the post war period were largely directed toward a narrow focus of maximizing the growth of GDP. Since the mid sixties there has been a marked change in this emphasis. This change is reflected in both the mix of the investment portfolios aimed at economic growth, and in the sectoral emphasis of development policies. While in the earlier period great stress was laid on large scale infrastructural investment, recent years have witnessed greater awareness of the role of human capital. Widespread gains in real welfare depend not only on the deepening of a country's physical capital but also on the productivity of its people as manifested through their nutrition, health, longevity and education. Together with this increased recognition of the nature and importance of human capital has come a reassessment of the place of agriculture and the role of research in agricultural development.

In the absence of technological change, discrimination against agriculture implicit in import replacing policies will lead to stagnation in the output of food. The resultant pressure on food prices reinforced by high population growth and migration to urban centers in search of employment will create a political climate for some form of price ceilings or subsidies. It is indeed rare to find such a scheme that has not had a disincentive effect on food production. Some compensatory policies then follow to try, through cheap inputs or credit, to stimulate the flagging farm sector.

The result is a complex series of successive layers of distortions each having its rationale in the existence of other policies, and each contributing to the circumstances which perpetuate the need for them. Subsidies add pressure to the internal balance and extra food imports (or reduced exports) add pressure to the external balance, both forces having macro-economic consequences extending far beyond the food sector.

2.2 Food Production and Imports in Latin America

The growth rates of production in major food crops over the last 25 years in Latin America has been consistently better than in most other regions among the developing countries. From 1962-72 total food production grew at a rate of 4.2% in Latin America, compared to 3% over all developing countries. In the following decade the Latin American growth rate was equal to the overall average. In the sixties growth in yields per hectare accounted for 35% of the increased output, while in the seventies this contribution had risen to over 60%.

The growth rates in food output have been sufficiently rapid to allow an increase in output per capita. In fact food production per capita rose at over 3% per year in the sixties and seventies, with a marked slowing in the early 1980s. Once again Latin America's performance has exceeded the overall growth in food output per capita.

This generally impressive record for Latin America does not, however constitute the base for any complacency. The average performance disguises an almost frightening diversity. This diversity is manifest across countries, across regions, across commodities and through time. Table 1 gives a flavour of the diversity by crop and region. Table 2 summarizes the growth of food production per capita in the countries of the region over three decades ending in 1984.

These results indicate a highly erratic pattern over time. Almost no countries have been able to consistently improve the level of food production per capita each decade. The data are characterized by wide swings, whereby a high relative growth in one period can be followed by a poor record in the next. The only exceptions are Brazil and Honduras. Civil and political upheavals, changes in world markets and climatic variability are surely part of the explanation. But it is clear that few countries can create an environment that is conducive to both the generation and adoption of technology in a sustained manner.

Growing incomes, greater urbanization, increased labor force participation by women, and population growth all combine to continually increase the demand for food. Overall, the growth of food consumption in Latin America has exceeded the growth of production for the last two decades. The difference has been met by a dramatic rise in food imports. This has resulted in a reversal of the trading pattern in basic food staples. In the 1960s, the region was a net food exporter; in the years 1961-65 nearly 4 million tons per year were exported. By 1978-80, this trade had become almost 4 million tons of net imports and the dependency on imported food is forecast to increase further by the end of the century. In the last two decades food imports have trebled in Central America and the Caribbean, doubling in upper South America. For the whole of the region, food imports rose at annual rate of over 7% between 1976 and 1984. Cereals and vegetable oils account for a very significant part of the rise in the food imports of Latin America.

2.3 Agricultural Research in Latin America

The history of research in Latin America goes back well over a century to the establishment of a number of early experimental farms many of which became the core of the modern research systems. Often the stimulus for their establishment was the need to address a problem in a specific crop.

A more systematic approach evolved in the period after World War II, and research divisions of Ministries were created with national scope. Commencing in the late 1950s a series of more autonomous, decentralized national research institutes were established and in most cases form the core of the public sector's investment in research today.

These institutes with their broad mandates and political constituency were able to command additional resources and grow at a rapid rate. In the 1960s public expenditure trebled in real terms. This growth coincided with the first real signs that the reliance on import substituting industrialization may not be a model for ensuring sustainable long term economic growth. Recurring crises in the balance of payments, stagnating export growth and, ironically greater not lesser dependence on imports all started to emerge as products of the trade and development regimes that had been so prevalent. Attempts at regional integration and free trade areas were

aimed at expanding the size of the market and rationalizing the pattern of industrial production.

The growing support for agricultural research can be viewed at least in part as an attempt to compensate for the implicit taxation of the sector by the trade and exchange rate regimes. The introduction of subsidized credit and tax incentives for export activities was further evidence of the concern for the role of agriculture. Growing unemployment and migration from the rural areas added additional weight to these concerns.

In addition to the need to offset the effect of discriminatory policies investment in research was also stimulated by the growing realization that extension efforts alone would not result in sustained growth in agricultural productivity. In 1959 there were 4.2 extension workers in tropical South America for every research scientist. By 1970 that ratio had been reduced to 2.8, as countries increasingly recognized the need to have a national research system which could generate and adapt technology to local circumstances. The scope for simply extending technology borrowed from foreign sources was much less promising than had earlier been thought.

As a consequence of these developments the growth of research funding has been remarkable (Table 3). While it is true that more recently the growth has slowed down and certainly the fluctuations in funding continue to be a serious handicap in some countries, Latin America has now built a system of research that equals that of any region of the developing world. Research spending on average ranges between 0.6 and 1.0 percent of the value of agricultural output (Table 4). In fact today over one third of the countries in Latin America invest between 1.0 and 1.5 percent of the value of output.

A sample of 67 countries was examined for 1980; 21 of these were from Latin America. These 21 countries, while constituting 31 per cent of the sample, had 48 percent of the total research funding of all developing countries. At the same time they included only 24 per cent of the scientists, indicating that the cost per scientist is higher in Latin America. In large part this reflects the greater investment in training; while the total number of scientists has risen so has the quality per scientist.

Despite the overall growth in the level of research funding, there are still great inequalities between commodities (Table 5). In general terms, the funding of research for basic food staples still lags well behind the funding for export and industrial crops. The fragmented and heterogeneous nature of the production systems for food crops has meant they lack the political base that characterizes crops such as sugar or cotton. The politically and socially more powerful and vocal sectors, both rural and urban, have influenced the direction of technological change in agriculture, and resulted in a pattern of institutions and funding in which some of the basic food staples remain underrepresented.

It is now widely accepted that research is a form of capital investment, which like any other form implies the foregoing of current consumption with the expectation of greater future levels of real income. Research contributes to the stock of knowledge which is as much a part of the stock of resources in any country as the physical stock of capital. But both the generation and adoption of new technologies which result from that expanded stock of knowledge involve significant lags. These lags can easily be of the order of a decade or more.

Evidence of both the impact of the increased research spending and the lag is beginning now to emerge. Seventeen countries from Latin America have been grouped according to their spending on research (Table 6). During the decade 1963 to 1973, there was no perceptible difference in the growth of their agriculture sectors, regardless of the level of spending on research. It was during this period that research expenditures were growing rapidly but much of the research was in the investment phase. The payoff was to come later. In the decade ending 1984, the growth of agricultural output was nearly 30 percent greater in the countries with high levels of research investment compared to the low group. Furthermore among the high research countries, the growth of output accelerated in the 1970s relative to the 1960s. In contrast, agricultural output fell in the group of countries characterized by low levels of research. While there is clearly no presumption that the level of research spending is the only determinant of agricultural growth, the evidence now accumulating from both within and outside Latin America leaves little doubt that a strong, dynamic agricultural

sector is unlikely to emerge where research systems are weak and poorly funded.

2.4 The CGIAR in Latin America

By the late 1950s, it was becoming increasingly clear that agricultural productivity could not be raised by technical assistance and community development programs. Agricultural development efforts relying solely on the technology transfer model had rarely resulted in sustained growth in output or productivity. As technology tends to be fairly location specific, there were narrow limits on the benefits to be gained from the direct transfer of technology from developed to developing countries.

However, at the same time there had been other moves to enhance the growth of productivity through the evolution of different institutional arrangements. In a number of tropical crops including rubber, sugar, pineapples, tea and sisal, research institutes had evolved to facilitate both the international transfer of technology and to ensure its adaptation to particular environments. Another important strand was the experience of the Rockefeller Foundation in its collaborative program in Mexico, dating from 1943. The combination of a limited number of expatriate specialists, a staff of motivated national scientists, adequate support services and a clear commodity focus laid the ground for a subsequent contribution to world food production almost certainly unparalleled in history.

This experience formed the basis of subsequent collaboration with the Ford Foundation in the establishment of the International Rice Research Institute in 1959. This model was followed with the creation of CIMMYT in 1963, the first of the international centers in Latin America. Further collaborative efforts saw the establishment of CIAT in 1968.

By now the potential was realized for building a network of international research institutes, although this would clearly require a broader base of funding than the foundations alone could provide. Through the joint sponsorship effort of IBRD, FAO and UNDP, the Consultative Group on International Agricultural Research was formed in 1971 - arguably one of the most significant steps this century in the evolution of new mechanisms for the

global support and funding of agricultural research. Under the auspices of the CGIAR, the International Potato Center (CIP) was formed in 1972, completing the present day structure of three centers based in Latin America.

Despite the growth in the system from 4 centers in 1971 with a budget of $US 20m., to a network today of 13 centers and a budget of $US 185m., the CGIAR represents only a tiny fraction of the total resources for development assistance or for agricultural research. The CGIAR budget is about 2 percent of all official development expenditure for agriculture, and about 2 percent of global agricultural research investment. It represents about 5 percent of the total spent on agricultural research in the developing countries, although because of its limited focus on food crops this proportion is much higher in some commodities (eg., wheat 4%, rice 7%, maize and beans 11%, cassava 15%, and potatoes 21%).

The three international centers in Latin America currently have a combined core budget of $54m. This represents less than 6 percent of expenditures on agricultural research and extension by national governments in the region. In fact, the national programs in Argentina, Brazil and Mexico are greater than the entire CGIAR budget for the global system on centers.

In 1983, about 20 percent of the total CGIAR budget, or some $37.7m., was directed toward Latin America (Table 7). As a result, the contributions of the IDB and the Latin American donor countries constitute almost 30 percent of the total effort of the international centers in Latin America.

While it is true that only part of the work of the three centers based in Latin America is actually addressed to Latin American agriculture, many of the other international centers have linkages with Latin America. The extent of this involvement of other parts of the CGIAR system with Latin America is probably not as widely known or understood. These linkages which take a variety of forms, have increased in importance over time, as the other international centers have matured and increasingly fulfilled their global mandates. Table 8 provides a measure of the contacts between the national programs in Latin America and all the international centers, both within and outside Latin America. In Central America and the Caribbean 29 percent of the contacts between national programs and the CGIAR centers are with those whose

base is outside the region; while in South America, 38 percent of the contacts with the centers are with those not based in Latin America. Clearly, the importance of the CGIAR in Latin America does not rest solely on the three centers based in Latin America. In fact, a very significant proportion of the contacts that national programs have with the centers, is with those from outside the region.

It should however be stressed that this contact with the other international centers is in many cases facilitated by the three centers in Latin America. Some of the other centers base staff in the Latin American centers in order to serve better the needs of the region; and the knowledge of the entire system by resident staff forms the basis of contacts between national programs and the centers located outside Latin America. The presence of a scientist from IRRI based at CIAT for example, enhances the access that CIAT's Latin American rice program has to the global stock of materials and information on which it can draw to address the problems of rice production in the region. The support of the Latin American centers by IDB contributes to this multiplier effect, whereby the national programs of Latin America have access not only to the work of these three centers, but to the entire global system of international centers.

3 THE RESULTS

This section draws on the findings of a major review of international centers sponsored by the CGIAR and conducted in 1984-85. This study, while conceived and executed as a review of the collaboration between national programs and the centers, has been widely referred to as "the impact study". Such a term raises the expectation that the results will provide an assessment of the impact of the centers.

The international centers however, were never conceived as independent entities, but rather a part of a global interrelated system for agricultural research. The very notion of seeking to identify the impact of the centers in isolation from their partner institutions, is a contradiction of the most fundamental premise of their very existence. Nowhere is this seen more clearly than in the selection, adaptation, screening, testing and release of new plant materials. This has always been viewed as the core of the activities of the international center; in fact to some, there has been an obsession with the yield per hectare of cereals, to the exclusion of the other many and varied products of the investment in the centers.

The entire process of the generation and successful diffusion of new plant materials is, however, one dependent on a host of collaborative linkages at every stage, from the identification and collection of materials, to the selection, screening, testing, multiplication, development of appropriate agronomic practices and diffusion to producers. To attribute the ultimate rise in food production to the investment in the centers would be to ignore the essential contributions of many other actors. Likewise, to ascribe automatically a sluggardly growth in production to the shortcomings of an international center, would be equally as inappropriate. In some cases the work of the centers may be a necessary input; but like the efforts of the partners, it is seldom if ever, sufficient.

From the outset the study was designed to cover a wide range of facets of the work of the centers, rather than limit itself to further documentation of

the spread of high yielding cereals. The role and contribution of the centers has become closely identified with this feature. This is a potentially dangerous perspective. In the first place notwithstanding the early successes attributed to the centers, it is a matter of debate whether their role, as distinct from the efforts of breeders in national programs was as pivotal as has often been portrayed. But be history as it may, undue focus on the rise in yields as a sole or even primary criterion for assessing the contribution of the centers can raise expectations about the nature and timing of technological advances in commodities other than wheat and rice which are simply not realistic.

The centers of the CGIAR system provide intermediate products which are used by national programs as inputs into their efforts to generate and diffuse new technologies relevant to the circumstances of their producers. Improved germplasm continues to be one of the important products of the centers, but it is far from the only one. Others relate to crop husbandry, protection, harvesting, storage and processing. Another set of products relates to increasing the capacity for research in national programs through the organization and management of research, the training of staff, the development of research techniques and the operation of experimental sites. Analysis of food and agricultural policies contribute to the public debate and decision making. It has become impossible to associate in any simple way the broad and growing range of activities of the centers with any one single objective.

With this in mind the goals against which the centers were measured were (a) to assist countries enhance their capacity to undertake research, and (b) to contribute, through their collaboration with national researchers, to increased food production and human welfare.

These goals provide the framework for the following discussion of the results. In the first instance a necessary condition for the centers to operate effectively is their linkages to the national programs (Section 3.1). Attention is then turned to the various contributions to the capacity of national programs through training, the flow of materials and information, the

funding of national research, and the formation of research networks (Sections 3.2 to 3.5). Finally, after consideration of the policy environment (Section 3.6), the implications for output and the economic and social consequences are addressed (Sections 3.7 to 3.9).

3.1 Linkages with National Programs in Latin America

As noted earlier, some 21 percent of the total core funding of the CGIAR system is directed toward Latin America. In order to quantify the extent of contacts between the centers and countries in the region, an index was constructed to capture both the various forms that contacts can take and to weight these by the intensity. A total score was computed for each region (Table 9). This shows that 18 countries in Central America and the Caribbean and 12 in South America captured 26 percent of the total country contacts made across the entire system. This is some 25 percent more than would have been expected on the basis of the distribution of funding alone.

In addition to the total score, the average index per country was calculated. Here it is found that there is a marked contrast between Central America and the Caribbean and South America. In the latter region the intensity of contact per country is well above the global average. In contrast, the larger number of small countries in Central America and the Caribbean have a significantly lower level of contact per country. There are simply major diseconomies of scale and the centers naturally have had a greater intensity of contact with the larger countries. This question of size is one that pervades all the results of the study.

A dramatic demonstration of the problems associated with scale is provided by the case of the cassava program at CIAT. Between 1977 and 1983, staff from the program made one visit to Brazil for each million tons produced, 13 visits per million tons in the rest of South America, and 109 visits per million tons to countries in Central America and the Caribbean. There are simply very high cost to servicing small programs.

In 1984 there were a total of 739 scientists in the centers, of which 189, or 26 percent were based in Latin America. Of these 159 were in the host countries of the centers (Mexico, Colombia and Peru), while another 30 were posted to other non-host countries (including Guatemala, Costa Rica, Panama, Ecuador, Brazil, Chile, and Argentina). The importance of Latin America to international centers not located there is underlined by the fact that five of the remaining 10 centers have staff based in the region.

While 11 percent of the total number of scientists employed in the entire system are nationals of Latin American countries, 37 percent of those working in the region are nationals. This has been an important aspect of building linkages to the national programs. The ability to work directly with the centers in Spanish was cited as an important feature by many researchers in national programs. At the same time they noted that the centers should place great importance to providing published materials in Spanish.

3.2 Training and Information

From their inception, the international centers have recognized the need for enhancing the capacity of national efforts by building up the stocks of human capital. Training, in a wide variety of forms has constituted a major effort by the centers. This is particularly true in Latin America.

Almost 50 percent of the total number of professionals in agricultural research in Latin America have had some form of training at the centers. It must be stressed that naturally not all those trained are currently employed by national research programs; some will be in universities, agro-industries, public administration or overseas. But directly and indirectly, most will be contributing to the agricultural sector.

In contrast to Latin America, only 10 percent of the total number of Asian professionals have had training at the centers. In addition to training at three centers based in Latin America, significant numbers of professionals

from the region have participated in various forms of training in the other international centers (see Table 10). Often the contacts for these courses are made through the centers in Latin America. This is another example of the manner in which the centers provide a conduit to the wider scientific community.

Of the total core budget spent by all the centers in Latin America in 1983, $5.9m. or 16 percent was dedicated to training and communication. For comparison, $15.5m. was spent on crop and livestock research directly. In other words, for every $1 spent on research by the centers in Latin America, another 40 cents is dedicated to training and communication. This serves to underline the importance placed on these activities by the centers.

This importance stems not only from the direct contribution that training makes. Those having been at the centers return with a better understanding of the role and place of the centers, and above all form a network of contacts with the centers. This continuity of contact is a major feature of the relations with the national programs. The relevance and frequency of the contacts with the centers is a special feature of the follow-up to the training programs of the centers, and not one that typically characterizes the training in other institutions. In smaller countries, it is not uncommon to find that the entire staff of a particular research group has been trained at a center, a factor contributing to the cohesion and stability of these small groups. The systematic and continuous follow-up that the centers have given to their alumni has often reduced the professional isolation felt so acutely by small groups at regional research stations.

As the capacity of the national programs has improved over time, so has the nature and mix of the training offered by the centers evolved to meet those needs. In Brazil, for example, a major national effort has been effective in raising the skills of EMBRAPA's staff. As a result the needs for training have shifted away from the production to research methods. The centers have also increased the extent of in-country training, and this has resulted in a cost effective mechanism for reaching much larger numbers. For example, close to 100 Cuban production experts in cassava have attended in-country training courses, and are now running their own courses.

3.3 Materials

The international centers involved in plant improvement have placed high priority on providing the national collaborators with a wide range of genetic diversity. The access to this material has meant that the plant breeders in the national programs have been able to select and develop varieties more suited to the particular environmental circumstances they face. In every country study this feature of the work of the international centers was the most widely cited single contribution.

Virtually every country in Latin America is receiving materials regularly from the international centers. Some countries are partners in international testing programs for up to 10 different crops, including tropical pastures. Rice, potato, maize and wheat networks involve almost every country of the region. In addition, international testing networks for crops whose mandate lies at centers outside the region are assuming greater importance. About 15 percent of the networks are now in commodities such as chick peas, ground nuts and sorghum. The region's contacts with the entire CGIAR system are continuing to grow.

The centers have offered a systematic mechanism for the collection, identification, screening and dissemination of plant materials. Varieties from one country can be supplied as promising material to another and the process of improvement greatly accelerated by the access to a greater range of material. Centers have been able to supply countries with material already screened for say, tolerance to a pest known to be important in that country. The very lengthy breeding programs needed to develop new varieties have been shortened in some cases by growing the crop in countries with different seasonal patterns.

The naming and release of new varieties is a matter entirely up to the national programs. Latin American countries have released almost one half of all the varieties related to center materials. These include rice (129 varieties), maize (126), wheat (127), beans (90), and cassava (32).

3.4 The Level and Mix of National Research Funding

Perhaps one of the most important, and possibly the most controversial aspects of the international centers has been their impact on the amount and pattern of research funding that individual countries have undertaken. The question is important, as regardless of the short term effect of the centers, their only lasting contribution is a system of strengthened national programs, whose funding base is sufficiently secure to ensure that they will be able to contribute to the long term growth of agricultural productivity in their respective countries. On the other hand the question is controversial since in trying to identify the impact of the centers, one is forced to contemplate the counterfactual case: what would have happened in their absence?

Data on the spending on research in Latin America for the different commodities is extremely sketchy. However, it is widely accepted that in relation to the export crops, to industrial crops and to livestock, research spending on food crops is a small fraction. One estimate was that in 1976, food crops attracted only about 17 percent of total spending on agricultural research in 7 of the largest national programs in the region. In contrast the efforts of the international centers have been directed exclusively at these crops. Today, almost 50 percent of the core expenditures by the CGIAR system on crop improvement in Latin America is focussed on food legumes and roots and tubers. These commodities have been traditionally funded at very low levels by national programs, and in some cases there was simply no national research at all on some commodities. The political and economic structures have not been as conducive to expressing the demand for technological innovations in these commodities compared with the export and industrial crops. In 1983, national research expenditures were about 0.27 percent of the value of production of root crops, 0.54 percent in cereals and around 1 percent for crops such as cotton, soybeans, sugar and coffee. It seems clear that in the absence of external resources the total level of research spending on food crops in Latin America would be appreciably lower. Furthermore, it appears that the national research spending in Latin America has increased more rapidly, albeit from a small base, for commodities in the CGIAR portfolio than for agricultural research as whole.

It is however true that the level of investment in research has risen significantly in the last decade or so. Some of this rise reflects the changing perspective on the importance of the agricultural sector. At the same time, it is claimed that the progress made by the international centers in wheat and rice had a demonstration effect. This alone, while raising expectations would hardly induce a country to increase substantially its research effort in other crops. A much more plausible hypothesis is that the opportunity for a national program to become part of an international network (with greatly enhanced access to plant materials, information, publications and training) increases the productivity of national resources devoted to research in that commodity. The demonstrable improvement in the rate of progress that can be made, leads to an increase in the national resources available for research in that crop.

The parallel growth in the funding of the centers in Latin America with the increase in national funding for research, is taken by some observers to imply a positive effect of CGIAR funding. This arises due to some combination of the demonstration and productivity effects discussed above. Others argue that in fact the centers have attracted funds from other external sources which in their absence would have flowed directly into national programs. Furthermore it is argued that in some cases, the host country of a particular center has withheld funding from a commodity program on the grounds that the international center would attend to the domestic needs.

It is clear that contemporaneous correlations between national and center funding are far too simplistic an approach to untangle a complex set of interrelationships. Many factors govern the level of national spending on research; the extent of international funding is only one of these, and given the relatively small proportion of funding for Latin American research that comes from the centers, it would be surprising if the funding of the international centers were the principal determinant of national efforts.

In an attempt to isolate the effect of international funding a model of national research spending was developed. As the borrowing of research findings is an important source of technical change, the amount of research undertaken in other countries with similar geo-climatic regions was included, together with spending by the centers and all aid for research, from both

bilateral and multilateral agencies. Other variables included the importance of the crop, the extent of trade, agricultural pricing policies and the political weight of the sector.

Holding constant the effect of other factors, it was found that research spending in national programs responded positively to an increase in spending by the international centers. There was no evidence of any reduction, nor substitution of funding from other outside sources. In fact, a once and for all increase of $1m. in crop research by the centers would result in an increase in spending by national programs of $2.3m. over the ensuing decade. In contrast, the effect of aid for research is to increase national spending only marginally - in large part, the aid simply displaces national funding.

These results were calculated for a medium sized country measured by its cropped area. An important finding is that the influence of the centers on domestic research spending is strongly related to the size of the country. Larger countries benefit more from any given increment to knowledge generated by research, simply because of their greater area of land devoted to crops. Their spending rises in absolute amounts and they invest more per unit of crop area. In fact, in small countries there is a tendency to reduce their national effort when the spending by international centers rises.

Implicit in much of the debate about the effect of spending by the centers is the notion that funds allocated to them are simply a substitute for funds going directly to the national programs. Donors are often challenged by their constituencies to justify support for the international centers when, it is argued those same funds could be channelled directly to national programs. However, this argument of perfect substitutability overlooks the essential difference in the role of the two systems.

National agencies have the responsibility to develop, adapt, test, release and extend new technologies tailored to the myriad of ecological, cultural and economic circumstances confronting them. The fundamental premise underlying the existence of the international centers, is that the marginal productivity of the national research effort can be enhanced by providing linkages to the international scientific community so that the flow of materials and information between countries is enhanced. Investment in

national research provides the necessary basis for a country to capture the benefits of complementary research in other countries with similar geo-climatic conditions. This borrowed component of research is vitally important, and accounts for a very significant part of the gains in agricultural productivity in a given country.

A clear prescription for the pattern of expenditure on research emerges once this distinction is recognized. On the one hand, investment is needed in domestic research capacity to take advantage of the opportunities for this spill-in effect; on the other, investment is needed in mechanisms which facilitate the access of national programs to the materials and information which can dramatically increase the value of their own efforts. If Honduras devotes no resources to research and extension in beans, then its ability to draw on the virus-tolerant lines of beans coming from Guatemala would be severely limited. If the collaborative system of bean research for Central America and the Caribbean had not been initiated and supported by CIAT, it is not clear that Honduras or any one of the other 8 countries in the network would have had the opportunity to test material tolerant to one of the major constraints to bean yields in the region (bean golden mosaic virus).

A shift in funding from the international centers reduces their capacity to provide national programs with materials and services; furthermore the preliminary evidence is that the net addition to national funding from other external resources is very small. In contrast a shift of funds away from the national programs reduces their capacity to take advantage of wider opportunities; a balance between the two has to be struck.

3.5 Research Networks

In order to strengthen the linkages with the national programs the centers have increasingly focussed on the role of research networks. The earliest, and still among the most important of these are the various international testing networks that facilitate the interchange of plant materials. The Latin American countries are extensively involved in these networks. In Central America and the Caribbean, 17 countries receive materials for 4 different crops on average; in South America 12 countries are part of testing networks for over 6 commodities each, on average.

These testing networks now represent just the basis of the links to national programs. However the international centers have sought to develop a range of new mechanisms for collaboration with, and even more crucially between national groups. CIMMYT has regional programs in wheat and maize throughout Latin America with resident staff in each of the regions. This provides continuous contacts with national researchers, a feature which drew favorable comment from them. Resident staff coordinate and support CIAT's Central American bean network, which brings together scientists from 9 countries. Potato researchers in the same region are linked through a collaborative network (PRECODEPA) initiated by CIP. The budgeting, work plans and policy decisions of the group are made by a regional committee comprising representatives of the individual countries. The basic philosophy, as stated by the Coordinator of Mexico's program, is that countries with limited resources but similar agro-ecological, socio-economic and cultural conditions can advantageously divide among themselves the tasks of developing technical solutions to productivity bottlenecks, and share the results.

Networks of these types provide access to materials and information essential for national researchers. Even more importantly they allow small countries to concentrate their efforts on one or two key issues, drawing on the experience of other members to support remaining areas. This is a particularly valuable aspect for those countries who could not sustain a fully fledged national effort covering the full range of disciplines. The specialization and horizontal transfer makes more effective use of limited domestic resources. This specialization itself leads to greater international contacts; when one member of the network has a problem, it can call on specialist advice from another.

A particular advantage of a research network compared to individual activities is that experiences at several locations can partially substitute for variation over time at a single site. One year's trials in 5 member countries may provide each with information that may have taken 5 years to generate in any one country.

Both the productivity and the status of the national researchers are raised by their active involvement in the network, with its regional conferences and study tours. This added prominence has often resulted in

greater national support. In 1977-78 there were a total of 14 researchers in the national potato programs of 6 Central American countries. By 1983-84 that had grown to 95, with much greater stability than before (Table 11). National programs with strong international linkages are less likely to have their funding cut in times of fiscal austerity.

The existence of these networks has improved the level, the mix and the stability of national funding. In addition, they have linked with other regional groupings and institutions, and helped attract external funding. The centers have either created or become affiliated with a whole series of linkages with donors and national agencies. Examples include with USAID and Rutgers University in Panama; with the World Bank in Peru; with the Swiss Development Cooperation in Central America; with IICA and BID in the Southern Cone, and with CATIE and USAID for small farm production systems in Central America. Much of the growing strength of food crop research in Latin America, especially among smaller countries is due to the evolution of new mechanisms to expand the effectiveness of their limited national resources. The homogeneity of culture, history and language has made these type of associations more viable in Latin America than in some other regions.

3.6 Policy Analysis

Relaxing the biological constraints to food production has been a major force in the food economy of Latin America. It must continue to be so, and will demand the sustained efforts of the national and international research systems. However to understand and influence the production and consumption of food requires attention to issues that transcend those of technological change per se. Economic, political and institutional factors play an important, sometimes overriding role.

Many of these issues fall clearly in the domain of national policy makers; the international centers have always felt the need to tread with extreme caution, for fear of being seen to interfere in areas of national sovereignty. Nevertheless, the policies often impinge so directly on the generation and adoption of technology, that the centers are naturally drawn into the debate.

The work of ISNAR is concerned with national research policy; in particular the structure, the organization and management of research programs. It has collaborated with a number of countries in Latin America, most notably with the design of a new institution in the Dominican Republic.

The three centers in Latin America have all undertaken analyses of policy questions concerning their particular commodities, and through a continuous monitoring of production, consumption, and market developments have been well placed to contribute to the policy debate with ministers and key officials in national programs.

Economic analysis of the growth of the agricultural sector has often been restricted to a consideration of pricing policies and government expenditure for particular agricultural programs. Increasingly, the importance of trade and macroeconomic policies is being recognized. Studies conducted at IFPRI for Peru, Colombia, Argentina and Chile are contributing to a much better understanding of the intersectoral effects of economic policy.

3.7 Output

Four major food crops typically account for between 40 and 50 percent of the total calories in the diet in Latin America. These are wheat, maize, rice and potatoes. The growth of output and yields for these crops over the last two decades is shown in Table 12. As national programs have been strengthened and as the collaborative linkages with the international centers have matured, it would be expected that the growth rates for these crops should be higher now than in the 1960s and early 1970s. The aggregate data for Latin America bear this out. The annual average rate of growth in yield was 60 percent higher in the decade ending 1984. This is a significant change in the pattern of food production in the region.

For a long period up until the 1960s, the growth of output was much more a reflection of the expansion in the area sown to crops; that pattern has now been largely reversed, and currently most of the increments to output are due to improved productivity per hectare. Those gains in productivity have been of such magnitude that in some crops the total area sown has actually declined while production has continued to rise. The yield gains have either increased

over time (as in the case of the cereals); or declines, in the case of other basic food crops, appear to have been arrested (Table 13).

The spread of semi-dwarf wheats and rices throughout Latin America has been rapid and widespread. In 1970, 11 percent of the wheat area and 4 percent of the rice area was planted to these varieties. By 1983, these proportions had reached 83 percent for wheat and 28 percent for rice (Table 14). Excluding Brazil, where very large areas of upland rice are used as the initial stage of pasture establishment, the plantings to modern rices exceed 70 percent of the total area. In major wheat producing countries such as Mexico and Argentina, over 95 percent of the area is sown to semi-dwarf wheats. If these varieties have raised yield by 500 kg per hectare, then wheat production in the region is 5 million tons more today than it would be in the absence of the improved varieties.

High yielding rice varieties, initially developed at IRRI were adopted rapidly in Latin America starting in 1968. Subsequently new varieties breed through the collaborative efforts of CIAT, often drawing on materials from IRRI, and the national programs have been widely adopted. By 1981-82 it was estimated that the new varieties were averaging 1.2 tons per hectare more than traditional varieties; this meant that rice production in the region was 35 percent higher, equivalent to some 2.7m. tons of additional production.

An unexpected benefit has been the wide adoption under rainfed culture of a number of the varieties breed and selected for irrigated systems. By 1983, 29 percent of the upland rice areas were sown to these varieties. In Central America and the Caribbean 55 percent of the upland area is sown to semi-dwarf rices. These have increased yields by up to 2 tons per hectare under upland conditions.

To date the effect on the output of other crops has not been as generalized as in the case of the cereals. It is certainly true that in some countries, and more especially in some regions, there are now demonstrable gains in the yields and outputs of cassava, beans, potatoes and tropical pastures. Often these have come from a combination of varieties, agronomic practices, better storage techniques or the use of disease free planting materials.

Wheat and rice are grown under much more homogeneous and often larger scale conditions compared to other food crops. There are few differences in preferences, the crops store easily, and the existing transport and distribution systems are better established. In contrast, for some of the other food crops, there are wide differences in preferences, production conditions are seldom as favorable, and post harvest systems are still evolving. In addition, there was a very limited stock of knowledge available for these crops - in many cases the findings are less than a decade old. As a consequence it is not to be expected that the same "miracle seed" revolution will occur as has been ascribed to wheat and rice.

Furthermore it is not necessary that yields per hectare increase as evidence of successful technological change. Improved pest tolerance can lower chemical costs; tolerance to less favored soil or water conditions can extend the potential domain of the crop; post harvest techniques can open new markets and end uses; and improved storage methods reduce both seed losses and post harvest losses. In Latin America the international centers are involved with many of these advances; examples include the treatment of cassava roots to extend their fresh shelf life; the selection of acid tolerant rices for the savannahs of South America; the drying of cassava for use as a feedstuff; and diffused light storage for potatoes. None of these advances will necessarily result in higher yields per hectare; all however can make significant contributions to the food economy of the respective crops.

Agricultural growth rates are the result of many forces - technical, economic and political. Some are of domestic origin; others arise outside the country. However considerable evidence has now accumulated to suggest that a vigorous national research program with strong international linkages is an important element. In an attempt to discern whether such patterns are evident in Latin America, an index was constructed to measure the contact that each country has with the international centers. All countries were then ranked in terms of their contact, from Mexico at the top (with an index of 18) to Barbados with the lowest measure of contact with the centers (an index of 3). As complete data were not available for each country some were deleted; in total 16 from Central America and the Caribbean were included and 12 from South America.

Two groups of countries were then chosen. The first consisted of the six countries with the highest contacts with the centers (Mexico, Brazil, Colombia, Argentina, Chile and Venezuela in descending order). The second group included those with the lowest level of contactwith the international centers (Ecuador, Bolivia, Nicaragua, Honduras, El Salvador, Paraguay and Barbados). One would expect that if it is true that international linkages raise the productivity of domestic research, and if that in turn encourages more local investment, then the two groups should have different levels of research spending. In fact the HIGH contact group invests 1.15 percent of the value of its agricultural output on research, while the LOW contact group spends only 0.47 percent (Table 15). Furthermore in the 1970s research spending grew at more than twice the rate in the HIGH contact group.

If a more vigorous domestic research system does in fact lead to a more dynamic agricultural sector, then the two groups should display different levels of performance. While acknowledging that many other factors help govern that performance, it is notable that in the HIGH contact group of countries the gross domestic product generated in the agricultural sector grew at an annual average rate of 3.5 percent in the years 1970-80; this compares to an annual rate of 2.8 percent among the LOW contact countries.

These results suggest, without any pretense of proof, that countries having high levels of contact with the centers are those with the more dynamic research systems and more rapid growth in agricultural output. While this analysis has been based on the level of contact with the CGIAR centers, it is likely that countries with a high level of contact also have contacts with many other institutions and research networks. It is the larger countries that have the greater contacts, and in part this undoubtedly reflects some conscious decisions on the part of the centers. Larger countries gain more from the contacts and therefore have the incentive to seek out linkages; their stronger national systems reinforce this. On the other side, there are economies of scale for the centers in dealing with large clients. But in any event, the evidence is clear that those with the higher level of contact have invested more in research and have achieved higher rates of growth of output.

3.8 Economic Returns

Research spending is a form of economic investment. It must compete with other uses of scarce investment funds. For this reason it is vital that the rate of return generated by the investment in research be comparable to that which could be obtained in competing activities. If the returns are consistently low, then there would be a case to reduce the level of funding in research; conversely if it is the case that the returns are high, then there is a case for questioning whether there has been underinvestment.

There is now a considerable body of evidence concerning the pay-off to research from many evaluations in many countries. A summary of some of these studies carried out in Latin America is given in Table 16. The overwhelming conclusion is that the return to investment in research has been generally, although not universally, high. While there are acknowledged limitations in both the methods and the data, the fact that the studies now encompass a wide range of countries, of commodities and of time periods, lends considerable weight to these results.

Where there are extensive areas of food crops, it follows that even relatively small gains in productivity translate into significant absolute gains. Improved varieties of wheat and rice in Latin America have increased output by 5 million and 2.7 million tons respectively. Conservatively valued this represents an annual benefit of the order of $US 1.5 billion. Even if only a minor part of this were attributed to the impact of research, the benefits would exceed the total costs of national and international investments by a wide margin.

In Argentina, improved wheats have led to a steady improvement in yields; in fact for two decades from 1965-84 yields have risen at an annual average rate of 2.4 percent. By 1982 the net annual returns from the introduction of improved germplasm were estimated to be between $US 59m. and $US 78m. The returns from wheat alone exceeded the entire national average budget for research over the period.

In summary there is simply no consistent evidence to suggest that the return to research in the region has not been generally high. There is no way

that any meaningful separation of the returns to domestic versus international research efforts can be computed. As repeatedly stressed the generation and diffusion of technical advances is a process dependent on effective linkages between complementary elements. The returns to investment in a domestic program that is operating in relative isolation will be well below those of a system equipped to extract the maximum advantage from "borrowing". Investment in the international centers, in the absence of national programs capable of mounting the necessary collaborative efforts will prove fruitless.

3.9 Distributional Consequences

Technological change in agriculture brings with it widespread economic and social consequences. The change in the real incomes of different groups can vary crucially be they net consuming or producing households; be they owners of land or labor; be they rural or urban dwellers; or be they located in favored or harsh environments. Technical change is not simply a quest for greater economic efficiency - for improvements to productivity alone. It is also an instrument to change the distribution of income, and hence the control over the process of generating technology is fundamentally a political matter.

Different types of technological change have very different distributional consequences. Mechanization may have very little effect on output, but be adopted by landholders who can capture the gains. Biological innovations, in contrast may lead to a rise in output, the surplus in this case being transferred as a real income gain to the urban wage workers, or their employers. Much technological advance is generated in the public sector due to the nature of the research process in agriculture. If some groups are politically weak relative to others, the extent of their control of the state in the generation of technology will be commensurately weak. If such a group is unable to mobilize and coordinate government action in its favor, then what may well be a strong potential demand for research may never become translated into an actual demand.

The long standing biases against the basic food staples in the research portfolios of many Latin American countries is in no small part a reflection of the relative political weights of different groups. The international centers have in part corrected this by their choice of commodities. There is

the centers are aiming to develop technology relevant to the circumstances of remote, small, impoverished producers whose political voices are not always heard.

Of overwhelming importance for the distribution of income is the contribution the centers can make to reducing the real price of basic foods. The lowest income groups in Latin America spend 80 percent or more of total household income on food. A reduction in the real price confers a disproportionate income gain on the poorest households. In Colombia in the mid 1970s the poorest 25 percent of households received 4 percent of the income. The same group captured 28 percent of the consumer benefits arising from the introduction of modern rice varieties. Total calorie intakes among the poorest were increased by between 9 and 15 percent in the urban areas. The net effect on landless workers of the cheaper rice balanced by a decline in the demand for labor, was to increase caloric intake by 1 to 4 percent. The small producers of upland rice in regions for which the new technologies were not suited suffered a decline in income; assuming they had no alternative crops, calorie intakes among this group could have fallen by as much as 15 percent.

This example serves to illustrate the two principal elements of the effect of new technology on income and nutrition. Where the commodity is a basic food staple, any reduction in the real price will favor the low income consuming households, although this effect will be moderated if the commodity is extensively traded and the country in question has little impact on world prices. Secondly, those producers who for whatever reason do not adopt the new technology may well be disadvantaged; and to date the disadvantaged in Latin America have generally been the poorest of the rural sector. The centers are dedicated to redressing this balance; whether the internal political forces will thwart or support this endeavour remains unanswered. The increase in the research expenditures for food staples in some countries must be viewed as a positive sign.

4 THE FUTURE

4.1 Economic Policy Environment

It is now becoming more widely recognized that the growth of the agricultural sector is strongly influenced by the trade, exchange rate and macro-economic policies that are adopted. This is particularly true in Latin America where the agricultural sector is a major source of output and employment in many countries, and where agricultural inputs and products enter extensively into international trade.

In the past there has been extensive direct government intervention in the agricultural sector. This has involved both expenditure and policies to alter incentives. Expenditure on irrigation schemes, roads and storage schemes has been undertaken to promote the growth of the sector. At the same time a plethora of interventions have altered the relative prices facing consumers and producers; credit subsidies, input and output price fixing, state purchasing monopolies, import licencing, and taxes on exports are only a sample of the instruments that have been used. The level of the net tax or subsidy that has been applied has varied widely across commodities, and varied through time. Chilean wheat producers were taxed nearly 30 percent between 1971 and 1975. From 1976-80 there was a net subsidy of 5 percent from direct price interventions. This variability adds another source of uncertainty to that arising from weather and world prices.

In addition to these direct interventions, other policies related to the overall management of the economy have a major impact on the agricultural sector. These policies can either neutralize or accentuate the effect of the sector-specific interventions. As a general rule the trade and macro-economic policies that have characterized much of Latin American policy in the last four decades have not favored the agricultural sector. The protection of manufacturing results in a tax on the agricultural sector, partly through raising the prices paid by producers for imported inputs, but even more critically through overvaluing the real exchange rate. The effect of this is to lower the price of all tradeable goods relative to the non-traded sector of

the economy, and to encourage resources to move out of the production of exportables and import competing goods.

These signals tend to reduce the growth of the sector in the long run and discourage the accumulation of capital necessary for the adoption of new technology. The long run supply response of agriculture now appears to be very much higher than was implied in the discriminatory polices of the past. The critical economic problems now facing the region are leading to new attempts at economic liberalization. In particular the correct alignment of the real exchange rate is seen as an important step in encouraging the expansion and diversification of the export and import competing sectors. High levels of foreign debt are obliging policy makers to remove the disincentives from the traded goods sectors.

To the extent that economies become more open and their traded goods sector expands, the distribution of the gains from technological change may be affected. If in the past direct and indirect controls have meant that there was little if any external trade, then extra output stemming from the introduction of new technology resulted in a decline in the domestic price. This meant a real gain for domestic consumers. However, where the extra output enters world trade or reduces the need for imports, the domestic price will, in the absence of other interventions, reflect world prices rather than the level of domestic supplies. It is possible that in the first instance the benefits of new technology will not flow as directly to low income consumers, but rather come through the effect of higher incomes on the growth of employment.

Agriculture as an important part of the tradeable sector of many Latin American countries can only stand to benefit from these macro-economic adjustments. Already there is evidence of a marked rise in output and exports where the incentives facing producers have been changed. If those incentives are seen as permanent rather than transitory, then the rate of capital accumulation in the sector will increase. Such an economic climate will stimulate the derived demand for technological change. In summary, there is every indication that in the medium term the economic policies of the region will enhance the demand for the work of the national and international research systems.

4.2 Growth in Output and Demand

Over the last decade yields of the three basic cereal crops in Latin America have risen by an average of 40kg/ha each year (Table 17). The gains have been surprisingly uniform across all three crops. There is currently about 45m. hectares sown to these crops. If most of the future expansion in output is to come from higher yields rather than greater areas sown, then based on the recent performance, an extra 1.8m. tons would be added to total supplies each year.

If the population grows at 2.1 percent per year, and if the current level of per capita consumption of these crops is to be maintained then the demand would rise by 1.8m. tons per year. In other words, the rate of improvement in yields achieved in the last decade, if maintained, would just be sufficient to prevent the per capita consumption of these staples from falling. This makes no allowance for increasing exports, for reducing imports or for the effect of rising incomes on the demand.

The compelling conclusion that follows, is that the rate of technological change must be accelerated if the supplies of basic foods are to match the short-term growth in demand.

4.3 Food Imports

While for many countries in the region agricultural exports are of importance, there has been a marked change in the pattern of foreign trade over the last two decades. Since the mid 1970s total food imports to the region have been growing at over 7 percent each year. In addition to large increases in the imports of oilseeds and vegetable oils, cereal imports for the region have also increased (Table 18). Twenty years ago the region was a net exporter; today per capita imports are about 10 kg, or 5 percent of total consumption of the three main cereals. This is still a modest level of imports; in fact food imports represent 3 to 6 percent of total export revenues in the food deficit countries. This is generally regarded as quite low and there has been no significant trend, although in exceptionally poor years this ratio can reach 10 to 15 percent.

Raising incomes combined with rapid rural to urban migration have put pressure on food supplies in many countries; and then growth rates of those supplies have not always been as high as they might otherwise have been had the incentives been more favorable. Political pressure in urban areas to hold down food costs can lead to an increase in subsidized imports.

Of particular note is the change in food consumption patterns over time. In Latin America the per capita consumption of wheat and rice has risen steadily over the last two decades, in marked contrast to the consumption of roots and tubers, other coarse grains and maize. As incomes rise two major substitutions typically occur. Consumers switch from basic staples to preferred cereals, and there is a strong increase in the demand for livestock products. Milk, eggs, poultry meat and pork are dominant among these.

As a result of these forces, there is a decline in the demand for some staples and for maize as a direct food. At the same time there is rapid growth in the demand for livestock feedstuffs. Poultry production in the region was increasing at an annual rate of nearly 9 percent between 1977 and 1984. As each kilogram of meat requires 3-4 kilograms of feed grains, middle income developing countries can expect to see sustained and substantial rises in the demand for animal feedstuffs. The effect of these trends is already well evidenced in the rising imports of wheat and rice and the very marked fall in the net exports of maize from Latin America (Table 18). Economic growth will lead to increased not decreased demand for the crops within the mandates of the international centers, either as preferred staples (eg. wheat and rice), or as feedstuffs (eg. maize, sorghum, cassava) to meet an almost explosive growth in the demand for livestock products.

4.4 Changes in Funding

There are a number of important forces operating to change the nature of funding of research in Latin America; these have implications for the activities of the international centers.

By its very nature research is a long-term investment; the fact that current reductions in funding have no immediate consequences for agricultural output heightens the political vulnerability to cuts in national budgets.

This instability of funding continues to plague research programs in the region; the last decade has seen truly massive and sudden shifts in public allocations for research. Fiscal crises have been accompanied by real cuts of up to 40 percent in one year. With salaries representing 70 percent of total costs, even a 10 percent drop in the total budget can reduce effectiveness by cutting the operating expenses by 30 percent.

Grants and loans from international sources may help to reduce this problem; but history shows that strong political elements enter into the allocation of these funds, and at times they can exacerbate the instability. The presence of the centers, through raising the returns to national efforts, has helped ensure a more stable level of funding for certain crops. The provision of small grants by the centers, or facilitating access to supplies and equipment has helped some national efforts to remain operative in the face of limited domestic resources.

National research institutes have been forced to rely more on project rather than core institutional funding, in an attempt to have the beneficiaries of the research contribute more directly. This has not necessarily been a bad development; it can lead to research being much more closely linked to the needs of client groups. It does however mean that the efforts of the national system become increasingly dominated by those clients who have the political and economic leverage.

In some cases the research becomes wholly supported by the industry and both the funding and the conduct of the research fall outside the state sector. This is particularly true in the case of export crops. In addition, the increasing share of purchased inputs implies a much greater role for agro-industry, and the proportion of the research undertaken by the private sector firms who supply inputs is likely to continue to grow.

This tendency will be reinforced by the changing nature of agricultural technology. New advances may be of a type that permits private firms to appropriate the benefits, and hence have the incentive to invest in their development. The evolution of legal systems and patenting to protect property rights will further expand the potential role of the private sector.

Economic liberalization policies are leading to a greater role of the traded goods sector. As more crops become tradable, with their prices set in world and not domestic markets, the producers will capture a greater share of the direct benefits of technological change. This may well lead to an enhanced and more stable base of funding for research; the well funded Thai program of cassava research where the entire crop is processed and exported as an animal feed, stands in contrast to the support of cassava research in Latin America, where it is still largely a non-traded staple.

The net effect of all these changes is that new patterns for the conduct and funding of research in the region are continually evolving. Many of the changes will tend to reduce the role of the multi-commodity national institutes. They will tend to be left with the responsibility for those crops and regions that do not, for political and economic reasons, attract other sources of funding. This may well leave them more vulnerable than before.

The national research institutes in Latin America have been the traditional focal point for contact with the centers. To the extent that they become the residual elements of the research systems, it will be even more vital for the support from the centers to continue. Much of the technological advance in basic food crops such as cassava, beans and potatoes still will have to come from the public agencies. The nature of these crops and the clients is such that they will continue to be neglected in the absence of a conscious and collaborative effort between the centers and the national programs. At the same time the centers will need to broaden their connections to include input suppliers, the seed industry, the universities, the statutory boards and the industry research associations. To restrict their contacts to just the national programs, would leave them successively more isolated from a growing part of the research system.

4.5 Size of Country

It has been repeatedly noted that the nature and role of the centers is influenced by the size of the client country. Most of the larger countries in the region now have research systems many times the size of the international centers. The self sustaining nature of these programs means that their demand for services from the centers has changed over time. Broadly based production

training courses have given way to more technical and specialized training in research methods. Their larger collections of plant materials and wider international linkages mean that the access to genetic material from the centers, while still important, represents a smaller share than in the past.

The larger scale permits them information services, documentation, computing, and laboratory services that a small country cannot match. It is not simply that these larger countries are typically at higher income levels and so, in some sense can afford these ingredients of a research system. It is largely a rational response to the economies of scale.

On the other hand there are many smaller countries for whom the establishment and support of a fully fledged national program is neither financially feasible nor economically warranted. Here the collaboration with the centers in materials, in training, in documentation and in access to regional networks is vital; without it research on basic foods in some countries could simply not be sustained. Carrying out research with collaborating countries whose domestic systems vary from robust to fragile to non existent, poses serious challenges to the centers in their setting of priorities.

4.6 Contacts with Other Research Centers

The extent of the contact with the international centers not based in Latin America has risen markedly; this is only a beginning however. Much of the work in these centers is barely 10 years old, and is only beginning to produce results that can be adapted to the ecological circumstances of individual countries. As the work of these other centers becomes more widely known, as the capacity of domestic programs grows, and as the demand increases for technological change in a wider range of crops, then it is to be expected that contact with the other centers will expand.

Advances in research techniques are occurring continuously; in the next 20 years biotechnologies could revolutionize the process of crop improvement. Much of this work is taking place in the universities and research institutes of the industrialized countries. The centers in Latin America are increasingly involved in research contracts and informal contacts with these

agencies. Such linkages form a conduit for the flow of information, training and techniques to the individual countries of the region, especially for those whose size would preclude many independent contacts.

The centers are not by any means the only mechanism for ensuring these flows. Bilateral arrangements, degree training, and foreign sponsored specialists all play a role. However in this, as in other areas the international centers have a number of unique characteristics that make them particularly suited to this role. Their apolitical nature, their long-term programs, their wide scientific connections, their stable funding and broad base of support are not features easily replicated by other institutions. It might well transpire that future support for the CGIAR centers in the region can be justified solely on the importance of their role in facilitating the flow of information and techniques to collaborating countries. Any tendency to argue that in small low income countries the application of new scientific advances is not appropriate to their less developed circumstances should be strongly resisted; it is a hangover from the appropriate technology school. If there are advances in breeding techniques that can reduce the time to develop a new variety suited to the particular ecological conditions in a given country from 8 to 4 years, then every effort must be made to ensure it is implemented. The potential contribution to human welfare through increased availability of staple foods requires nothing less.

4.7 Future Pay-offs

Past experience shows that the return to investment in research has yielded handsome dividends. The importance of the link between investment in research, the rate of technological advance in agriculture and the overall rate of economic growth cannot be over-emphasized.

At the same time there is considerable variation in the record; and the literature is not replete with analyses of failures. Furthermore, pursuing the strategies of the past in an attempt to emulate the dwarf gene story in other crops provides no guarantee of continued high returns. Donors will, and must, question the centers about the expected pay-off to current and future work. Past success does not absolve the system from demonstrating that donors can continue to expect an adequate return on the funds. As the CGIAR system

has grown it has embraced a wider range of crops, focussed greater attention on harsher environments, and sought collaboration with many more countries where the research and extension base was fragile. These considerations together with the long lags of 10 to 15 years in the generation and diffusion of technology naturally raise questions about the future pay-off.

It is difficult to make general statements about the expected return to entire centers, or regions or crops, other than those based on some overall assessment of the strategy, the management and the quality of the research. The extensive annual and quinquennial reporting provide the opportunity to form these judgements. In contrast if one is interested in the expected rate of return, then it is necessary to examine a particular research area of project. The case of upland rice in Latin America is discussed here as one such illustration.

Collaborative efforts to date have resulted in substantial gains in rice production in Latin America. These gains have come in large part although not exclusively from irrigated culture. Vast areas of favored upland rice lands exist; while receiving adequate rainfall, yields are limited by high aluminum concentrations in the soil. Up to 2.1 million hectares of this land could produce rice yields of 2 to 3.5 tons/ha if tolerant varieties incorporating disease resistance were available. In an attempt to assess the possible economic return from this program, the following assumptions were made:

- The research would cost $5m per year shared equally between the centers and the national programs;
- The research lag would be five years;
- Subsequently the new material would be adopted over a 10 year period, to a maximum of 80 percent on the total area;
- The maximum increase in yield would be 1500 kg/ha;
- Only 20 percent of this gain would be attributable to the international centers, while 80 percent would be due to the collaborating research and extension programs on the individual countries;
- After the first 5 years there would be maintenance costs of $2m. per year which would continue indefinitely.

Such a program would have a net present value of $81m; or alternatively an internal rate of return of 22 percent per year in real terms. While acknowledging the difficulties and limitations of such analyses, the assumptions were sufficiently conservative that the results are indicative of the potential return to investment in the centers.

This example provides an opportunity to illustrate and underline the importance of the joint collaborative nature of this scientific strategy. The investment in the centers is a necessary condition to provide access to a broad based germplasm, international testing networks, and to facilitate the rapid incorporation of new research techniques. However without the backing of effective national efforts the process would be slower and vastly less effective. In the case of upland rice research, it was assumed the adoption lag was 10 years. If through the efforts of the national program that could be reduced by one year to 9 years, the present value of the proje[illegible] would rise from $81m. to $86m.; in other words, it would be worth investing up to $5m. more today in the research and extension programs of collaborating countries if that were to reduce the lag in adoption by one year in some 15 years time.

This is striking testimony to the return to enhancing the capacity of national programs to receive, test, adapt, release and extend technologies developed through collaboration with the international centers. Sustained investment is needed in all elements of this scientific network - to view one part as in any sense a substitute for another would be to negate the sound and proven principles on which the system is built.

APPENDIX

TABLE 1: AVERAGE RATES OF OUTPUT GROWTH: 1970-1981

COMMODITY	COUNTRY	RATE(%)
Wheat	Mexico	+4
	Colombia	Negative
	Ecuador	Negative
Beans	Argentina	+7
	Brazil	+2
Cassava	Cuba	+6
	Ecuador	Negative
Potatoes	Colombia	+9
	Peru	Negative

TABLE 2: FOOD PRODUCTION PER CAPITA: THREE DECADES

	1964		1974		1984	
	1952-54=100		1961-65=100		1974-76=100	
INCREASES	MEX	126	C. RICA	125	CUBA	135
	BRA	123	VEN	122	BRA	117
	VEN	119	BOL	117	ARG	108
	PAN	113	BRA	111	BARB	107
	HON	105	PAN	111	CHI	105
			HON	108	HON	104
			GUAT	105	MEX	104
			GUY	105	COL	104
			D.REP	104	URU	102
			EL SAL	102		
			NIC	102		
SAME	GUAT	100	ARG	100	-	
DECREASES	PERU	98	COL	98	PAR	99
	COL	98	MEX	98	PAN	97
	CHI	94	URU	97	GUAT	96
	ARG	90	CUBA	97	D.REP	96
	URU	86	CHI	96	JAM	90
	CUBA	80	HAITI	93	EL SAL	90
			PAR	91	ECUA	90
			JAM	90	HAITI	89
			PERU	89	GUY	88
			ECUA	83	PERU	87
			BARB	82	VEN	85
					BOL	85
					COL	79

TABLE 3: RESEARCH SPENDING IN LATIN AMERICA
($US 1980 millions)

REGION	1959	1970	1980
C.AM & CAR.	14	30	113
S.AM. TROP.	35	129	269
S.AM. TEMP.	31	57	80
TOTAL	80	216	462

TABLE 4: RESEARCH SPENDING IN LATIN AMERICA
(PERCENT OF AG. GDP)

REGION	1959	1970	1980
C.AM & CAR.	0.2	0.2	0.6
S.AM. TROP.	0.3	0.7	1.0
S.AM. TEMP.	0.4	0.6	0.7

TABLE 5: RESEARCH SPENDING BY COMMODITY
(PERCENT OF VALUE)

HIGH >1%	MEDIUM 1/2-1	LOW <1/2
WHEAT	BEANS	RICE
VEG.	CITRUS	POTATOES
POULT.	COFFEE	MAIZE
	BANANAS	SW. POTATOES
	BEEF	CASSAVA
	PORK	

TABLE 6: RESEARCH SPENDING AND THE GROWTH OF AGRICULTURE IN LATIN AMERICA: AVERAGES FOR THREE GROUPS OF COUNTRIES

RESEARCH SPENDING IN 1980	INDEX OF AG. GDP 1973	INDEX OF AG. GDP 1984	RATIO
(% Ag.GDP)	1963=100	1973=100	1984/1973
HIGH (1.25%)	99	110	111
MED (0.45%)	100	98	98
LOW (0.25%)	103	86	83

The countries included in each of three groups were:
HIGH: Argentina, Barbados, Mexico, Brazil, Venezuela and Chile
MED: Colombia, Uruguay, El Salvador, Guatemala, Ecuador, Bolivia and Peru.
LOW: Nicaragua, Costa Rica, Jamaica and Dominican Republic.

TABLE 7: EXPENDITURE BY CGIAR CENTERS DIRECTED TOWARD LATIN AMERICA: 1983 - $USm.

CATEGORY	AMOUNT
Crop/livestock Improvement	15.5
Food policy	0.3
Genetic resource conservation	11.0
Research support	6.0
Training and communication	5.9
Management/administration	9.0
TOTAL FOR LATIN AMERICA	37.7

TABLE 8: CONTACTS(a) BETWEEN NATIONAL PROGRAMS IN LATIN AMERICA AND THE INTERNATIONAL CENTERS

LOCATION OF INT. CENTER	C.AM/CAR.	S.AM.
With 3 centers based in Latin America (CIMMYT,CIAT,CIP)	70	79
With centers based outside Latin America:		
IBPGR	8	14
ICARDA	0	1
ICRISAT	8	9
IFPRI	2	3
IITA	1	3
ILRAD	1	6
IRRI	6	11
ISNAR	3	1

(a) The numbers in the table are relative indices based on the transfer of genetic materials, the extent of conferences and training, the extent of collaborative research and the presence of center staff based in a country.

TABLE 9: INDEX OF CONTACT WITH THE INTERNATIONAL CENTERS: BY REGION (a)

REGION	NO. OF COUNTRIES WITH CONTACTS	TOTAL SCORE	AVERAGE SCORE PER COUNTRY
S.ASIA	8	85	10.6
E.& SE ASIA	10	92	9.2
N.AFRICA & M. EAST	17	90	5.3
E. & S. AFRICA	18	174	9.7
W. AFRICA	22	222	10.0
C.AM & CAR.	18	109	6.1
S. AMERICA	12	129	10.8
PACIFIC	8	22	2.8
TOTAL	110	923	8.4

(a) See note to Table 8.

TABLE 10: TRAINING OF LATIN AMERICAN PROFESSIONALS AT THE CENTERS: 1962-84

CENTER	GROUP COURSES	DEGREE RESEARCH	INDIVIDUAL TRAINING	POST DOCTORAL
IN LAT.AM (CIAT, CIMMYT & CIP)	1990	223	1809	64
IBPGR	62	5	5	0
ICRISAT	13	4	2	9
IITA	44	2	0	2
ILCA	0	0	6	0
ILRAD	7	0	0	5
IRRI	15	13	14	0
ISNAR	121	0	0	0
IFPRI	0	0	0	6
TOTAL FOR L.AM.	2252	247	1836	77
TOTAL FOR LDCs	11573	1477	3493	472
SHARE L.AM(%)	19	17	53	16

TABLE 11: TOTAL PERSONNEL IN POTATO PROGRAMS

COUNTRY	1977-78	1983-84
MEXICO	4	18
GUATEMALA	4	31
HONDURAS	1	11
COSTA RICA	1	9
PANAMA	2	9
DOMINICAN REP.	2	17

TABLE 12: GROWTH OF OUTPUT AND YIELDS (% p.a.)

CROP		1965-74	1975-84
RICE	O:	2.0	1.5
	Y:	1.0	1.8
WHEAT	O:	2.2	3.9
	Y:	1.9	3.8
MAIZE	O:	2.3	3.5
	Y:	1.9	2.7
POTATOES	O:	1.6	1.9
	Y:	2.0	2.5

TABLE 13: GROWTH IN YIELDS IN TROPICAL LATIN AMERICA(a)

CROP	1960-69	1969-78	1978-83
		(percent per year)	
RICE	-0.8	1.0	3.0
MAIZE	1.1	1.4	4.4
WHEAT	4.9	-0.5	7.3
AVERAGE	1.7	0.6	4.9
CASSAVA	0.4	-2.3	-1.2
BEANS	-0.2	-2.0	0.0
POTATOES	-0.5	2.2	1.2
AVERAGE	-0.1	-0.7	0.0

(a) Excludes Argentina, Chile and Uruguay.

TABLE 14: PROPORTION OF AREA SOWN TO MODERN VARIETIES OF WHEAT AND RICE: 1970 AND 1983

COUNTRY	WHEAT		RICE	
	1970	1983	1970	1983
	percent of total area			
ARGENTINA	0	95	-	34
BOLIVIA	3	9	-	-
BRAZIL	3	43	-	14
CHILE	8	70	-	-
COLOMBIA	22	95	17	92
CUBA	-	-	-	100
ECUADOR	0	36	11	53
GUATEMALA	30	95	-	29
GUYANA	-	-	-	60
HAITI	-	-	-	22
HONDURAS	-	-	5	89
MEXICO	88	95	67	83
NICARAGUA	-	-	34	79
PANAMA	-	-	31	69
PARAGUAY	7	8	2	64
PERU	-	-	13	74
SURINAM	-	-	13	70
URUGUAY	0	62	-	-
VENEZUELA	-	-	-	80
LATIN AMERICA	11	83	4	28

(-) not applicable or no information.

TABLE 15: CONTACT WITH CENTERS AND GROWTH OF NATIONAL PROGRAMS: 1970-80

LEVEL OF CONTACT WITH CENTERS(a)	RESEARCH AS % of AG. GDP 1980	GROWTH OF RESEARCH SPENDING 1970-80	GROWTH OF AG. GDP 1970-80
	%	% p.a.	% p.a.
HIGH	1.15	12.4	3.5
LOW	0.47	5.9	2.8

(a) For details of index of contacts see note to Table 8.
HIGH: Mexico(18),Brazil(17),Colombia(17),Argentina(13) Chile(13),Venezuela(13)
LOW: Ecuador(9),Bolivia(8),Nicaragua(7),Honduras(7), El Salvador(7),Paraguay(6),Barbados(3).

TABLE 16: ESTIMATED RATES OF RETURN TO INVESTMENT IN RESEARCH IN LATIN AMERICA

AUTHORS	COUNTRY	COMMODITY	PERIOD	RATE OF RETURN (%)
ARDITO BARLETTA	MEXICO	WHEAT	1943-64	69-104
		POTATOES	1943-64	69
		MAIZE	1943-64	26-59
HINES	PERU	MAIZE	1954-67	35-40
HERTFORD et al.	COLOMBIA	RICE	1957-72	60-82
		WHEAT	1953-73	11-12
		COTTON	1953-72	NIL
SCOBIE & POSADA	COLOMBIA	RICE	1957-74	79-96
MUCHNIK	LAT.AM.	RICE	1968-90	89
YRARRAZAVAL	CHILE	MAIZE	1940-77	32-34
		WHEAT	1949-77	28
AYER & SCHUH	BRAZIL	COTTON	1924-67	77-110
AVILA		RICE	1959-77	87-119
EMBRAPA		HUMAN CAPITAL	1974-96	22-30
ROESSING		SOYBEANS	1975-85	52

TABLE 17: GROWTH OF YIELDS OF FOOD CROPS IN LATIN AMERICA

CROP	AVERAGE YIELD kg/ha		AVERAGE ANNUAL GAIN IN YIELD kg/ha/yr
	1972-74	1982-84	
WHEAT	1,484	1,929	+45
RICE	1,690	2,115	+43
MAIZE	1,489	1,849	+36
	WEIGHTED AVERAGE GAIN		+40

TABLE 18: NET IMPORTS OF GRAINS IN LATIN AMERICA
('000 TONS p.a.)

CROP	1962-64	1972-74	1982-84
RICE	151	171	302
WHEAT	2,133	5,529	4,261
MAIZE	-2,854	-2,943	-654

BIBLIOGRAPHY

Anderson, J.R., R.W. Herdt and G.M. Scobie (1985) "The Contribution of International Agricultural Research to World Agriculture", Am. J. Ag. Ec. 67:1080-1084.

Arndt, T.M., D.G. Dalrymple and V.W. Ruttan (eds) (1977) Resource Allocation and Productivity in National and International Agricultural Research, Univ. Minnesota Press.

CIAT (1986) Trends in CIAT Commodities, Cali, Colombia.

CIMMYT (1984) Maize Facts and Trends, Mexico.

CIMMYT (1985) World Wheat Facts and Trends, Mexico.

CIP (1985) Potatoes for the Developing World, Peru.

Corbo, V. (1986) "Problems, Development Theory and Strategies of Latin America", World Bank, mimeo.

De Janvry, A. (1981) The Agrarian Question and Reformism in Latin America, Johns Hopkins Press.

De Janvry, A. and J.J. Dethier (1985) Technological Innovation in Agriculture: The Political Economy of its Rate and Bias, CGIAR, Study Paper 1.

Elias, V. (1985) Government Expenditure on Agriculture and Agricultural Growth in Latin America, IFPRI, Research Report 50.

Evenson, R.E. and Y. Kislev (1975) Agricultural Research and Productivity, Yale Univ. Press.

Evenson, R.E., C.E. Pray and G.M. Scobie "The Influence of International Research on the Size of National Research Systems", Am. J. Ag. Ec. 67:1074-1079.

Hazell, P.B.R. and J.R. Anderson (1984) "Public Policy toward Technical Change in Agriculture", Greek Ec. Rev. 6:453-482.

Homen de Melo, F.B. (1985) Brazil and the CGIAR Centers, CGIAR Study Paper 9.

Mellor, J.W. and B.F. Johnston (1984) "The World Food Equation: Interrelations among Development, Employment and Food Consumption, J. Ec. Lit. 22:531-574.

Lipton, M. and R. Longhurst (1985) Modern Varieties, International Agricultural Research and the Poor. CGIAR Study Paper 2.

Martin del Campo, A.C. (1985) Main Factors in Mexico's Agricultural Development, mimeo.

Muchnik de Rubinstein, E. (1985) The Impact of Technical Change in Rice on Calorie Intake by Low Income Households in Colombia, IFPRI, mimeo.

Nestel, B. and E.J. Trigo (eds) (1984) Selected Issues in Agricultural Research in Latin America, ISNAR, The Hague.

Oram, P. (1981) Support for Agricultural Research in Latin America, IFPRI, mimeo.

Palma, V. (1983) Review of Evaluation Studies on Returns to Agricultural Research, Paper for Latin American Congress of the Econometric Society, Santiago.

Paz Silva, L.J. (1986) Peru and the CGIAR Centers, CGIAR Study Paper 12.

Pineiro, M. and E.J. Trigo (eds) (1983) Technical Change and Social Conflict in Agriculture: Latin American Perspectives, Westview Press.

Pinstrup-Andersen, P. (1982) Agricultural Research and Technology in Economic Development, Longmans.

Pinstrup-Andersen, P. and P.B.R. Hazell (1985) "The Impact of the Green Revolution and Prospects for the Future", Food. Rev. Int. 1:1-25.

Posada T., R. (1986) Ecuador and the CGIAR Centers, CGIAR Study Paper 11.

Ruttan, V.W. (1982) Agricultural Research Policy, Univ. Minn. Press.

Sanchez, P.A. and G.M. Scobie (1986) Cuba and the CGIAR Centers, Study Paper 14.

Scobie, G.M. and R. Posada T. (1977) The Impact of High Yielding Rice Varieties in Latin America, CIAT, JE-01.

Scobie, G.M. (1979) Investment in International Agricultural Research: Some Economic Dimensions, World Bank SWP 361.

Scobie, G.M. (1979) "The Demand for Agricultural Research: A Colombian Illustration", Am. J. Ag. Ec. 61:540-545.

Stewart, R. (1985a) Costa Rica and the CGIAR Centers, CGIAR Study Paper 4.

Stewart, R. (1985b) Guatemala and the CGIAR Centers, CGIAR Study Paper 5.

Valdes, A. (1986) Trade and Macroeconomic Policies' Impact on Agricultural Growth: The South American Experience, IFPRI.

Valdes, A. (1983) Latin America's Food Situation in a Global Context, IFPRI.

Venezian, E. (1986) Chile and the CGIAR Centers, CGIAR Study Paper 20.

World Bank (1981) Agricultural Research Sector Policy Paper.