Consultative Group on International Agricultural Research

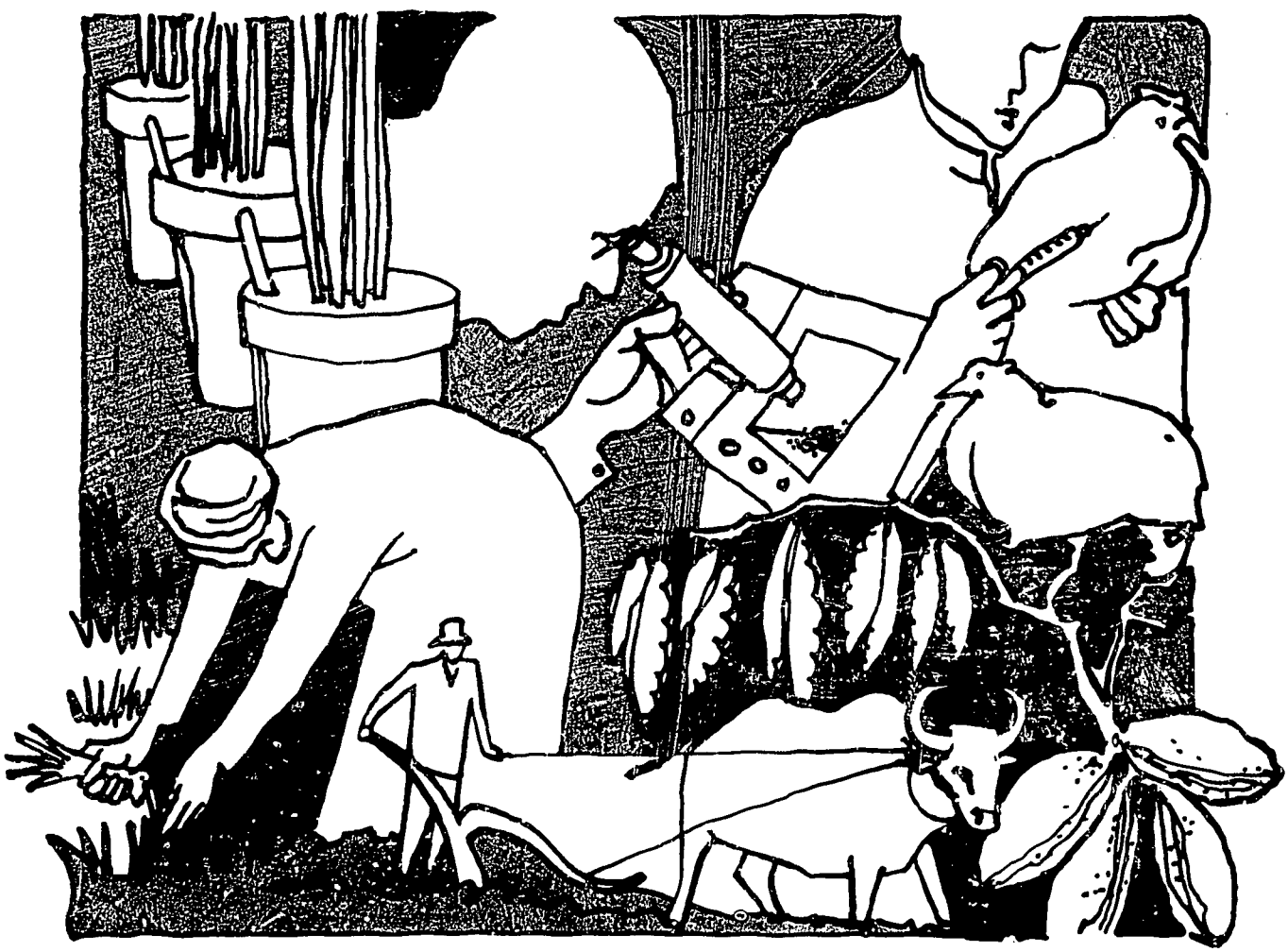
CGIAR

Study Paper Number 9

Brazil and the CGIAR Centers

A Study of Their Collaboration in Agricultural Research

Fernando Homem de Melo



Consultative Group on International Agricultural Research

CGIAR

Study Paper Number 9

Brazil and the CGIAR Centers

A Study of Their Collaboration in Agricultural Research

Fernando Homem de Mélo

The World Bank
Washington, D.C.

The International Bank for Reconstruction
and Development/THE WORLD BANK
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

First printing January 1986

Manufactured in the United States of America

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 oganizations 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.

Fernando Homem de Melo is professor of economics at the University of São Paulo, Brazil, where he is also senior researcher at the Foundation Institute of Economics Research.

Library of Congress Cataloging-in-Publication Data

Homem de Melo, Fernando Bento, 1942-
Brazil and the CGIAR centers.

(Study paper / Consultative Group on International Agricultural Research, ISSN 0257-3148 ; no. 9)
Bibliography: p.
1. Agriculture--Research--Brazil. 2. Empresa Brasileira de Pesquisa Agropecuária. 3. Consultative Gorup on International Agricultural Research. 4. Agriculture--Research--International cooperation. I. International Bank for Reconstruction and Development. II. Title. III. Series: Study paper (Consultative Group on International Agricultural Research) ; no. 9.
S542.B6H66 1986 630'.72081 85-31469
ISBN 0-8213-0694-4

C O N T E N T S

T A B L E S

LIST OF ABBREVIATIONS

CFP - Production Financing Company

CIBRAZEM - Brazilian Warehousing Company

COBAL - Brazilian Food Company

INCRA - National Institute of Colonization and Agrarian Reform

EMBRAPA - Brazilian Company of Agricultural Research

EMBRATER - Brazilian Company of Technical Assistance and Rural Extension

ACAR - Credit and Rural Assistance Association

ABCAR - Brazilian Rural Credit and Technical Assistance Association

IAA - Sugar and Alcohol Institute

PLANALSUCAR - National Program of Sugarcane Breeding

COPERSUCAR - Cooperative of Sugar Producers

IAC - Campinas' Agronomic Institute

DNPEA - National Department of Agricultural Research and Experimentation

NARS - National Agricultural Research System

CGIAR - Consultative Group on International Agricultural Research

CIAT - Centro Internacional de Agricultura Tropical

CIMMYT - Centro Internacional de Mejoramiento de Maïz y Trigo

CIP - Centro Internacional de la Papa

IRRI - International Rice Research Institute

IFPRI - International Food Policy Research Institute

CPA - Centers for Agricultural Research

ICRISAT - International Crops Research Institute for the Semi-Arid Tropic

CENARGEN - National Center of Genetic Resources

IBPGR - International Board for Plant Genetic Resources

CTAA - Center for Agricultural and Food Technology

SNLCS - National Service for Soil Survey and Conservation

SPSB - Service for Production of Basic Seeds

IPAGRO - Agronomic Research Institute

IRGA - Rio Grande do Sul's Rice Institute

IAPAR - Paranã's Agronomic Institute

CEPEC - Center for Cocoa Research

IARCs - International Agricultural Research Centers

IITA - International Institute of Tropical Agriculture

CNPAF - National Research Center for Rice and Beans

CPAC - Research Center for Cerrados' Agriculture

UEPAE - State Unit of Research Execution

EMPASC - Santa Catarina's Agricultural Research Company

EMCAPA - Espírito Santo's Agricultural Research Company

EMGOPA - Goiãs' Agricultural Research Company

EMPARN - Rio Grande do Norte's Agricultural Research Company

CNPMS - National Research Center for Maize and Sorghun

CPATSA - Research Center for Semi-Arid Agriculture

CNPMF - National Research Center for Cassava and Tropical Fruits

CNPT - National Research Center for Wheat

IRAT - Institute de Recherches Agronomiques Tropicales

IPA - Pernambuco's Agricultural Research Company

IIAC - Interamerican Institute of Agrarian Sciences

PESAGRO - Rio de Janeiro's Agricultural Research Company

EPAMIG - Minas Gerais' Agricultural Research Company

OCEPAR - Organization of Paranã's Cooperatives

FECOTRIGO - Federation of Rio Grande do Sul's Wheat Cooperatives

CNPA - National Research Center for Cotton

CNPS - National Research Center for Soybeans

UNESP - São Paulo's State University

UEPAT - Territorial Unit of Research Execution

EMAPA - Maranhão's Agricultural Research Company

EPABA - Bahia's Agricultural Research Company

EMPAER - Mato Grosso do Sul's Agricultural Research Company

A STUDY OF COLLABORATION BETWEEN INTERNATIONAL AGRICULTURAL RESEARCH AND BRAZIL

1. Background

1.1. The Country

1.1.1. Natural and political setting

In territorial extension - 8.51 million square kilometers - Brazil is the fifth largest country in the world, coming after the Soviet Union, Canada, China and the United States. It covers 47 percent of the total extension of South America. The country is divided into five geographical regions: a) South, including the states of Rio Grande do Sul, Santa Catarina and Paranã, with 6.8 percent of total area; b) Southeast, including the states of São Paulo, Minas Gerais, Rio de Janeiro and Espírito Santo, with 10.9 percent of total area; c) Center-West, including the states of Mato Grosso do Sul, Mato Grosso, Goiãs and the Federal District, with 22.1 percent of total area; d) Northeast, including the states of Bahia, Sergipe, Alagoas, Pernambuco, Paraíba, Rio Grande do Norte, Ceará, Piauí and Maranhão, with 18.2 percent of total area, and e) North, including the states of Parã, Amazonas, Rondônia and Acre, as well as the territories of Roraima and Amapã, with 42.1 percent of total area. Most of the country's area is tropical with adequate rainfall. An important exception is part of the Northeast region, where in some areas rainfall is less than 10 inches a year. Although most of this region has a rainfall range of 20-25 inches there has been irregularity in the recent past (Baer, 1983).

Three levels of government prevail in Brazil: federal, state and city. The 1964 law, by which the President and Governors were elected by the so-called electoral college and not by the people directly, was changed in 1982 so that all the state governors were again elected in normal and direct elections. The

tradition in Brazil has been a strong executive branch as compared with the legislature (Congress), mainly in terms of the setting of economic policies. Brazilian development model has been based on the ideology of market economies, including its industrialization after the thirties, but with a quite important presence of the public sector not only in decisions about policies and regulations but also in direct involvement in productive activities (Baer, 1983). After twenty years of a military type of federal government, in january 1985 a civilian was elected President, with the innovation of being from the opposition forces in the country. It is very likely that in 1988 the country will return to the system of direct elections for the Presidency.

Economic policy in its different components, macro-economic, fiscal, monetary, agricultural, industrial, commercial, etc, is largely determined at the federal level and by the executive branch of the government. The states and cities, for instance, have little autonomy in deciding about fiscal matters, but even at those levels of government, when deciding about expenditures, the executive is the most powerful branch. However, with the political changes under way presently in Brazil it is likely that in the future, when returning to a full democratic form of government, the legislature at all three levels will have greater power in deciding about economic and other critical problems. In agricultural policy such a change would involve more discussions in the legislature about specific policies, including price supports, buffer stocks, credit, research, extension, regional development and others.

1.1.2. Population

In 1980, when the last census took place, Brazil's total population had reached 119.0 million people with an average rate of growth during the seventies of 2.49 percent. For the second consecutive decade, the rate of population growth has declined: during the forties it was 2.39 percent, in the fifties,

2.99 percent, in the sixties, 2.89 percent and, finally, 2.49 percent during the seventies. Brazil's total population in 1980 made the country the sixth largest one in the world. The distribution of population then over the country's geographical regions was as follows: South, 16.0 percent, Southeast, 43.5 percent, Center-West, 6.3 percent, Northeast, 29.3 percent and North, 4.9 percent. It can be seen that Brazil has a high degree of concentration of its population in the Southeast and Northeast regions, the former with 10.9 percent of total area had 43.5 percent of the population, while the Northeast had 18.2 and 29.3 percent respectively. The population density in Brazil varies from 1.6 per square kilometer in the North to 255.3 in the state of Rio de Janeiro, part of the Southeast region.

Besides still having a high rate of population growth, it is important to note that Brazil has had, over the period of its more intense industrialization (after the thirties), a much more rapid rate of growth fo the urban population than the rural. In 1940, 31.2 percent of the population was urban and 63.8 percent rural; in 1960, 14.7 percent urban and 55.3 rural; in 1970, 55.9 percent urban and 44.1 percent rural and in 1980, 67.6 percent urban and 32.4 percent rural[1]. In 1980, the rural population experienced a decline in absolute terms for the first time. These figures indicate clearly a drastic and quite rapid move towards urbanization of the Brazilian population and very likely at a higher rate than that experienced by countries with an earlier pattern of industrialization. The resulting problems in terms of housing, education, transportation, water and other urban services are clearly visible even today in major Brazilian cities.

As mentioned, the population growth rate in Brazil during the seventies was 2.49 percent. In addition, it is worth mentioning that as between states and territories, the observed

---

(1) During the forties the average annual growth of the urban population was 3.84 percent, in the fifties, 5.47 percent, in the sixties 5.16 percent and in the seventies, 4.48 percent.

range was from 0.97 percent in the state of Paranã (South) to 16.0 percent in the state of Rondônia (North, but just west of Mato Grosso state in the Center-West region). The state of Paranã is very well established and developed in terms of agricultural production, with its growth concentrated in the last forty years. Until the sixties its growth was based on coffee – an exported crop – and mayze and edible beans – domestic crops. After the mid-sixties, however, crop mix changed, mainly towards the combination soybean – wheat, the former an exported crop and the latter an import – substitution one. As a result, employment growth was much lower (Homem de Melo, 1983).

At the same time an opposed pattern was developing in Rondônia and a few other states in Brazil's North and Center-West regions, either because of the crop mix – Rondônia, with coffee, cocoa, domestic food crops – or because of a high growth rate in total cultivated acreage – Mato Grosso, as the best example with 6.6 percent for the population growth rate. Other states with relatively low rates of population growth in the seventies were Rio Grande do Sul (South) with 1.56 percent and Minas Gerais (Southeast) with 1.54 percent. With relatively high rates, besides Rondônia and Mato Grosso, we can mention the states/territories of Parã (North) with 4.64 percent, Amazonas (North) with 4.10 percent, the Federal District (Center-West) with 8.13 percent, Amapã (North) with 4.37 percent and Roraima (North) with 6.86 percent. These numbers indicate a process of relative change in size of population, from the older and more developed states to the more distant ones – the so-called "frontier" states – in the Center-West and North regions, characterized by a low proportion of total arable land in cultivation (Dias, 1978).

Some progress has been made in Brazil with respect to the rate of literacy of the population 15 years and older: 49 percent in 1950, 61 percent in 1970 and 69 percent in 1980 (75 percent 10 years and older) (Baer, 1983). Of the 62.7 percent of the population in 1980 that was 15 years or older, only 13.7 percent had nine or more years of schooling. The highest percentages with nine or more years of schooling were found in

the states of Rio de Janeiro, 23.2 percent, São Paulo, 17.5 percent and Rio Grande do Sul, 16.6 percent; the lowest were in Maranhão, 5.65 percent, Piauí, 6.85 percent and Alagoas, with 6.94 percent, all in the Northeast region, the problematic and low-income part of the country. Finally, in 1980, 36.8 percent of the population was economically active (work force), of which 27.5 percent were women (30.4 percent in the state of São Paulo, the highest figure).

1.1.3. Economy

The structural transformation experienced by the Brazilian economy over the last fifty years has been very significant. While in 1920 the country had 69.7 percent of its work force still engaged in activities of the primary sector, in 1980 the percentage was only 29.9. This shift can also be expressed by the average growth rates for the different sectors of the economy between 1949 and 1981: agriculture, 4.7 percent; industry, 7.9 percent; commerce, 6.2 percent; transportation and communication 8.5 percent. The industrialization occurring in Brazil before World War II resulted much more from incentives coming from external conflicts and a severe world economic depression (besides the gradual development of internal demand), than from something resembling a deliberate industrialization policy. For instance, Furtado (1965) mentions the increase in capacity of the industrial sector during periods of depreciation of the Brazilian currency. Between 1929 and 1937, when imports declined 23 percent, industrial production increased 50 percent, and, after the mid – thirties, the growth in industrial output was accompanied by expansion in capacity (Baer and Villela, 1973). However, as late as 1940 Brazil still had 67 percent of its work force in the primary sector and only 15 percent in the secondary sector of the economy.

Several reasons have been presented in the economics literature to explain why Brazil reached such a point in the twentieth century with its industrial and service sectors so

relatively little developed. First, we can mention Portugal's commercial policies towards its colony, with respect to reserving the Brazilian market for Portuguese and British manufactures (Baer, 1965). Second, the institutional-social structure of the country did not evolve in a way facilitating industrialization. That is, interest groups, formed by large land owners engaged in exporting as well as the commercial sector in coastal cities, influenced the formulation of exchange and commercial policies, education, labor and fiscal policies in ways unfavorable to an earlier industrialization (Bergsman and Candau, 1969). Finally, the highly profitable opportunities for agricultural exports, mainly coffee, attracted resources, including entrepreneurial capacity, from the industrial sector. It is well known that support policies for coffee production resulted in sizeable excess production. Krasner (1973), for instance, mentions that Brazil started to tax the coffee sector only after World War II.

A deliberate policy with a high degree of priority given to industrialization was started in Brazil only at the end of the forties to the mid - fifties. At that time, several Latin American countries foresaw low growth for their agricultural exports, mainly with markets in the already developed countries, while they were facing high population growth rates and problems related to rural-urban migration (Wionczek, 1973). The result was the definition of a development strategy through industrialization, in the expectation of high growth rates. Also, with the creation of a modern industrial sector, the countries expected to decrease their dependence on the world economy, including that related to fluctuations in foreign exchange revenue. Prebish (1959) was the most important voice for the argument favoring a deliberate industrialization policy, based on the unequal distribution of gains from international trade. Hirschman (1968) also mentioned that with such a development strategy the countries in question were hoping to escape from the economic, social and political backwardness prevailing up to that moment.

As mentioned at the beginning of this section, the

transformation of the Brazilian economy over the last fifty years has been quite significant, particulary after the implementation of a deliberate industrialization policy 30-35 years ago. In 1980, the country had only 29.9 percent of its work force in the primary sector, against 22.9 percent in industry, 9.4 percent in commerce, 4.2 percent in transportation and communications, 4.1 percent in public administration as well as 2º.5 in other industrial and service activities. For a more precise comparison, we can mention the same figures for 1950: 59.9 percent in the primary sector, 12.8 percent in industry, 5.5 percent in commerce, 3.7 percent in transportation and communications, 3.0 percent in public administration and 14.3 percent in other activities.

During 1950/81 the average annual GNP growth was 6.8 percent, 7.9 percent an average for industry and 4.7 percent for agriculture as already mentioned. In 1980, Brazilian GNP was US$ 274.3 billion (1981 dollars) and in "per capita" terms, US$ 2.303. The sectoral contribution (income) in 1980 was the following: agriculture (primary), 13.0 percent, industry, 34.0 percent and services, 53.0 percent.

In 1973, Brazil's trade account was in balance: exports of US$ 6.199 billion as against imports of US$ 6.192 billion. In that same year, the country's total external debt was at US$12.60 billion with reserves valued at US$ 6.42 billion. The first oil "shock" in 1973/74 brought serious problems to Brazil's external sector. Although growth rates kept close to the historical average, around 7.0 percent, they were lower than those observed during 1968/73, about 11.0 percent. Also, after 1973, Brazil's total external debt increased quite strongly, coming to a total of US$ 43.51 billion in 1978. Gradually, the Brazilian economy, due to the size of its external debt, became extremely vulnerable to increases in interest rates internationally.

In fact, 1979 was the beginning of a very unfavorable period for Brazil. First, it saw the first round of the second

deficit situation of US$ 2.84 billion in 1979 and US$ 2.83 billion in 1980. Secondly, the country's external vulnerability was clearly evidenced by the beginning of a dramatic increase in interest rates, nominal and real, internationally. The "prime rate" in the United States increased from 11.75 percent in December 1978 to 15.25 percent in december 1979 and finally to 21.50 percent in December 1980. The impact of these changes in the total value of interest paid by the country was subatantial: from US$ 2.70 billion in 1978 to US$ 9.16 billion in 1981 and US$ 11.36 billion in 1982. Thirdly, the country also experienced a substantial decline in terms of trade, 38 percent from 1978 to 1982, a situation which was aggravated by the recession observed in international trade. At the end of 1982, Brazil's total external debt had reached US$ 69.65 billion and the country was signing an agreement for "economic adjustment" with the International Monetary Fund.

After the deficits in the trade account during 1978/80, there was a surplus in 1981, US$ 1.20 billion, which continued in 1982, 1983 and 1984. In 1982, the surplus was at US$ 779 million, in 1983, US$ 6.50 billion and in 1984 it reached about US$ 13.00 billion. Several attempts were made by the Brazilian government after 1978 to implement more favorable exchange and commercial policies. However, because of other goals of economic policy, mainly control of inflation, those attempts were not effectively translated, over the period, in a consistent devaluation pattern. Only in the second semester of 1982 and most clearly after the signing of an agreement with the International Monetary Fund in early 1983 can it be said that Brazil started to have a consistent exchange rate policy. In February, 1983 there was a major turning point in the exchange rate policy with the introduction of a thirty percent devaluation of the cruzeiro vis-a-vis the American dollar. From that point to the present the cruzeiro has been devalued monthly in magnitudes exactly equal to internal inflation. As a result, it can be said that from early 1983 to the present, Brazil

with previous years. Certainly, this was one of the factors responsible for the good performance of the country's trade account in 1983 and 1984.

1.2. The Agriculture Sector

1.2.1. Structure

Agricultural production in Brazil can be considered still highly concentrated regionally. For instance, taking into account only six domestic food crops, the share of Brazil's South and Southeast regions during 1970/74 was the following (Homem de Melo and Accarini, 1979): potatoes, 97.9%; onions, 85,4%; maize, 81.1%; edible beans, 59.5%; rice, 56.7%; and cassava, 41.3%. When including the Center-West region in rice production, the Center--South's share goes to 82.0%. However, taking a longer time period into consideration, a greater participation of the Northeast region in the production of a few domestic food crops can be noticed. In the production of edible beans, the Northeast share evolved from 13.3% in 1931/33 to 21.8% in 1952/54 and to 31.0% during 1979/80. In cassava, the respective figures were 21,6, 44.5 and 53.9%. In rice, the figures were 6.9, 10.5 and 16.5% respectively (Homem de Melo, 1983).

On the other hand, production of coffee, soybeans, peanuts, tobbacco, cotton and oranges, all of them exported crops, are even today concentrated in the South/Southeast regions or more broadly in the Center-South region. Cocoa is a Northeast crop – basically concentrated in the state of Bahia – and sugarcane has a significant production share – 34.5 percent – coming from the coastal area of the Northeast. If a pattern can be detected in the regional crop distribution, it is towards the South/ /Southeast regions and more broadly the Center-South region becoming more specialized in production of export crops, those

foods (Homem de Melo, 1983).

During 1979/80 total cultivated area for 22 crops was 47.34 million hectares. The ten most significant crops in share of total area at that time were the following: maize, 24.3%, soybeans, 18.1%, rice, 12.3%, edible bean, 9.5%, cotton, 7.8%,wheat, 7.3%, sugarcane, 5.5%, coffee, 4.6%, cassava, 4.4% and orange, 1.2%. In total, the ten crops occupied 95.0 percent of the total cultivated area. The share of area in sugarcane has been increasing since 1979/80 because of the introduction of the alcohol program which effectively started in 1977.

Since the importance of exported crops in the agriculture of Brazilian's Southern region was mentioned, it is also relevant to point out the great dependence, historically, of the country's exchange revenue on agricultural exports. For instance, as late as 1960/67 the share of agricultural in total exports was 86 percent (Zockun et al, 1976). In 1970 it was 75 percent while by 1974 agriculture's share had declined to 67 percent.Certainly, the decrease of agriculture's share is also the consequence of progress made by Brazil in exporting industrial products after the introduction by the government of a program of export promotion. This program exempted industrial exports from all indirect taxes as well as giving them a credit of equal value. Another important measure taken in the second half of the sixties to stimulate exports in general was the use of short term mini-devaluations of the cruzeiro, as compared with the previous practice of devaluing only after six to twelve months in line with high domestic inflation.

This last measure, together with a favorable period of international prices, greatly benefited agricultural exports and, as a consequence, the share of exports in total agricultural product increased considerably: for instance, from a share of 10.7% in 1960, exports represented 13.3% in 1970, 20.8% in 1975 and 20.2% in 1980 (Mendonça de Barros, 1982). At the same time, Brazilian agricultural exports became more diversified. From an

sugar, cocoa and cotton, up until the mid-sixties, the composition of agricultural exports gradually became a more diversified. Substantial growth, in quantity and value terms, has occurred in the cases of soybean and its products, and in beef, orange juice, poultry and tobacco. Consequently, the so-called "traditional" exports – which include those with low growth of world demand, mainly coffee, cocoa, sugar and cotton – have in the last years had a share considerably lower than that observed during the fifties and sixties.

Let us take a look at those shares for the year 1981. With total exports of US$ 20.13 billion, the joint share of coffee, cocoa, cotton and sugar was 14 percent, while at the same time the joint share of soybean and its products, beef, orange juice, tobacco and poultry was 23 percent. In other words, "traditional" agricultural exports have became less important to Brazil than those exports which practically just started after the late sixties. This capacity the coultry has shown over the last 20 years, of diversifying its agricultural export composition, is clearly a favorable aspect of its agriculture. That is, Brazil's agriculture was able to respond effectively to different circunstances in its external sector, either domestically – through exchange rate policy – or internationally – through favorable prices and growth in trade. In fact, an important segment of Brazil's agriculture is and has been competitive national markets. Later on this international competitiveness of this segment of Brazilian agriculture will be contrasted with the situation of domestic crops, which are mainly important foods for low-income families.

In 1972, Brazil had a total of 3.328 million farms with the following distribution of the work force: 4.102 million owners and their families; 925 thousand permanent salaried workers; 7.820 million temporary salaried workers; 380 thousand sharecroppers and 112 thousand land renters (Homem de Melo and Accarini, 1979). The work of family members has been more important

region – as well as in Espírito Santo – Southeast region – and Ceará – Northeast regions – and less important in the states of Paraná – South region –, São Paulo and Minas Gerais – Southeast region –, and Pernambuco – Northeast region.

One of the critical aspects of the recent development of the Brazilian economy is the disequilibrium between the rural and urban sectors. For instance, average urban income was 117 percent higher than rural in 1960, 174 percent higher in 1970 and 133 percent higher in 1976. It is very likely that the comparison for aggregate average income hides the situation for different components of Brazilian agriculture, such as export – commercial crops versus domestic – subsistence ones, or Southern region versus North/Northeast regions. However, the discrepancy is so large that it can not pass unnoticed. With respect to regional differences, during 1970/72 the state of São Paulo – the most advanced agricultural state in the country – had a value added per worker 352 percent higher than that in the Northeast, 160 and 76 percent higher respectively than those of neighboring states of Minas Gerais and Rio de Janeiro, as well as 48 percent higher than that of the developed South region (Paraná, Santa Catarina and Rio Grande do Sul) (Mendonça de Barros, 1982).

Also, the disequilibrium just mentioned seems to be reflected in the rural-urban distribution of poverty: for instance, taking as a measure of poverty those receiving incomes below two minimum-wages in 1974/75, Mendonça de Barros (1982) indicated that 42 percent of rural families were poor as against 10 percent in metropolitan areas and 24 percent in other cities. In the Northeast, 62 percent of rural families were considered poor as against 18 percent in the South region, another evidence of the regional imbalance in Brazilian agriculture.

However, adopting a more rigorous concept of poverty – defined in terms of basic needs and adjusted for regional price differences – Fava (1984) came to somewhat different conclusions. In Brazil as a whole, 31.8 percent of rural families were poor

cent in metropolitan areas. This approximately even pattern was observed for states such as São Paulo, Minas Gerais and Espírito Santo (Southeast region) as well as for the South and Northeast regions. However, a severe regional imbalance remains: while in the Northeast 45.1 percent of rural families were poor, in the South only 14.7 percent were in this category and in the state of São Paulo, 22.7 percent. Fava's conclusion was that "the results obtained do not support claims that poverty is predominantly a rural phenomenon. This conclusion normally comes from research adopting only one poverty line for urban and rural areas" (p. 130). With such results in mind, at least part of the drastic difference in average rural/urban incomes above indicated would be mitigated by regional variations in the cost of living which would tend to make real incomes more equal.

Finally, a word about the pattern of land distribution in Brazilian agriculture. The available comparative evidence shows a high degree of concentration of land ownership in the country, which has had a tendency to increase over time[1]. In 1970, for instance, farms with areas below the median occupied only 3 percent of the total area while the 5 percent of largest farms occupied 67 percent of the total area. In 1960 the Gini coefficient in Brazil was 0.828. At approximately the same time, the Gini coefficient for other countries were: Austria, 0.684; England, 0.700; Canada, 0.541; Mexico, 0.929; United States, 0.707; Colombia, 0.823; Uruguay, 0.816; Venezuela, 0.920; India, 0.379; Philipines, 0.409; South Africa, 0.644; Egypt; 0.410; Australia, 0.830; New Zealand, 0.735. With these figures, there is no doubt that land ownership is highly concentrated, as it seems to be in many other South American countries (Gini coefficient of 0.844 in 1960). In Brazil's states, the lowest values for the Gini coefficient in 1970 were for Espírito Santo, Santa Catarina and Paraná in the South/Southeast regions as well as in Rondônia, Acre and Roraima in the North. The highest ones were

(1) For details and the following data, see Hoffman and Graziano da Silva (1975).

for Mato Grosso, Maranhão and Piauí, the last two in the Northeast. Among the most important implications of the historical pattern of concentration in land ownership, two will be here emphasized: first, the resulting concentration in the distribution of income in rural areas (Hoffman and Graziano da Silva, 1975) and second, its influence on generating an extensive pattern of agricultural growth in a country relatively abundant in land resources (Dias, 1978).

1.2.2. Infrastructure and institutional support

There was clearly on option in Brazil for highways as compared to other modes of transportation. Also, contrary to a frequent argument, this option preceded the creation of the Brazilian automobile industry late in the fifties, more precisely in 1957[1]. In 1950, for instance, the share of highway transportation in the total for goods was 38.0 percent as against 29.2 for railway, and 32.4 percent for waterways/coastal ships. In 1955, just before the beginning of the domestic automobile industry, those shares were respectively 52.7, 21.2 and 25.8 percent and an additional 0.2 percent for air transportation. In the same year as the first oil "shock" in 1973, the distribution of transport for goods was even more concentrated in highways, with 70.0 percent, while railways had 17.7 percent, waterways/coastal had 10.0 percent, pipelines had 2.1 percent and air transportation stayed at 0.2 percent. Finally, the respective shares for 1980 were: 70.5, 16.3, 10.1, 2.9 and 0.2 percent.

It is also interesting to note that Brazil has had one of the highest shares of highway transportation in the world and one of the lowest for railways. In 1976, the situation was the following: Brazil, 68.5 percent for highway and 19.1 percent for railway; Third World, 42.3 and 38.5 percent; developed capitalist countries, 30.0 and 40.0 percent; communist countries, 7.0 and 73.0 percent; world average, 22.4 and 53.0 percent (Homem de Me-

(1) For details, see Homem de Melo and Fonseca (1981).

lo and Fonseca, 1981). Given the territorial dimension of Brazil and the spatial distribution of agricultural production, it is possible to note how the country in general and producers / consumers of agricultural commodities in particular were negatively affected by the two successive oil price increases during the seventies. Although the growth in cultivated acreage has been the most important source of output growth in Brazilian agriculture over time, the drastic increase in the relative price of oil products will make it much more difficult for that strategy to continue in the future.

Brazil has invested considerably in the development of its transportation system, but as can be noted with the figures provided above, such investment has been highly biased towards highways. The share of highway investment during 1960/77 was in the range 72.7 - 81.7 percent of total investment in transportation. The attempt made by the Brazilian government to change this situation after the first drastic increase in oil prices during 1973/74 was not succesful. The intention was to change the transportation mix by the end of the seventies to 32 percent railway, 54 percent highway and 14 percent waterway/coastal. In 1980, however, such shares were respectively 16.3, 70.5 and 10.1 percent, with even a small reduction in the railway share from that of 1973.

On the positive side, however, it is relevant to point out that such investments led to an impressive growth of the Brazilian highway network, which from the agriculture side represented a significant step towards integrating producing and consuming regions. From 1960 to 1977 the total length of the highway network increased 224 percent, with the share of paved highways increasing from 11.7 percent to 36.6 percent. In 1977 the total of mid/long distance paved highways was 72.4 thousand kilometers. On the other hand, from 1970 to 1979 the total length of the railway network in the country declined from 31.3 to 30.0 thousand kilometers (Homem de Melo and Fonseca, 1981).

In spite of a high degree of concentration in highway

investment, it is clear that Brazil has made significant progress in its transportation system. For instance, when comparing the situation in the late sixties with the one prevailing in the late forties and early fifties, Smith (1969) concluded that "most of the bottlenecks have been eliminated in the Center-South of Brazil, largely through public investment in roads and storage and private expansion of marketing facilities in response to high profits. This has been accompanied by a definite downward trend in marketing margins through wholesale in much of the region". In addition, Smith found that in the mid-sixties margins through wholesale for rice, mayze and beans in several producing areas in the Center-South were quite similar to those prevailing in the United States.

Quite likely the same problems caused by a poorly developed transportation system, as detected by Smith in the late forties for the older agricultural states of Brazil, may be occurring today for the newer agricultural states in the Center-West, North and Nostheast regions. That seems the case also for storage in the states of Mato Grosso and Goiãs (Center-West), Rondônia and Parã (North) as well as in Maranhão (Northeast). In a way, it could even be considered normal that in a country with the territorial dimension of Brazil, public investment in infrastructure should lag behind the penetration of productive activities. Presently, however, some important construction is underway: two highways, Cuiabã (Mato Grosso) - Porto Velho (Rondônia), Cuiabã - Santarẽm (Parã), and one railway in the state of Maranhão, with 900 kilometers, to serve the export of minerals from Project Carajãs, undoubtedly bringing a new impulse to agricultural activity in the area.

With respect to institutional support for the agricultural sector, a few comments can be made. The first one will be about the organization of services and the formulation of agricultural policy at the federal level. Probably somewhat different from other countries, e.g. Argentina, the Brazilian Ministry of Agriculture is at the same level as other ones, particulary those

involved in economic decision-making (Treasury and Planning Ministries). However, as past experience has indicated, in matters where agricultural policies relate closely to broader economic policies, much discussion goes on but, in the end, decisions are actually taken either at Treasury or Planning, or even by both together. On some occasions, this pattern of decision-making has caused political "noises" and strong reactions from the leadership of the agricultural sector.

In spite of those problems, it is quite difficult to imagine a different type of decision-making, particularly one where major policy decisions related to agriculture would be taken by the Ministry of Agriculture, viewed as a political organization to represent and defend the producers' interests. In our opinion this is so not only because of the existence of a broader development strategy for the country, but also because of the distributive implications, mainly when consumers are taken into account, of policy decisions related to agriculture. In addition, there are also the short-run implications of such decisions for monetary, credit, fiscal and other macro-economic policies. A few data will illustrate our point about distributive implications of agricultural policies. During 1974/75 the share of food in total family expenses were as follows: for the expenditure class below two minimum-wages[1], 50.9% in the state of São Paulo, 49.0% in Rio de Janeiro, 58.5% in the South region and 63.0% in the Northeast region; at the other extreme, for families with total expenditures above 30 minimum-wages, such shares were: 6.1% in São Paulo, 6.5% in Rio de Janeiro and 5.6% in the South region[2].

The concentration of power over economic decision-making in the Treasury and Planning ministries is most clear in credit, price support and commercial policies. Formally, decisions related to these areas are taken by the National Monetary

(1) In december, 1984, the minimum-wage in Brazil was Cr$ 166.560.

(2) In the Northeast, 16.9% for the expenditure class above seven minimum-wages.

Council, a forum with representatives from several ministries and the private sector, but effectively controlled by the ministers directly involved with economics. Some of the technical work prior to the actual decision-making is done by the Ministry of Agriculture. It is the case, for instance, of the Companhia de Financiamento da Produção (CFP)[1] in matters connected with definition of minimum prices for different crops just before the beginning of every crop year[2], as well as the requirements of working capital for each crop and type of technology. Nowadays, the minimum prices set before planting time are indexed to the monthly inflation rate until the beginning of harvest time, with the objective of keeping constant their real values.

At that moment, however, the monetary implications of this policy of price support become very clear. Two basic instruments exist to implement the policy. These are the so-called Acquisitions of the Federal Government (AGF) and Loans of the Federal Government (EGF). The first one represents the farmers' right, established by law, to sell any quantity he wants to the federal government, represented by the Companhia de Financiamento da Produção (CFP) and the Bank of Brazil, at the indexed minimum price. In other words, the federal government cannot refuse to puchase the amounts being offered. In practice, however, farmers have ofter faced difficulties in making such a transaction because of a lack of financial resources at the Bank of Brazil, resulting from short-run restrictions in monetary policy.

The same difficulties, probably to a higher degree, have been faced by farmers when trying to make an EGF transaction. This is a loan of 3 - 6 months, allowing farmers to wait for the best moment to sell. Here, however, there is no legal obligation for the federal government to actually extend the credit, as part of the price support mechanism. Its willingness has always

---

(1) Production Financing Company.

(2) The crop year goes from September 1st to August 31st.

depended on the over-all conditions of monetary policy, particulary when subsidized rates prevailed. It is not implied by these comments that such problems with implementing AGF and EGF transactions have occurred every year in the past. However, they have occurred ofter enough to make the price support policy an instrument of low credibility from the farmers' point of view.

Because of the low effectiveness of this policy, Brazil has not been able to form buffer stocks of sufficient size to have an influence on price stabilization. In India, according to Brown (1984), grain stocks have typically ranged from 11-15 million tons but had already reached 21-24 million tons, before coming down to 12-15 million tons during the 1979/80 drought. In Brazil, on the contrary, it is quite unlikely that the average carry-over held by the government of basic domestic crops has been higher than 5 percent of the level held by India. With this is mind, it should be no surprise that when considering 11 crops and five different indicators of farmers' price instability for the period 1948/76, it was found that together with coffee, the other five crops with highest instabilities were domestic (non-traded) (cassava, edible bean, onions, potatoes and rice), while the remaining ones were exported or had prices administered by the government (sugarcane)[1].

Within the structure of the Ministry of Agriculture there are several services in support of agriculture. Usually the institutional organization of such services is in the form of state-owned companies, today a quite frequent arrangement in other areas of the federal government, even in some cases, at the state level. In agriculture, this form of organization was instituted in the early sixties with a ministerial reform. At that time two such companies were created: CIBRAZEM - Brazilian Warehousing Company -, which was given responsibility for investment in storage as well as to make storage capacity available to farmers, and COBAL - Brazilian Food Company - given responsibility for the distribution of stocks as well as special pro-

(1) For details and specific results, see Homem de Melo (1979).

grams for food distribution mainly at urban centers.

It is worth noting that during the fifties, as a result of a report submitted by Klein and Saks (in 1954) and other reports by the joint Brazil – United States Economic and Technical Commission, marketing inefficiency was considered "one of the chief hindrances to development of Brazilian agriculture" (Smith, 1969). The recommendations of the latter commission included more infrastructure investment in transportation and storage, as well as more credit to farmers. As a result, it is possible to understand the creation of CIBRAZEM and COBAL in the early sixties as an effort of the Brazilian government to implement those recommendations. Particulary in the case of storage facilities, either through the direct action of CIBRAZEM or by special credit programs to increase capacity in the private (or cooperative) sector by farmers, traders or processors, the action of the government seems to have been reasonably successful. Actually, despite some quality deficiencies, most of the Center-South region is well-equipped in terms of storage capacity. As in the case of transportation, however, either quality or quantity problems exist in the newer agricultural states such as Mato Grosso, Goiãs and Maranhão.

INCRA - National Institute of Colonization and Agrarian Reform - has been responsible, until recently in the Ministry of Agriculture, and nowadays as part of the Ministry of Agrarian Reform and Development, for action related to land distribution and ownership. Clearly, Brazil did not have anything close to an agrarian reform with INCRA, created in the late sixties, or even before its creation. INCRA's work, until the second half of the seventies, was concentrated in the development of a few colonization projects in the so-called "frontier" states of the Center-West and North regions. From the late seventies to the present, INCRA intensified its work mainly related to regularizing titles of land ownership in conflict areas involving small sharecroppers, reaching a total of 800 thousand new titles. Attempts to increase land taxation to force large owners to either start

producing or sell the land have not brought significant results[1].

Two other important activities are under the direct coordination of the Ministry of Agriculture, agricultural research and extension, the first of which will be covered in greater detail beginning in the next chapter. In 1973, Brazil created two state-owned companies, to replace the previous research organization in the form of a direct public institution: EMBRAPA - Brazilian Company of Agricultural Research -, and EMBRATER - Brazilian Company of Technical Assistance and Rural Extension-, with responsibility, respectively, for research and extension activities. The extension service in Brazil was first developed in the Ministry of Agriculture under the name of Serviço Federal de Fomento (Federal Extension Service) and later on as Serviço de Promoção Agropecuária (Rural Promotion Service) (Schuh and Alves, 1971). Previously in 1945, ACAR - Credit and Rural Assistance Association -, was created in the state of Minas Gerais, starting a national system which in 1956 was named ABCAR-Brazilian Rural Credit and Technical Assistance Association. ACAR had in its beginning financial support from the American International Association (AIA) and the government of the state of Minas Gerais. From the early sixties, ABCAR received financial support from the federal government.

The popularity, in the fifties, of the "diffusion model" of agricultural development seems to have influenced the formulation of the strategy of agricultural support in Brazil, as is implied by the above brief historical review. In addition, the detailed work of Schuh and Alves (1971) showed that at the same time the activities related to agronomic research at the federal level were deciling, beginning in the early fifties, support for extension at that level was increasing, which was translated into greater financial outlays for it. It is not implied here that public expenditure on ex-

---

(1) Brazil has a land reform law, called Estatuto da Terra (Land Statute) since 1964. See details in Smith (1969).

tension was unnecessary at that time in terms of transferring new knowledge to farmers per se. However, in the case that the decision to emphasize extension is made on the wrong assumption that such technical knowledge already exists when, in fact, it doesn't, at least for the majority of farmers in their specific ecological conditions, the social rate of return on that investment may be quite low.

1.2.3. Pricing

When describing the mechanism of pricing in Brazilian agriculture it is useful to make the distinction between domestic (non-traded) and exported crops, as well as that between those whose prices are administered by the federal government and the others. Before going into the more controversial distinction — domestic versus exported crops — it should be mentioned that wheat, sugarcane and milk are the most important agricultural products with administered prices. Wheat has been imported by Brazil for quite some time and in the last few years the share of imports in total consumption has been around 0.60-0.70. In addition, since 1972, there has been a policy of subdizing consumers and, even before that, there was a policy of protection for domestic producers (Knight, 1971). The beginning of the wheat subsidy to consumers was more related to anti-inflation policies in 1972 than to any nutritional or distributive objectives.

However the subsidy was kept from 1972 until 1984 and only after Brazil's agreement with the International Monetary Fund early in 1983, was an effort has been made for its elimination. In 1984 the subsidy had a total cost in the range of US$ 400-500 millions. Although bringing benefits to an impressive number of low-income urban families it has, at the same time, unnecessarily favored middle and high-income ones, as well as bringing less benefits to rural families and to the Northeast, the poorest region of the country (Homem de Melo, 1984, p.04). In his review of consumer food subsidies, Pinstrup-Andersen

mentions that "a shift of existing explicit subsidies on wheat to rice would lower incomes to the rich, increase incomes of the middle-income group slightly and lower slightly to the poor" (Pinstrup-Andersen and Alderman, 1984). Although not being an ideal change on distributive grounds, it also shows that the wheat subsidy has its problems.

In spite of the fact that wheat production in Brazil has been protected — an import-substitution policy — since the fifties, at variable levels over time (Knight, 1971), imports still represent a large part of total consumption. Nowadays prices are fixed before planting, although adjusted monthly by the devaluation of the cruzeiro vis-a-vis the dollar, and the government buys the entire crop. Production has grown at rates in the range of 6.0-7.0 percent, mostly due to the growth in cultivated acreage in the states of Rio Grande do Sul, Paranã and more recently Mato Grosso do Sul. Yield growth has been minimum (except in the sixties) and production costs have been high. For instance, Knight (1971) mentions the following reasons for such a poor yield/cost performance: low quality of land, high cost of industrial inputs, varieties that fall down under high nitrogen doses, difficult climatic conditions and insufficient technical and scientifical support. Yields in Brazil are relatively low and have not experienced much growth over time. From the early fifties to the late seventies three year yield averages in Brazil were in the range of 507-956 kg/ha, with the same average range in the states of Rio Grande do Sul being 432-926 kg/ha, in Paranã, 758-1,058 kg/ha and in Mato Grosso, 407-1,376 kg/ha. Such large yield ranges are good evidence for what Knight (1971) called "difficult climatic conditions" for wheat production in the country. When examining the pattern of yield instability over the period 1967/76, we found that among 10 crops, coffee and wheat had the highest values for the different indicators used (Homem de Melo, 1982). As a matter of fact, Knight considers such climactic instability the most difficult factor for science to solve, at least under the conditions of Rio Grande do Sul. Late frosts, excess rains in certain critical periods and warm spring

favoring the incidence of diseases, are the factors that could not be altered with the technology available in the early seventies. In seems that such difficulties have acted to shift part of the Brazilian wheat production to the central part of the country, mostly in irrigated systems.

The system prevailing in the case of sugarcane production is also one of administered prices, which are fixed three times a year (February, June and October) by the IAA - Sugar and Alcohol Institute - of the Ministry of Industry and Commerce. However, just as was the case when discussing the political power of the Ministry of Agriculture, in deciding about sugar and alcohol prices the final decision belongs to the Planning Ministry. This has been much more so since Brazil implemented the alcohol production program to substitute for gasoline. With that, alcohol price became a component of the country's price policy for oil products. While real wheat price remains constant over the year because of indexation to a dollar value, sugarcane, sugar and alcohol prices lose in real terms during the months they are fixed in nominal terms.

Another important difference is that sugar is a traditional export crop, and all exports are made by the government through IAA[1]. Although the share of sugar production for the domestic market goes through private companies, it is at the fixed prices set by the government. It is important to emphasize that this is not a protection scheme (except in the Northeast), as in wheat production, but rather a price stabilization one. When, for instance, during some years in the seventies, international sugar prices reached US$ 1,000 per ton, domestic prices to all agents involved were much lower than that. On the other hand, as nowadays, when international sugar prices are about US$ 100 per ton, domestic prices are much higher. It seems that, as a result of such internal policy, farmers' prices have been more stable than international sugar prices: for the period 1967/76, the average percentage deviation (from the trend line) of

(1) For a historical analysis of the sugar industry in Brazil, see Szmrecsányi, T. (1979).

prices in Brazil was 9.7 percent as against 23.0 percent internationally (Homem de Melo, 1981). The same was true for wheat: 8.0 percent domestically as against 14.3 percent internationally for the average deviation.

There is a growing recognition in Brazil that sugarcane has benefited from technological innovations over time (Pastore et al, 1976, and Homem de Melo, 1983). This started in the last century with the importation of varieties from French Guyana and Java, as well as with the use of a native variety "Cristalina". However, the research work was intensified after 1930 in Campos' experimental station (Rio de Janeiro) and at Campinas' Agronomic Institute (São Paulo). The Javanese varieties were improved and others were developed (CB - Campos/Brazil). The research teams were small but highly capable. In 1971, all research work at the federal level was centered at PLANALSUCAR - National Program of Sugarcane Breeding - an organization within the Ministry of Industry and Commerce. This research institution received quite large additional support from the federal government and is today acknowleged as very well-developed and competent. In addition, this is one of the few areas where the private sector is effectively engaged in research, through the Technological Center of COPERSUCAR in Piracicaba, São Paulo. COPERSUCAR is, in a very atypical manner, a cooperative of private companies in the sugar industry, involved in agricultural production as well as in industrial transformation.

However, the technological progress brought about by such long term emphasis on sugarcane research has been highly concentrated in the Southern region of Brazil and particulary in the state of São Paulo. The average annual rate of growth of sugarcane yields in São Paulo between 1931/80 was 1.91%, followed by Paranã with 1.64%, Pernambuco, with 1.04%, and Paraíba, with 0.24%, these last two states in the Northeast. All the remaining producing states had no significant changes in yields or had declining rates. At the same time this unbalanced regional pattern of technological innovations was taking place in the sugar-

cane sector in Brazil, there was a substantial shift in the geographical location of this agricultural activity. The most dramatic one was represented by the state of São Paulo: from an area share of 8.94% during 1931/33, this state passed to 21.31% during 1952/54, to 31.04% during 1970/72 and to 38.28% during 1979/80 (Homem de Melo, 1983). Simultaneously there was a strong decline of the Northeast's share in the total sugarcane area.

With respect to the distinction between domestic (non-traded) and exported crops, let us start by saying it has nothing to do with food versus non-food. As a matter of fact, most domestic crops in Brazil are important foods for low-income families, but on theoretical grounds we could very well have a situation where a non-food crop was included in the category of domestic goods. It seems to us quite clear now that Brazilian agriculture has been for quite some time composed of two subsectors, one being the export subsector and the other the domestic one in the sense of being formed by non-traded goods[1]. This distinction is not based, as just said, on consumption patterns but on the nature of each market, being either open or closed to international transactions.

In an open agricultural economy, prices received by farmers closely follow changes in international prices and in the exchange rate, with the proper adjustments for marketing costs. Generally, we might think in terms of the export supply and demand functions. On the other hand, in a closed economy the relevant factors for price determination are the internal supply and demand functions. This last case is usually a consequence of the commercial policy adopted, through instruments such as tariffs, import licensing and, in the extreme, import prohibitions, as well as unfavorable internal cost conditions vis-a-vis international ones. Under the assumption of a "small country" case in international trade, there would be an influence from

---

(1) This part is based on Homem de Melo (1983). We are leaving aside for reason of simplicity the case of crops with administered prices as above described.

prices and rates of profitability of exported crops to prices of domestic (non-traded) crops, but not the reverse. As a result, we may have a situation where internal prices of domestic crops stay above the correspondent external ones (FOB or CIF), due to inadequate cost and supply behavior and existence of import restrictions. An intermediate case is also possible, that is, internal prices of domestic crops stay above the export price but below the import one[1]. In addition, it may be the case that a crop classified as domestic can be potentially exportable when there exists a well-developed international market or a developing one, although in the short-run internal cost conditions may prevent it from being internationally competitive.

The subsector of exported crops in Brazilian agriculture has included, over time, soybeans, oranges, sugar[2], tobacco, cocoa, coffee, peanuts, cotton, castor beans and a few others of lesser importance for the country's foreign exchange revenue. More recently, beef and poultry have become of some relevance with high export growth rates. On the other hand, the domestic sub-sector has included, with some variations over time, rice, edible beans, cassava, maize, potatoes, milk and onions, most of which are important foods for low-income families. As we said above, maize, rice and cassava can be considered as potential exportables since there exist either well-developed international markets, as are the cases with maize and rice, or a developing one, in the case of cassava, mainly as feed in the European Economic Community. However, in varying degrees over time, internal cost conditions have prevented a favorable competitive position internationally and, as a result, such crops have not been exported regularly on a significant basis as compared to domestic production. Among the domestic crops just mentioned, maize was the only one showing some exports, although quite irregularly, between 1967/79: During thes

(1) See the discussion about import and export points in Hinshaw (1975).

(2) A qualification is made for this product, since as discussed above, internal prices are administered by the government.

thirteen years, in four, exports were less than 1.2 percent of total production, in two, they were 3.4 and 5.1 percent, and in seven, between 6.8 and 10.3 percent of domestic production. Since 1979, maize has been imported rather than exported[1].

When computing the ratio of domestic (producers') to average international esport (FAO) prices (in cruzeiros) for the period 1948/77, the following picture emerges (Homem de Melo, 1983). First, the domestic crops rice, edible beans, potatoes and onions, had price ratios above one, in many years above two and, occasionally, above three. Second, sugarcane, coffee and cotton, three of our exported crops, had a regular pattern for the price ratio and always with values below one. Soybeans, on the other hand, had most values above one during the fifties but, consistently, below one during the sixties and seventies. Just about the same pattern was observed for maize and peanuts. Third, with respect to wheat, an imported product but having an import substitution policy, the price ratios were always above one and in many years above two. For some of the products included in the analysis, a downward trend seemed to exist, mainly in the cases of wheat, peanuts, maize, potatoes and soybeans.

As a result of such analysis, the conclusion, usually presented in the economics literature (Peterson, 1979; Alves and Pastore, 1978), of an implicit taxation of agriculture cannot be accepted as a general one. Clearly, some nutritionally as well as budgetarily important foods, such as rice and edible beans, had domestic prices in Brazil considerably above the international level over a long time period. For instance, Alves and Teixeira (1978), working with São Paulo's family - budget survey of 1971, have shown that rice and edible beans were responsible for 35% of the calories and 39% of the proteins consumed by low-income families (up to one minimum-wage "per capita"). In terms of food budget shares, rice and beans had in 1974/75 the following importance: in the state of São Paulo, 27.9% for families

(1) The exception was a special deal with the Soviet Union involving an export of 400 thousand tons in 1983, but immediately followed by imports.

with total expenditures below two minimum-wages; in the state of Rio de Janeiro, 21.8% below one minimum-wage; in the South region, 26.6% below one minimum-wage; in the Northeast region, 21.1% below one minimum-wage (32.8% when including cassava flour) (Homem de Melo, 1983).

It should not be implied, however, that, with the evidence just presented we are arguing that agriculture was not taxed over time in the process of Brazil's development strategy. After all, a price ratio below one does not imply absence of taxation, although it does indicate, respecting marketing costs, competitiveness in the international market. What seems to be the problem with the argument of several authors in the economics literature is that explicity or implicity they assume that all agriculture was an exporting sector, failing to see it as a segmented one, that is, formed by both domestic and exporting subsectors. A recent and comprehensive review by the Food and Agriculture Organization (FAO, 1983), basically with the same methodology employed in our analysis[1], shows that for some crops in certain countries during the seventies the situation was similar to that of Brazil, in the sense of having price ratios (domestic/international) above one. A few examples will suffice: maize, in Colombia, Egypt, Ghana, Morrocco, Philippines and Venezuela; potatoes, in Venezuela; rice, in Sri Lanka, Colombia, Republic of Korea, Nigeria, Philippines and Venezuela; sorghum, in Venezuela; wheat, in Algeria, Bangladesh, Brazil, Egypt, Morrocco, Peru, Sudan and Turkey. Variations of the price ratios over the years, as expected, were also observed[2].

If we accept this evidence, that is, a part of the Brazilian as well as the world agriculture is "semi-open"[3]

---

(1) The major noticeable difference is that in FAO's study producers' prices are compared with border prices (CIF and FOB).

(2) The results for rice in Brazil are quite different in our study and FAO's. Our price ratios were so high that we do not think taking CIF prices rather than average export price would explain the discrepancy.

(3) The term "semi-open" is also used by Myint in a manner quite similar to ours, although in a different context. See Myint (1975).

to international trade and not entirely open as usually assumed, it becomes relevant to analyse how the process of technological innovations can affect resource use among the subsectors domestic and traded. Let us start by assuming a strong bias favoring technological innovations in the traded (exported, mainly) subsector. Such innovations would provide the necessary conditions for altering the output mix through changing farmers' expected returns from available options. First, we will see the argument in general. A likely outcome is one in which resources are transfered from one set of activities to another favored by technological change, as such new technological options become diffused and available. If the total cultivated acreage could increase, incorporating new lands, the expansion may be predominantly oriented towards those crops favored by innovations.

Relevant factors influencing such an outcome are the type of technological innovation, market conditions and possibility of factor substitution. Here we want to discuss the effects of land-saving innovations, the so-called bio chemicals[1]. These innovations arise through the work of selection and varietal improvement, including a greater response to fertilizer application. In addition, they result in larger yields, cause practically no change in the final product and reduce production costs (Kuznets, 1972).

With respect to market conditions, reference is here made to price elasticity of demand, as particularly important for a greater generality of the result, that is, technological innovations affecting crop mix in favor of the benefited products. The higher the price elasticity of demand, the more likely is the occurrence of such a result. This conclusion can be obtained from Castro (1974), who developed a model for analysing distributive questions, with a two-stage production function and four factors: land and land-saving capital (bio chemicals) on the one hand, and labor and labor-saving capital (machinery) on the

---

(1) For a discussion of types of innovation, see Hayami, Y. and V.W. Ruttan (1971).

other, with a high degree of substitution in each stage but with low substitution between the two stages. Working with constant prices for all four factors, Castro showed that the demand for land would increase if $S_T n + S_L 6 > 6_T$, where $\underline{S}$ corresponds to factor shares of the aggregate factors (land plus bio chemicals; labor plus machinery), $\underline{n}$ to the price-elasticity of demand, 6 to the elasticity of substitution between the two subfunctions and 6_T to the same parameter in the land subfunction (land and bio chemicals)[1].

Now, if we introduce the case of a "semi-open" economy – traded and domestic goods – the picture described becomes clearer. Some of the recent literature reflects an increasing recognition of the possibility of such circunstances. For instance, Abbott (1979) mentions the case in which self-sufficiency is a national policy aim and the government allows consumption to increase or to decline with the level of domestic production. In addition, Castro and Schuh (1977) indicate that the choice of products is important for the determination of beneficiaries from agricultural research, because of the different demand price--elasticities, according to the market being open or closed to international transactions.

With such a situation in mind, we can analyze the implications for the production and consumption sides of the economy resulting from a process of technological change biased, in a certain time period, towards one or more of the exported crops. If we consider the case of land-saving biochemicals, the individual marginal cost curves and the market supply curve would shift to the right. With a perfectly elastic export demand, the cultivated acreage of the crop in qucstion would increase, with all these effects occurring with a constant product price. This represents the specific case where all direct benefits from technological change are appropriated by domestic producers (Schuh, 1976), including increases in land prices, mainly considering the location-specific nature of research results.

(1) See, also, De Janvry, A. (1977).

When total acreage is fixed, the change in the expected rate of return for the exported crop (or crops) benefited by innovations, would lead to the attractions of resources previously employed in the domestic subsector (possibly, also, from exportables not benefited) and, consequently, the relative prices of domestic crops would increase. This would continue until a new ewuilibrium relative price is attained, always assuming no change in the factors which brought the domestic subsector into existence. In other words, the composition of output would be affected in favor of the exportables benefited by technological change. A second possibility, already mentioned, is when total cultivated acreage can increase. In such a case, the process of acreage growth would tend to be directed towards the favored crops, in addition to the effect in regions already under cultivation. In those cases where the innovations are specific to a certain agricultural region of the country, the unfavored regions could show an increase in the production of domestic crops (because of higher relative prices) – by assumption, crops not benefited by technological innovations –, partly compensating the production fall in the former region. The important point to emphasize is that, as a result of such a pattern of innovation, prices of domestic crops internally may stay above the international ones or the difference may even be increased.

Furthermore, if the so-called domestic crops include important foods, in terms of budget shares of low-income families, as shown to be the case for Brazil, the increase in relative prices, following the contemplated change in growth rates, would be like a tax with regressive incidence. As a result, the unbalanced nature of the process of technological change among crops with different market characteristics, could bring a worsening of income distribution (from the expenditure side) (Williamson, 1977). For that scenario, it is necessary that we maintain the assumption of no changes in commercial policy or, alternatively, that the international market, at least for

certain commodities, is not a supplier able to complement domestic production. In addition, as important intermediate case should be mentioned: internal prices of domestic crops stay above the export prices but below the import ones. In such a case, the product would not be exported or imported.

The remainder of this section will examine the evidence concerning agricultural technologies originating from federal and state institutions until the early seventies[1]. After that time, changes in policy have brought a greater emphasis on research investments, mainly at the federal level, through EMBRAPA, with research centres in several states. With respect to the development of research at the federal level, after a short period in which several experimental centers were built and research conducted, there was a substantial decline in financial support beginning in the fifties. This and the low quality of the staff were the factors explaining the problems detected by Schuh and Alves (1971): lack of contact between researchers and farmers, repetitive experiments, no clear criteria for the choice of products and low emphasis on basic research. Most experiments were strictly routine, involving only comparison of varieties and fertilizer response.

At the state level of support, Pastore et al (1974) indicated only a few, São Paulo, Minas Gerais and Rio Grande do Sul, as having created and maintained research centers in the last 100 years. However, only São Paulo's experience had a greater success. In terms of effective results, the report of a Commission of the federal government in the early seventies indicated the following crops and locations showed significant developments in terms of higher yielding varieties: wheat in Rio Grande do Sul, sugarcane in Rio de Janeiro, as well as coffee, cotton, citrus and maize in the state of São Paulo (Paiva et al, 1973). Other researchers identified important results for coffee and cotton in São Paulo and sugarcane in Rio de

(1) This part of the paper draws heavily from Homem de Melo (1983).

Janeiro and São Paulo during the forties. Also, Fundação Cargill (1977) reported significant improvements for soybeans, beginning in São Paulo and later on going to Rio Grande do Sul (in the sixties).

As a result of this evidence, it seems that the claim that appropriate technologies were available in Brazilian agriculture in the fifties, is to say the least, an exagerated one. A few reasons justify this conclusion. First, of the crops with significant varietal improvements, only maize can be considered an important domestic product (only irregulary exported), the remaining ones being already exported, non-food or, even, an imported product (wheat). Secondly, although some of the technological developments occurred before or during the fifties, these were extremely localized in terms of influence, mainly covering the Southern region of Brazil. On this, we will simply recall the argument of Perrin and Winkelman (1976), that is, the need for technological developments which increase yields for specific agro-climatic environments. Finally, with the exception of sugarcane in Rio de Janeiro and wheat in Rio Grande do Sul, there is no evidence of contributions exclusively from the federally supported research centers. On the contrary, the evidence indicates the greater importance of research supported by the state of São Paulo, for exportables as well as for domestic crops (Silva et al, 1979). Only in the seventies was this situation reversed.

When analysing the research results obtained by Campinas' Agronomic Institute (IAC), the most developed research center in Brazil before the creation of the EMBRAPA's system in the early seventies, we reached the conclusion that they were in accordance with the mechanism of induced innovation in the public sector, since there appears to have existed a close association between the state of São Paulo's crop mix and research results (Homem de Melo, 1978). In this sense, São Paulo's research investment over time was mostly directed to what was

important to farmers in the state[1].

When comparing the product mix (by value) in São Paulo's agriculture prevailing from the late forties to the mid-fifties, and the ordering of crops in terms of number of publications from 1949/1964, there appeared a reasonable agreement for the ranks[2]. The five most important crops, in order, were coffee, cotton, rice, maize and sugarcane, while the five with more publications were coffee, potatoes, mayze, cotton and sugarcane. The greatest deviation seems to be rice, followed by potatoes. The lowest five in value were potatoes, edible beans, peanuts, cassava and soybeans, while the lowest five in publications were peanuts, soybeans, edible beans, rice and cassava. The most important deviation here appears to be soybeans.

In addition, it is useful to recall that Guttman(1978) presented and tested a model of the demand for public goods to explain differences in public allocations to agricultural research in the United States based on farmers as interest groups. In Brazil, Pastore et al (1976) have also argued that agricultural research is responsive to the nature of the product in three cases: when the crop is geographically concentrated, when it can be industrialized and when technology transfer from abroad is feasible. In the Brazilian case, the results obtained by the authors showed that the first factor was most important for coffee, while the two other ones were more significant for cotton and sugar. Also, for these three crops, the existence of a well developed international market has been positive factor in stimulating research effort. On the other hand, for rice and edible beans those factors were not present in the same degree of importance.

For products already present in Brazil's export list in the forties and fifties, the new technologies mostly bene-

---

(1) For the theoretical reasoning, see Biswanger H.P. (1977).

(2) The rank correlation coefficient was significant at 5 percent.

fited farmers because of the high price-demand elasticities they were facing. This would be a powerful incentive for farmers and their associations to press the public sector to continue investing in new production technologies. This, we believe, would be the cases of cotton[1] and sugarcane. A factor that might explain the emphasis on coffee, besides its importance as a crop in the state, is the fact that on the forties the federal government started the explicit taxation of coffee exports. As a result, new technologies would be a compensating factor[2].

For the other crops, the situation seems to be much more complex. For instance, the possibility of bringing the product to the exportables category and, as a result, generating benefits for São Paulo's producers, might help explain research effort for maize, soybeans and peanuts[3]. Also, the possibility of technology transfers from abroad might have acted as a facilitating factor for certain crops. That is, this transfer would be expected to lower the cost of doing research for certain commodities. Pastore et al (1976) mention cotton, sugarcane and maize (hybrid seeds) as benefiting from such a transfer. When examining Revista Bragantia, the scientific journal of Campinas' Agronomic Institute, it appears that soybeans, with American varieties (Fundação Cargill, 1977), and potatoes, with European ones, fit in this case. As a result, the domestic crops mainly edible beans, rice and cassava, with fewer export possibilities and/or no knowledge transfer from abroad, besides being less important in the state's product mix, were less contemplated by São Paulo's research effort.

In conclusion, it could be said that São Paulo's research program appears to have been mostly concentrated during

---

(1) The cotton research program is well documented by Ayer, H.W. and G.E.Schuh (1972).

(2) A compensating factor of this nature is mentioned by Scobie, G.M. (1979).

(3) The case of rice in Colombia where the prospect of exporting was an incentive for farmers to support a research program is mentioned by Scobie (1979).

1941/74 in coffee, cotton, sugarcane, potatoes, and maize. There was an intermediate degree of effort on peanuts, soybeans and, perhaps, edible beans, with the qualification that for this last crop it was much more routine as well as recent research. Finally, the lowest emphasis was on rice and cassava, two of the food products for the domestic market. If we add to the previous information that, at the federal level, significant results were obtained only for wheat and soybeans in Rio Grande do Sul and sugarcane in Rio de Janeiro, we have completed the picture in terms of availability of new technologies in Brazilian agriculture. Even with the limited number of crops being analysed, this is a heterogeneous picture and it should help explain the behavior of domestic-international price ratios as earlier discussed.

In addition, it is useful to check to what extent the observed technological developments were reflected in higher yields. It seems that generation of new technologies in Brazil was concentrated in the Southern states, mainly São Paulo, and on certain crops. It would be expected, however, that, even taking into account the location-specific nature of crop technologies of the biological type, states close to São Paulo, such as Minas Gerais, Paranã and Goiãs, would also benefit, although probably not to the same extent as farmers localized there.

Although using growth rates in yields as an indicator of the occurrence (and adoption) of biological-chemical technological developments, it should be emphasized that it is not a perfect one. Yields per hectare are also influenced by other factors, such as soil fertility, climate, and product and factor prices. Table 1 shows, for eleven crops and four ten-year periods, the rates of yield growth for those states where they were above 2 percent per year, as well as the observed rates for Brazil. Although this cutting-off point is arbitrary, it is sufficiently high to provide quite a large number of occurrences. Looking at these states with annual rates of growth above 2 percent, and the respective time periods, it is possible to get a better picture of technological developments:

TABLE 1

RATES OF GROWTH IN YIELDS, 11 CROPS, BRAZIL AND SELECTED STATES[1], DECADES

CROP	1940/49	1950/59	1960/69	1967/76
COTTON	BR = -5.99	PR = 6.39 SP = 4.91 BR = 1.07[2]	GO = 6.11 BR = -1.69	GO = 7.42 PR = 2.54 SP = 2.68 BR = -1.24[2]
PEANUTS		MT = 5.79 PR = 2.22 SP = 3.93 BR = 3.55	PR = 5.35[2] BR = -1.64[2]	SP = 2.55[2] BR = 1.17[2]
RICE	BR = -0.62[2]	BR = -0.42[2]	BR = -1.58	PR = 5.59[2] BR = -0.30[2]
COFFEE[3]	MG = 5.48 PR = 4.74 BR = 0.62[2]	ES = 3.17 SP = 2.22 BR = 1.23	BR = 0.18[2]	SP = 7.55 BR = 3.41[2]
SUGARCANE	CE = 3.80 SP = 5.70 BR = -0.11[2]	BR = 0.71	BA = 2.26 MG = 2.05 BR = 0.90	BR = 0.70
EDIBLE BEANS	SC = 3.26 SP = 5.96 BR = -2.90	BA = 4.61 BR = -0.22	BR = -0.32[2]	BR = -3.72
MANIOC	RGS = 7.77 SP = 9.21 BR = 0.48[2]	BR = 0.24[2]	PE = 2.35 SC = 3.88 BR = 1.28	BR = -2.44
CORN	MG = 3.19 BR = -0.29[2]	BR = -0.04[2]	BR = 0.42[2]	GO = 2.42 MT = 2.44 PR = 3.54 SP = 2.21 BR = 1.65
POTATOES	SP = 4.62 BR = -3.69	SP = 3.68 BR = 1.52	MG = 3.20 PR = 7.06 SC = 9.93 BR = 2.75	MG = [illegible]2 RGS = [illegible].06 SP = 5.69 BR = 3.53
SOYBEANS[3]		PR = 10.03 BR = -1.82[2]	BR = -0.21[2]	PR = 6.52 RGS = 5.51 SP = 4.78 BR = 6.16
WHEAT	BR = 1.76[2]	BR = -4.41[2]	PR = 2.29 RGS = 5.96 BR = 4.80	BR = -0.33[2]

(1) The states' abbreviations are: PR-Paraná, SP-São Paulo, GO-Goiás, MT-Mato Grosso, MG-Minas Gerais, ES-Espírito Santo, CE-Ceará, BA-Bahia, SC-Santa Catarina, RGS-Rio Grande do Sul, PE-Pernambuco.

(2) Not significantly different from zero at 5 percent.

(3) Coffee, 1967/75, Soybeans, 1952/59.

Source: Basic data, Fundação Instituto Brasileiro de Geografia e Estatística (FIBGE).

- Cotton: São Paulo and Paranã in the fifties, reaching Goiãs in the sixties and continuing in all three nearby states during 1967/76. This appears to be a case of technological transfer from São Paulo to other neighboring states. Ayer and Schuh (1972) mentioned that the new seeds developed in São Paulo were adaptable to Goiãs, and Minas Gerais.

- Peanuts: São Paulo, Paranã and Mato Grosso in the fifties, Paranã in the sixties and São Paulo during 1967/76. The occurrence in the fifties is in agreement with the concentration of research results at that time, a good part of which were on varietal improvement. Transfer of technology to neighboring states also appears to have happened.

- Rice: Paranã during 1967/76. It is not possible to relate this to technological developments.

- Coffee: Minas Gerais and Paranã in the forties, São Paulo and Espírito Santo in the fifties and São Paulo during 1967/75. The concentration of research results in São Paulo was from the late forties to early sixties. The occurrence of those two states in the forties might be related to soils of higher natural fertility.

- Sugarcane: São Paulo and Ceará in the forties, as well as Minas Gerais and Bahia in the sixties. For Ceará, a Northeastern state, there is no evidence of technological developments, but for São Paulo there is, as previously mentioned. Also the detected concentration of research results in São Paulo from the late fifties to the late sixties appears to have had no major impact on yields up to the mid-seventies (Homem de Melo, 1983).

- Edible Beans: São Paulo and Santa Catarina in the forties and Bahia in the fifties. There is no evidences to relate these occurrences to technological developments.

- Cassava: São Paulo and Rio Grande do Sul in the forties, as well as Pernambuco and Santa Catarina in the sixties. In both periods, the states were relatively distant geographically

and, also, there is no documented evidence of technological change.

- Maize: Minas Gerais in the forties. After that, not until 1967/76 were there signs of growth in yields in São Paulo, Goiás, Paranã and Mato Grosso. The concentration in research results was from the late fifties to the early sixties, including the development of new hybrid seeds. From that period to the present, new hybrids came out of Campinas' Institute (Homem de Melo, 1977). The period 1967/76 may mark the beginning of technological progress (and adoption) in maize production in the Center-South region of Brazil.

- Potatoes: São Paulo in the forties and fifties; Minas Gerais, Paranã and Santa Catarina in the sixties, and Minas Gerais, Rio Grande do Sul as well as São Paulo, during 1967/76. This is the case with the largest number of states, all of them relatively close geographically, and with the highest rates of growth in yields. The concentration of research results was from the late forties to the late sixties, which coincides with the pattern of yield gorwth in Southern Brazil.

- Soybeans: Paranã in the fifties; after that, not until 1967/76 was there considerable yield growth in Paranã, Rio Grande do Sul and São Paulo. The research record for this crop shows that the work started in 1939 in Campinas, with American varieties (Fundação Cargill, 1977). The lineage L-326 obtained in 1958 was taken to Rio Grande do Sul where, in 1963, it became, after further work, known as Santa Rosa and commercially available. Another variety, Hardee, of American origin, was introduced in 1965. It appears that these results affected the pattern of yield growth in Southern Brazil through a process of technology transfer.

- Wheat: Paranã and Rio Grande do Sul in the sixties. The report of a federal commission, above mentioned, emphasized this crop as having had significant research results during or prior to the sixties in Rio Grande do Sul.

From this review, it appears that technological progress, reflected in yields per hectare, has occurred for certain crops and time periods: cotton, beginning in the fifties; peanuts, during the fifties; coffee, mostly in São Paulo during the fifties and 1967/76; sugarcane, in the forties; maize, during 1967/76; potatoes, beginning in the forties and again in 1967/76; soybeans, during 1967/76, and wheat, in the sixties.

This does not appear to be a poor record for Brazil's research institutions as well as its agriculture. But it certainly is an unbalanced one in crop terms. It also helps to understand the presence or absence of the respective product in Brazil's exporting list and the behavior of the price ratios (domestic--international) over time. For instance, coffee, cotton and sugar have traditionally been exported and show price ratios below <u>one</u> in almost every year during 1948/77. The evidence gathered for technological developments, indicates substantial work on varietal improvement in these crops, mainly from São Paulo's institutions (Campinas' Agronomic Institute). On the other hand, technological improvements appear to have been important in making soybeans a regular and expanding exported product beginning in the early sixties.

Three other products experienced a declining price ratios over 1948/77: maize, wheat and peanuts, with greatest emphasis on the first. It is interesting to note again that maize was exported from the late sixties to the mid-seventies, although in relatively small amounts and somewhat irregularly. Also there is some evidence of technological developments for this crop beginning in the late fifties from Campinas' Agronomic Institution. The same pattern, but somewhat less well-documented, appears to have happened with peanuts in the fifties. Wheat, on the other hand, is an imported product with producers' prices entirely regulated by the government, which pursues an import-substitution policy as earlier described. The price ratios were very high during the fifties but have experienced some decline in the sixties and seventies. The evidence on technological developments

seems to indicate progresses occurring in the sixties.

For the domestic (non-traded) crops, the price ratios were substantially above one in the fifties and, in some cases, even in the sixties and seventies. For rice and edible beans there is very little evidence of technological development. The price-ratio for rice had values above two twice during 1966/77 and above 1.5 three times. For edible beans, also with no major evidence of new technologies, there appears to have existed some decline in the price ratios in the sixties and seventies, although following a very unstable pattern. It seems relevant to point out that this product had the highest rate of increase in international prices during 1966/77, of 17.0%, which should affect the denominator of the ratio. Finally, potatoes show a declining price ratio and also present evidence of technological developments in São Paulo, also reflected in other Southern states. In summary, we think that the evidence presented for an unbalanced pattern in the generation of new technologies of the biological type by the public sector helps to explain the unequal pattern of domestic-international price ratios and the segmented nature of Brazilian agriculture, that is, traded and non-traded (domestic) goods.

1.2.4. Past and Present Performance

In the previous section we argued that Brazilian agriculture should be looked at as composed of domestic (non-traded) and exported subsectors, forming what has been called a "semi-open" agricultural economy. Also we argued that, in such a circunstance, an unbalanced pattern of technological change, in the sense of most benefiting the crops in the exported (or exportable) subsector, could result in changes in the crop mix. Our conclusion was that the pattern of technological change in Brazil was actually an unbalanced one, in crops as well as in regional terms. That is, exported crops and the Southern region of the country have had more technological change than domestic

crops and the Northeast region.

The largest production growth in Brazil from the early sixties to the late seventies was in soybeans, which became in this period very important for the country's foreign exchange revenue. Due to the size of such production growth, this part of the paper will analyze it in greater detail. At the same time data will be provided to help understand the performance of Brazilian agriculture on an individual crop basis, as well as how the growth in soybean production has affected performance of other crops, particulary domestic food crops. More specifically, we intend to show that one of the main reasons for the tremendous growth in the production of soybeans, since the early sixties, has been the development of technological innovations occuring in Southern Brazil[1]. In addition, we will show that such growth resulted in significant changes in the composition of output (against domestic-food crops), resulting in an inadequate rate of output growth. Finally, we attempt to show the effects of such changes in the index of food prices for families at different income levels.

It should be noted, however, that by focusing on these aspects of technological innovation we are not saying that Brazil has not benefited from technological innovation in soybeans. The most important way, in our view, was to make possible a stronger export performance, today of great importance with respect to the Brazilian external debt crisis. We want also to call attention to the fact that technological innovation in soybeans was one of three main factors favoring exports in Brazil since the mid-sixties. The other two were: a) the introduction, in 1968, of the system of exchange mini-devaluations, and b) a favorable period of international prices, mainly during the first half of the seventies. Consequently, the evidence of changes in crop mix and resulting price effects, presented below, must be understood as the joint result of the above forces, and not just from tech-

(1) The following draws heavily from Homem de Melo, F., (1984).

nological change in soybean production. We hope to show, however, that this last factor is of great importance in explaining the change in crop mix that began in the second part of the sixties.

Soybeans, in Brazil, represent the most recent example of a large expansion in acreage during a short time interval and in a limited geographic area. In 1960, total soybean acreage was 177 thousand hectares, with 159 thousand in the state of Rio Grande do Sul. By 1980, the respective figures were 8.965 million and 3.988 million. In 1980, soybean exports were US$ 2.5 billions, about 12 percent of Brazil's total. During the sixties, the annual rate of growth of soybean acreage was 16.3 percent and, in the seventies, 20.7 percent. The increase in international prices started in 1971-72 and reached maximim levels in 1973 and 1974. In 1972, total soybean acreage already was at 2.292 million hectares. Certainly, the favorable period of international prices during the early seventies made a positive contribution to the growth of acreage. However, this was not be the principal factor behind the commencement of soybean expansion in Brazil, since during the sixties prices remained practically constant in nominal terms. In addition, it should be noted that several commodities had price increases during certain years in the seventies, but none of them experienced an area expansion comparable to that of soybeans.

Table 2 shows a summary of the agronomic research for soybeans in Brazil, in terms of new varieties, the time of their introduction and the impact in actual yields. Two of these varieties – Santa Rosa and Hardee – were very important for the expansion of soybeans during the late sixties and early seventies. The former, as already mentioned, originated in Campinas' Agronomic Institute (São Paulo), beginning with the introduction of American varieties and, later on, the development of lineage L-326 in 1958. In the mid sixties it became commercially available in Rio Grande do Sul under the name of Santa Rosa. The variety Hardee, also of American origin, was researched and adapted at Campinas after 1965. Such facts, again, reveal the importance of

TABLE 2

TIME OF INTRODUCTION AND ADOPTION OF NEW SOYBEANS VARIETIES IN BRAZIL AND EFFECTS IN YIELDS

PERIOD	AVERAGE YIELD BRAZIL (Kg/Ha)	NEW VARIETIES
1960	-	Amarela comum, Abura, Pelicano e Mogiana.
1960-68	1,060	Hill, Hood, Majos, Bienville e Hampton.
1969-74	1,394	Bragg, Davis, Hardee, Santa Rosa, Delta, Campos Gerais, IAC-2, Viçoja e Mineira.
1975-80	1,541	IAS-4, IAS-5, Planalto, Prata, Pérola, BR-1, Paraná, Bossier, Santana, São Luís, IAC-4 e UFV-1.
1980	1,740	BR-2, BR-3, BR-4, Ivaí, Vila Rica, União, Cobb, Lancer, CO-136, IAC-5, IAC-6, IAC-7, UFV-2, UFV-3, Cristalina e Dokko.

Source: M. Kaster and E.R. Bonato, "Contribuição das Ciências Agrárias para o Desenvolvimento: A Pesquisa em Soja", Revista de Economia Rural 84 (1980): 405-34.

international knowledge transfer for the process of technological change in Brazilian agriculture, mainly by obviating the need to repeat research completed elsewhere and so leading, as in the case discussed by Guttman (1978), to a decline in research costs. Also of note is that from the 48 varieties recommended for planting in 1980, 26 had originated in national programs and 22 came from the United States, half of which were in the form of lineages (Kaster and Bonato, 1980).

Several other agronomic aspects of the crop were emphasized over the years by the research centers: selection of Rhizobium's lineages, direct planting, control fo weeds, diseases and pests, density and planting time. The indications are that in the late seventies, soybean research was one of the most developed in the country. For instance, in recent years these research centers have been involved in developing production systems for other regions besides Southern Brazil, such as East and Center-West regions. In addition, "the research is aiming to develop technology specific for soybean production in regions with latitudes below 15º S. The prospects for obtaining varieties specifically adapted to lower latitudes, as well for knowledge about crop management are excellent, and new in the world" (Kaster and Bonato, 1980, p. 432). Several new varieties developed from the late seventies to the present (Tropical, Savana, Cristalina, Carajás) for the Center-West and Northeast regions of Brazil confirm that prediction. It should be noted that during 1967/76 (Table 1), the average annual rate of growth of soybean yields in Brazil was 6.16 percent (5.51 percent in the state in Rio Grande do Sul, 6.52 percent in Paranã and 4.78 percent in São Paulo), a rate well above those observed for other crops, either exported or domestic.

Table 3, on the other hand, shows the rates of growth in production during 1960/69, 1967/76 and 1970/79 for fourteen crops, among exported and domestic ones. When examining such data, it should be noted that from the sixties to the seventies, Brazilian agriculture experienced a number of important changes:

TABLE 3

ANNUAL RATES OF GROWTH OF DOMESTIC PRODUCTION, BRAZIL, 14 COMMODITIES, 1960/69, 1967/76 and 1970/79 (in %)

COMMODITIES	1960/69	1967/76	1970/79
1. Domestic			
Rice	3.20	2.47	1.46 (a)
Edible Beans	5.37	-1.93	-1.90
Cassava	6.05	-1.86	-2.09
Mayze	4.74	3.55 (a)	1.75 (a)
Potatoes	4.34	1.34	3.73
Onions	3.87	4.77	9.27
2. Exported :			
Soybeans	16.31	35.03	22.47
Oranges	6.01	12.73	12.57
Sugarcane	3.63	5.10	6.30
Tobacco	5.30	-	6.16
Cocoa	2.55	-	3.73
Coffee	-7.10	-6.34 (a)	-1.54 (a)
Peanuts	5.89	-6.80 (a)	-12.06
Cotton	1.51 (a)	-1.99	-4.41

Source: Production data from FIBGE-Fundação Instituto Brasileiro de Geografia e Estatística.

(a): This letter indicates the coefficient as not significantly different from zero at the 5% level.

after a relatively uniform performance between crops and a quite good one in "per capita" terms (2.9 percent population growth) during the sixties, in the seventies the country had a substantial deterioration in the performance of domestic crops and a great expansion of certain exported ones, a process clearly led by soybeans. As can be seen, the worst cases were cassava and edible beans, with large declines, while the production levels of rice and maize stagnated during the seventies. At the same time the population was growing at an annual rate of 2.47%.

If the first five domestic-food commodities of Table 3 are aggregated in terms of "per capita" caloric/proteic availability[1], the data shows an annual rate of decline, during 1967/79, of -1,34% and -1,31% respectively. The availability in Brazil of rice, maize and edible beans was only very slightly increased by imports over the period. These five domestic-food crops, in addition to cotton and pasture land, were the agricultural products most affected by the substantial expansion of soybeans in Southern Brazil (Zockun, 1980). Furthermore, as expected, the substitution effect of technological change was not limited to domestic crops. As can be seen, cotton, an exported crop, was also negatively affected in area and production.

Even when we consider other food products, such as sugar, wheat, meat (beef, pork and poultry), eggs and milk, total "per capita" caloric/proteic availability declined during 1967/75 (annual rates of -0.52% and -0.62% respectively), with a small recovery during 1976/79. The importance of wheat and sugar also increased over the period, the former being a traditionally imported food which had, as earlier mentioned, a policy of price subsidies for consumers beginning in 1972. During 1970/79, the growth rate for wheat availability was greater than that for domestic production, indicating a greater role of imports. Without the policy of consumption subisidies and larger wheat imports, the

(1) That is, domestic production minus exports plus imports. Use as seeds, losses and changes in stocks were not considered because of lack of annual data. See, for other details, Homem de Melo, 1983.

fall in caloric/protein availability would have been larger than that observed.

As a consequence of this unbalanced performance in terms of domestic production and availability of important food products, it is relevant to verify how different classes of family income were affected. To do this, the information from the family budget survey (ENDEF-FIBGE)[1] carried out in 1974/75, for the states of São Paulo, Rio de Janeiro, as well as South and Northeast regions were used. Such data shows important differences in consumption amongst expenditure classes[2] and regions. For instance, the share of rice and edible beans in total food expenditure varied between 21.1 - 27.9% in the lowest income (expenditure class) and between 3.3 - 7.2% in the highest one for the four regions. Similar behavior was observed for the shares of maize and its products, wheat and its products (except in the Northeast), tubers and roots (cassava, potatoes) and sugar. The contrary, however, was seen to occur in the case of meat and eggs/milk/cheese, that is, increasing shares as incomes rise. Also, a few important differences could be observed in the Northeast: cassava was much more important in lower income classes, while wheat was more important for higher income classes.

These strong differences in consumption structures between income (expenditure) classes, as well as the distinct behavior of physical availabilities, are good reasons for expecting, in addition, an uneven impact in terms of prices and real incomes for Brazilian families. This would occur through changes in market prices and consequent income effects, via each product's share in total food expenditure. After examining the behavior of thirteen food items at the retail level in São Paulo during 1967/79, it was noticed that those with largest price increases were cassava, edible beans, beef, pork and maize, three

(1) More details about the results that follow can be found in Homem de Melo, 1983.

(2) Defined in terms of consumption expenditures plus taxes as well as labor and retirement/health contributions.

of them being domestic foods, originating in the crop sector, and of greater importance for lower income families.

In an attempt to verify the distributive effects of this situation, we estimated the increase of the food price index by expenditure classes (based on ENDEF-FIBGE, 1974/75) for São Paulo, Rio de Janeiro, as well as South and Northeast regions (Homem de Melo, 1983). These indices were computed by taking the shares (weights) of each product in total food expenditures for the two states and two regions of Brazil and the observed prices in São Paulo (Cost of Living Index). Excepting São Paulo it should be clear that we are only approximating the situation faced by families over different income classes.

Table 4 shows the estimated food price index only for the Northeast region. The direction of the change, however, was the same in the two states and the other regions analysed, showing larger increases for the lower income families. In other words, these were the families mostly affected by the transformations wich occurred in the composition of agricultural output, in response to technological innovations in soybeans and to changes in external variables (prices and exchange rate). The case of the Northeast region, however, was the most serious one and for that reason it is explicity shown in Table 4. For instance, when we compare the lowest and highest income classes in terms of annual rates of growth of nominal food prices, it can be noted that during 1961/79 they were 28.6% and 26.2% respectively.

In discussing the different results among states and regions, two main reasons should be mentioned: a) the greater importance of cassava and edible beans for lower income families in the Northeast as compared to other regions (26.7% against 2.4% among the income extremes in that region, versus 14.2% against 1.4% in the South). These two commodities were the ones with the greatest increases in retail prices during 1961/79; b) the relatively small importance of wheat in the consumption habits of lower income families in the Northeast (4.2% against 10.0% among the extremes in the Northeast, and 8.9% against 7.1% in the South).

TABLE 4

INDICES OF NOMINAL FOOD PRICES, EXPENDITURE CLASSES, NORTHEAST REGION, 1967/79

(1967=100)

YEARS	<1.0	1.0-1.5	1.5-2.0	2.0-3.5	3.5-5.0	5.0-7.0	>7.0
1967	100	100	100	100	100	100	100
1968	126	124	123	122	122	121	120
1969	160	155	152	150	148	148	147
1970	198	191	188	185	183	181	181
1971	253	243	237	231	228	225	223
1972	319	302	291	280	275	270	268
1973	430	407	389	374	365	359	356
1974	557	533	514	498	490	483	479
1975	766	721	688	658	640	624	606
1976	1,133	1,033	970	912	876	848	817
1977	1,546	1,401	1,317	1,242	1,195	1,156	1,124
1978	2,087	1,947	1,856	1,768	1,720	1,671	1,631
1979	3,311	3,081	2,917	2,770	2,686	2,609	2,542
Annual Rate	28.6	28.0	27.5	27.0	26.7	26.5	26.2

Source: Primary data, ENDEF-FIBGE (Weights) and FIPE-Fundação Instituto de Pesquisas Econômicas (Prices in São Paulo) as reported in Homem de Melo, F., O Problema Alimentar no Brasil..., 1983.

It should be recalled that, beginning in 1972, the Brazilian government subsidized wheat prices for all consumers, which, in the Northeast, had a regressive incidence. Results such as those described, particularly for the Northeast, can aggravate those obtained for nominal income distribution in Brazil with the census data of 1970 and 1980, in the sense of greater concentration of the real income distribution.

After such an unbalanced performance – growth of exportables and "per capita" decline in availability of domestic food crops – with a very likely negative effect on real income distribution, agriculture was targeted as a sector with high "priority" in the overall economic strategy beginning in 1979. In addition, to that "priority" a few other factors were added, the most important being the balance of payments crisis which occurred with the second oil "shock" in that same year. In other words, it was clear that Brazil should increase its exports and decrease its imports. The first real devaluation of the cruzeiro took place in December, 1979 and in July of that same year the alcohol program, introduced to substitute gasoline in 1975, received a new and larger support as well as incentives to private investors.

In Table 5 we show for 1977/84 the indices of "per capita" production for domestic crops and exported ones with sugarcane shown separately because of the alcohol program[1]. Again, as unbalanced performance can clearly be noticed. First, the decrease, -1,94 percent annual rate, in the "per capita" production of domestic food crops (rice, edible beans, maize, cassava and potatoes). This, we recall, happened after the decline in "per capita" production of the same crops during 1967/76 (Table 3)[2]. For individual crops during 1977/84, rice, edible beans and maize had zero rate of growth in "per capita" production, while cassava and potatoes had declines, -5.29 percent and -2.27

(1) In terms of production (not availability), 1977 is the recommended year to start the series since 1979 and 1978 had extremely adverse climatic conditions.

(2) As already mentioned population growth rate in Brazil was 2.9 percent during the sixties and 2.5 percent during the seventies.

TABLE 5

GROWTH IN "PER CAPITA" PRODUCTION OF DOMESTIC, EXPORTED CROPS AND SUGARCANE, 1977/84[a]

YEAR	DOMESTIC CROPS	EXPORTED CROPS	SUGARCANE
1977	100.0	100.0	100.0
1978	86.0	88.0	105.1
1979	87.3	94.0	110.5
1980	90.8	112.8	115.6
1981	90.2	110.6	118.3
1982	96.5	104.2	137.9
1983	73.6	107.2	156.4
1984	84.9	113.3	174.8
Annual Growth Rate (%)	-1.94	2.56	7.84

(a) Production data from FIBGE (Brazilian Foundation for Geography and Statistics). Laspeyres indices, 1977 prices, population growth of 2.5 perdent during 1977/80 and 2.3 percent during 1980/84, Domestic crops: rice, maize, edible beans, cassava and potatoes. Exported crops: cotton, peanuts, tobacco, soybeans, oranges and cocoa. Significance tests at the 20 percent level.

percent annually respectively.

Second, Table 5 shows a substantial increase, 7.84 percent annually, for the "per capita" production of sugarcane, mostly as a result of the incentives given by the alcohol program. Thirdly, with an intermediate performance, Table 5 shows the exported crops, with a yearly growth rate in "per capita" production of 2.56 percent[1]. Such a rate is the result of the 3.40 percent annual growth in "per capita" soybean production, 6.15 percent in orange production and 3.07 percent in cocoa "per capita" production, although declines were verified for cotton, peanuts and castor beans[2].

This unfavorable performance of "per capita" production of domestic food crops should, in the absence of compensatory operations in stocks and/or imports, be reflected in higher relative prices. Given the importance of such foods for low-income families in terms of budget shares, this type of change could bring a worsening of the real income distribution. Even taking into account that other factors contributed to higher consumers' prices during 1977/84, such as increased oil prices in 1979/80 and the rise in international commodity prices in 1983, it seems important to mention that the minimum-wage (in São Paulo, Rio de Janeiro, Minas Gerais and the Federal District) in 1983, when deflated by the index of consumer food prices in Rio de Janeiro, was 26 percent lower than in 1977. In 1978 it was 0.9 percent higher than in 1977 and in all other years it was lower than in 1977 (in the range 5.0 - 8.8 percent). In 1982, 37 percent of the Brazilian economically active population — 17.8 million people — had incomes equal to or below one minimum-wage, a number which confirms the importance of the distributive issue in Brazil.

---

(1) Including coffee, the growth rate for exported crops was 2.53 percent.

(2) Most of the data in this part of the paper is from Homem de Melo, 1984.

1.2.5. Policy Issues

It is our opinion that one of the most important current problems in Brazilian agriculture is the unbalanced pattern of its growth. Obviously we are not implying that this is the only problem. From previous sections of this paper we could mention problems related to the concentration in land ownership, the occupation of the frontier states, the unbalanced pattern of agricultural growth in regional terms (Southern vs. Northeast regions) and a few others. In this section, however, attention will be given to the problem of unequal production growth in the Brazilian crop sector, particulary since the country faces a serious crisis in its external sector.

In Brazil, 1985, we think five factors are relevant for determining resource allocation between the domestic (non-traded), exported and sugarcane (alcohol/gasoline) subsectors: a) a technological disequilibrium favoring exported crops and sugarcane as against domestic crops; b) the exchange rate policy since the real devaluation in February, 1983; c) the behavior of international commodity prices; d) the future of the alcohol program; e) the recession of the Brazilian economy since 1981.

The first one, the technological disequilibrium, can be characterized by a greater intensity in the generation (and adoption) of technological innovations for crops in the export subsector vis-a-vis the domestic one. Information has already been given to support this. As a result, yield growth is higher for the former subsector, profitabilities are altered and agricultural growth is directed to the exported subsector. For instance, even in the recent period of 1977/84, the following was the annual aggregate rate of yield growth in Brazil: a) exports crops (cotton, peanuts, tobacco, soybean, oranges and cocoa), 4.05 percent; b) sugarcane, 2.79 percent; c) domestic crops (rice, edible beans, maize, cassava and potatoes), zero (in the trend line). As an example of the resulting unbalanced growth, between 1977 and 1984, even with declining international prices, soybean

area grew by 2.038 million hectares in the states of Mato Grosso do Sul, Mato Grosso, Goiás and Minas Gerais, regions which include Brazil's cerrados as well as areas below 15ºS, after the development of the appropriate varieties by the EMBRAPA system.

In addition, even within the domestic subsector, an unbalanced technological situation seems to exist. If we go back to Table 1, it can be noted that maize and potatoes did considerably better in terms of yield growth than rice, cassava and edible beans during 1967/76. Now, for the period 1977/83 the estimated rates of yield growth (three year moving average) for Brazil were: maize, 3.88%; potatoes, 3.24%; rice, 2.00%; cassava, -1.22% and edible beans, -1.40%. The rice yield growth went from zero to 2.00% between the two periods and the rates for maize and potatoes remained positive with a good improvement for maize. Later on in this paper we will come back to this matter. Although showing an improvement, mainly for maize and rice, it is quite likely that a disequilibrium still exists on technological grounds between exported and domestic crops. If this is so, an important implication is the difficulty of reverse it in a short time period, in spite of the fact that from the mid-seventies EMBRAPA has increased research investments for domestic crops through the creation of national research centres.

In the second place, the exchange rate policy followed by Brazil is worth mentioning. With the maxidevaluation (30 percent) of the cruzeiro in February, 1983 as well as the minidevaluations since then, it is clear that the behavior of the exchange rate has favored production for export. If we take into account Brazil's agreement with the International Monetary Fund – devaluation equal to the monthly rate of domestic inflation – up to 1985, as well as the country's urgent need for a large trade surplus, the conclusion is that for the near future, the exchange rate policy should continue to be one favoring agricultural exports.

In the third place, it is necessary to consider the recent behavior of "per capita" income. This is so because in

1981 we had the beginning of an economic recession and consequantly, the observed decline in income "per capita" contributed to a downward shift in the internal demand for domestic crops. This further favors export crops via the resulting increase in the price-ratio of exportables-domestic crops. To give a more precise idea of the importance of this problem we could mention Bacha's (1984) estimate of the average "standard" of living in 1984, which was 17 percent lower than in 1980. This estimate assumes zero growth in 1984 (actually it was positive), the deterioration in the terms of trade and the transfers of real resources to foreigners, in addition to the 14.1 percent decline in "per capita" GDP. The magnitude of such a fall indicates that in the next few years, even with the beginning of economic recovery, internal demand may be a constraint on the expansion of domestic crops.

In fourth place, there is the behavior of international commodity prices, at least those relevant to Brazil's agricultural exports. If, in the near future, such prices increase from the present low levels, the effect would be similar to the one caused by the exchange rate, that is, an increase in the relative exported - domestic crop price ratio with resultant changes in the crop mix. With the exception of the second semester of 1983 and the first one of 1984, international commodity prices have been quite low as compared to the level of 1980. For instance, after an average close to US$ 300 per ton in the second semester of 1980, the soybean price was near US$ 200 in the second semester of 1984. World recession, high real interest rates and the over-valued dollar, somewhat related factors, are recognized as reasons for the heavy declines in commodity prices.

Finally, the last relevant variable is the future of Brazil's alcohol program. This future is not clear to us from indications of recent governmental atitudes. The production goal for the crop year 1985/86 - 10.6 billion liters - will be in large part fullfilled, and quite a few new projects have been financed since the "boom" period 1979/82. From 1977/84 the sugar-

cane area increased at an annual rate of 7.43 percent, while the area with domestic and exported crops remained constant. In this context, it is not possible to disregard the competition for land and other inputs between sugarcane, exported and domestic crops. We believe there are grounds for reformulating the country's energy policy, that is, preventing additional expansion of sugarcane. This conclusion is based on the high social costs of producing alcohol in Brazil (US$ 79-91 per barrel-equivalent in 1981) (Homem de Melo and Pelin, 1984) and the existence of cheaper alternatives (domestic oil, coal, natural gas, shale oil, conservation, improved urban and long-distance transportation).

In conclusion, we believe that one of the most important problems today for Brazil is to design a compensatory policy for the expansion of the domestic crop subsector in light of the above five factors. Particulary important for such a policy are constraints due to the technological disequilibrium and the exchange rate policy. The former follows from the uncertain and long-run nature of research investments. EMBRAPA has increased such investments and it is very important that they are not discontinued in the future. The second one follows directly from Brazil's external debt and the need for substantial increases in exports.

2. The National Agricultural Research System (NARS)

2.1. Overview

In the previous chapter we mentioned that in 1973 there was an imporant change in the organization of agricultural research in Brazil, with the creation of EMBRAPA - Brazilian Company of Agricultural Research -, a state owned corporation included in the Ministry of Agriculture. Together with such an organizational change it seems that a major policy change also took place, in the sense that from that moment to the present, research activities at the federal level received a much greater support than in previous periods, such as that beginning in the early fifties when research activities were declining while those related to extension were increasing.

Agricultural research in Brazil has typically been concentrated in the public sector, both federal and state. The participation of the private sector has been quite small, with the most important exception being maize research (hybrid seeds), with national and foreign-owned companies. With respect to the development of agricultural research at the federal level, two periods are usually distinguished as representing different orientations after World War II. The first one, dating from before World War II lasted until 1971 (Schuh and Alves, 1971). In this first phase, the research organization was in the form of a traditional public service - the National Department of Agricultural Research and Experimentation (DNPEA) in the Ministry of Agriculture.

In this period, besides the lack of a continuing effort by the federal government, in the sense of providing agriculture with appropriate technological innovations, there also was inadequate geographical distribution of research units, as well as the absence of proper communication between researchers and farmers. Among the consequences, Schuh and Alves (1971) pointed out the co-existence of a large number of research projects wich

parallel objectives and for products without great importance as either food itens or as earners of foreign exchange. In addition, the level of salaries was a limiting factor in keeping researchers as well as for attracting new ones.

Also, as pointed out in the previous chapter, the indications (Pastore et al, 1974) are that only a few states, such as São Paulo, Rio Grande do Sul and Minas Gerais, created and were able to sustain research institutions during the last 100 years, of which only São Paulo's effort had great success. Our review in the previous chapter confirmed this last point for the cases of coffee, cotton, sugarcane, oranges, maize and potatoes in São Paulo. The first research center in the state, Campinas' Agronomic Institute, was created in 1887 mainly for coffee research. It was followed by the Biological Institute, the Division of Zootechonology and Animal Nutrition and the Department of Zoology, none of the four with any direct relation to universities. The state has also for a long time supported an agricultural school im Piracicaba (ESALQ) within the University of São Paulo. Other schools now exist.

The Campinas' Agronomic Institute (IAC), besides its headquarters in Campinas, had a total of 16 experimental stations spread over most of the agricultural regions in the state. For an individual state, São Paulo's effort was quite impressive, especially when the comparison is made to that at the federal level. For instance, in 1969 São Paulo's agricultural research system had 720 researchers, while the federal system (DNPEA) had 850 for Brazil as a whole (Paiva, 1973). This federal system was formed by nine regional research centers, each one with a network of experimental stations. Using the number of researchers in each center as an index of effort, a special favorable note could be made for the research centers located in Recife (Pernambuco), Sete Lagoas (Minas Gerais), Rio de Janeiro (the so-called Km 47) and Pelotas (Rio Grande do Sul). Each of the nine regional research centers of DNPEA supported research in crops important in their respective regions which as mentioned above, involved considerable amount of duplicated effort.

This pattern of agricultural research organization was called "the diffuse model of research" by Pastore and Alves (1984): "the main facture of this model is that each research unit tries to diversify its activities, researching many different products and attempting to generate a wide array of technologies". The criticism of Pastore and Alves was based on the expensiveness of such system of research organization, since only part of the new knowledge generated was effectively transformed into new technology. The second phase in the development of agricultural research in Brazil, dating from 1971 to present days, was an answer to such an inefficient situation. In 1971 a special committee was appointed by the federal government to evaluate the research situation in the country, and in 1973 changes were formalized through the creation of EMBRAPA, which started its operations on April 26, 1973.

2.2. Institutional Structure

The creation of EMBRAPA, a major policy and organizational change in Brazilian agriculture, was a recommendation of the special committee appointed by the Minister of Agriculture in 1971, with the objective of evaluating the federal system of agricultural research existent at that time. Its main conclusion was the need of an urgent reform of the research system in the country. Next we will be reviewing what were the basic principles of the research model implemented at that time and continuing nowadays. In the words of Pastore and Alves, "the basic tenet of EMBRAPA is that applied agricultural research should be guided by the concrete needs of the national society as expressed in government policies and in the concerns of farmers, extension agents, and industry. Execution of applied research directed toward immediate needs is seen as the province of the technological research institutes. More fundamental research in seen as the province of the universities" (Pastore and Alves, 1984).

In addition to this general principle for the reform of the agricultural research system in Brazil, six specific guidelines were used (Pastore and Alves, 1984): a) the transfer of foreign technology was considered valid but with limited importance in many instances. Training abroad and technical assistance were considered as important; b) research efforts should be concentrated on regional projects, due to the scarcity of human and financial resources; c) the private sector should participate in the development of most research projects; d) there should be administrative flexibility in the research system in terms of obtaining extra financial resources and in determining the level of salaries, as well as training needs; e) a close relationship should be established with the extension service and the input industry with the objective of improving the diffusion mechanism; f) knowledge from international institutes and from other foreign research centers should be adapted and spread throughout the country. Economics research should also be included in the system.

If we recall the deficiencies and low productivity of the previous research system in Brazil (DNPEA), we can have an idea of the challenge faced by those involved in planning the first steps of the new system. It is important to note, again for our comments later on, that agricultural research in Brazil, previous to EMBRAPA's creation, was almost entirely concentrated at Campinas' Agronomic Institute (IAC), a relatively large research center supported solely by the state of São Paulo.

It looks like the challenges as well as the difficulties to be faced by the new research system were clearly perceived by those, like Pastore and Alves, directly involved on the evaluation preceding EMBRAPA and in the initial planning after its formal creation. For instance, those same two authors emphasized that "the development of EMBRAPA implies the concentration of relatively large financial and human research resources on a limited number of products. The challenge that this model presents is that of defining priorities and responding to changing circunstances" (Pastore and Alves, 1984, p.124).

Although with quite a large responsibility in doing agricultural research and obtaining useful results to farmers, it is important to emphasize that from the beginning EMBRAPA was not supposed to be the only research institution to cover Brazil as a whole. The state research system still had an important place in the institutional model implemented after 1973 and EMBRAPA's role was to develop it when necessary and/or support it. EMBRAPA had the direct responsibility for creating and implementing commodity – oriented national research centers. As we mentioned before, just a few states in Brazil were able or willing to create or maintain agricultural research institutions, São Paulo being the main exception. As a result, this part of EMBRAPA's work had to start practically from scratch and was concentrated on training researchers for the several states as well as providing the respective state governments with assistance in the organization of their own research corporations (Pastore and Alves, 1984).

In facing the problem of establishing research priorities in terms of products, regions and resource areas, EMBRAPA came to the following decisions: wheat, sugarcane, maize, edible beans, soybeans, rice, rubber, livestock and dairy, in terms of products, and "cerrados", semi-arid agriculture and humid-tropics agriculture in terms of resource areas. National research centers were created for each of these products with the exceptions of sugarcane and coffee. As we mentioned in the previous chapter, sugarcane research has been, since 1971, under the responsibility of PLANALSUCAR, as institution belonging to the Ministry of Industry and Commerce. Since this last research center was created in 1971 before the organization of EMBRAPA, we can only speculate that EMBRAPA may have had, in its beginning, the goal of incorportaing sugarcane research in its own system. Even if that is true, the fact is that such incorporation has not occurred up to the present. About the coffee research center, what could be learnt from our visits for this research is that EMBRAPA offered it to the state of São Paulo in collaboration with Campinas'

Agronomic Institute, but that it was refused by the state government. Nowadays, the list of EMBRAPA's national research centers includes several others not in the initial definition of priorities, such as: cotton, cassava/fruits, pork/poultry, palm, goats, vegetables and agricultural chemicals for plant diseases. Their locations are the following:

a) Cotton: Campina Grande, Paraíba (Northeast)
b) Rice and Beans: Goiânia, Goiás (Center-West)
c) Goats: Sobral, Ceará (Northeast)
d) Agricultural Chemicals: Campinas, São Paulo (Southeast)
e) Livestock: Campo Grande, Mato Grosso do Sul (Center-West)
f) Dairy: Coronel Pacheco, Minas Gerais (Southeast)
g) Vegetables: Brasília, Federal District (Center-West)
h) Cassava/Fruits: Cruz das Almas, Bahia (Northeast)
i) Maize/Sorghum: Sete Lagoas, Minas Gerais (Southeast)
j) Rubber/Palm: Manaus, Amazonas (North)
k) Soybeans: Londrina, Paraná (South)
l) Pork/Poultry: Concórdia, Santa Catarina (South)
m) Wheat: Passo Fundo, Rio Grande do Sul (South)
n) Temperate Fruits: Pelotas, Rio Grande do Sul (South)

From this updated list of national research centers it can be noted that EMBRAPA's system has experienced a substantial expansion from its initial list of priority products. With the exception of sugarcane (covered by PLANALSUCAR) and coffee, we cannot think of any major product in Brazilian agriculture that is not presently covered by EMBRAPA's research system. Clearly, this expansion of the range of EMBRAPA's activities represents a policy change from the earlier orientation: "since resources are scarce, it is necessary to limit the number of production system prototypes developed and the number of commodities researched. Clearly priorities must be established, but this means that some groups of farmers may not receive the benefits of research" (Pastore and Alves, 1984, p.125). As we will see in the next section

EMBRAPA's budget grew considerably over the period 1974/82. It is possible that one way EMBRAPA's administrators during 1974/84 found research resources could be increased was to increase the number of commodities having a national research center rather than to convince government officials to raise support for a given number of centers. Eliseu Alves, former president of EMBRAPA, said that "mobilizing the overall support of society, including support by special interest groups is the best way to assure the continuous allocation of resources to a given activity such as agricultural research" (Alves, 1984, p. 181). In a rather articulate discussion about motivating investment in agricultural research, Alves (pp. 180-84) mentioned the following steps: a) showing the need to increase productivity; b) organizing a public information and education campaign; c) making efforts to identify and reach special target groups; d) coordinating efforts among various research institutions; e) using special skill groups to increase investment in agricultural research, and f) training research workers in communicating with the general public.

From the list presented above of EMBRAPA's national research centers, it can be noted that some of them cover commodities in the CGIAR system. That is the case of CIAT with rice, edible beans, cassava and pastures, CIMMYT with wheat as well as maize, CIP with potatoes (in the national center for vegetables) and IRRI with rice. It can also be noted that EMBRAPA does not have an economics research center but rather does research in this area, mainly in relation to agronomic research in each national center, as well as in its headquarters in Brasília with DEP-Department of Studies and Research - which has a collaboration with IFPRI.

On the other hand all three resource areas intially stated as priorities – "cerrados", semi-arid agriculture and humid-tropic agriculture-were developed as CPA - Centers for Agricultural Research. They are located respectively in Brasília (Federal District), Petrolina (Pernambuco, Northeast) and Belém

(Parã, North). The "cerrados" center has a collaboration with CIAT while the CPA – semi-arid has one with ICRISAT. In addition, EMBRAPA created the so-called "special services": CENARGEN, in Brasília, for genetic resources and collaborating with IBPGR; CTAA, in Rio de Janeiro, for agricultural and food technology; SNLCS, also in Rio de Janeiro, for soil survey and conservation, and SPSB, in Brasília, for production of basic seeds.

EMBRAPA's research system is completed by two special services and 16 research execution units at state or territory levels. The so-called special units are located in Seropédica (Rio de Janeiro, Southeast) for soil biology, and in Curitiba (Paranã, South) for forest research. The research execution units are located in Altamira (Parã, North), Aracaju (Sergipe, Northeast), Bagé (Rio Grande do Sul, South), Bento Gonçalves (Rio Grande do Sul, South), Cáceres (Mato Grosso, Center-West), Cascata (Rio Grande do Sul, South), Corumbã (Mato Grosso do Sul, Center-West), Dourados (Mato Grosso do Sul, Center-West), Manaus (Amazonas, North) Pelotas (Rio Grande do Sul, South), Porto Velho (Rondônia, North), Rio Branco (Acre, North), São Carlos (São Paulo, Southeast), Teresina (Piauí, Northeast), Boa Vista (Roraima, North), and Macapã (Amapã, North).

The above is EMBRAPA's research system from the point of view of the corporation's structure. To complete the national research system we have to mention the state research corporations as well as other agricultural research institutions. This is important because much of EMBRAPA's research is planned and executed in collaboration with such local organizations. In other words, EMBRAPA has a national rice research program, a national soybean research program and so on for those commodities already mentioned as covered by EMBRAPA's national research centres. The following states have agricultural research corporations financially supported by the respectives states as well as by EMBRAPA: a) <u>Northeast region</u>: Alagoas, Bahia, Ceará, Rio Grande do Norte, Paraíba, Maranhão and Pernambuco; b) <u>Southeast region</u>: Minas Gerais, Rio de Janeiro and Espírito Santo; c) <u>South region</u>: Santa Catarina;

d) Center-West region: Goiás, Mato Grosso do Sul and Mato Grosso.

A few important agricultural states, such as São Paulo, Paranã and Rio Grande do Sul, do not have research corporations. In two of these cases, São Paulo and Rio Grande do Sul, a research system in the state's public administration already existed and a decision was taken not to transform it into a research corporation. In São Paulo, besides the Campinas' Agronomic Institute, there are the Biological Institute (São Paulo), Agricultural Economics Institute (São Paulo), Food Technology Institute (Campinas) and the Zootechnology Institute (Nova Odessa). In Rio Grande do Sul there are IPAGRO - Agronomic Research Institute (Porto Alegre), the Veterinary Research Institute (Guaíba), the Zootecny Institute (Porto Alegre), as well as the rice experiment station of IRGA - Rio Grande do Sul's Rice Institute - in Cahoeirinha. In the state of Paranã, with no previous research institutions up to the early seventies, there is now Paranã's Agronomic Institute - IAPAR - in Londrina and organized as a foundation.

2.3. Allocated Resources

In previous sections of this paper we indicated that, before the creation of EMBRAPA, agricultural research at the federal level in Brazil was quite deficient either quantitatively or qualitatively. Important research results were not characteristic of the period before to the sixties. On the contrary, only the state of São Paulo was able to create and expand a series of research centers from late in the last century, with several important research results, particulary in the case of Campinas' Agronomic Institute. We mentioned the research successes in coffee, cotton, sugarcane, oranges, maize and potatoes, besides the fact that soybean research actually started at Campinas. We also emphasized the unbalanced nature of technological innovations in Brazil, in terms of domestic vs. exported crops, including in our evidence the behavior of individual crop yields over different periods of time.

Such a predominance of São Paulo's research institutions in the total Brazilian research effort was recently confirmed by the detailed analysis of Evenson (Evenson, 1984). Working with the concept of research units[1], he was able to show that São Paulo's share in total Brazilian research over time was the following: 95 percent in the thirties, 67 percent in the forties, 68 percent in the fifties, 83 percent in the sixties, 47 percent during 1970/77 and 19 percent during 1978/80. Such data also reveal the drastic fall in São Paulo's share in the seventies, exactly when EMBRAPA was created and was increasing its budget. We will come back to this point later in the paper. At this moment, however, it is relevant to point out that using Evenson's concept of "research units", Brazilian total annual research increased 384 percent from 1960/69, immediatelly before EMBRAPA, to 1978/80, about five years after its creation. However, in São Paulo, the observed growth in the same period was only 19%.

On a crop basis, the results obtained by Evenson tend to confirm ours: "in general, prior to the 1940s, only coffee, cotton, sugarcane and, to a lesser extent, citrus fruits, were receiving anything more than token attention. During the 1940s the situation changed little; research on potatoes and vegetables increased. In the 1950s, research on rice began and corn also received some attention. Even at the end of the 1960s, however, Brazil's research system did not exhibit evidence of wise planning for economic growth via investment in new technology. Important crops, notably peanuts, manioc, many vegetables and even wheat were given only token research. Cocoa, rubber and bananas, also important crops, likewise received little attention" (Evenson, 1984, p.250). We do not believe it would be an exaggeration to say that Evenson's results confirm our previous conclusion that there was an unbalanced pattern of technological innovation in Brazilian agriculture, at least until recently.

(1) Evenson's "research unit" is a double measure. First it represents a "standard" publication, constructed with different weights for commodities and general research. Second, with the expenditure data it can be transformed into a monetary value for each period.

In Table 6 we try to use Evenson's data to analyze the changes in agricultural research an a crop basis, which occurred from the average during 1960/69, before EMBRAPA, to 1978/80, after EMBRAPA. Two measures are used, both from Evenson's paper. First, the already mentioned concept of annual "research units", a weightet sum of publications in different commodities and areas, is an output concept. The second one, "research intensity", the ratio of the annual research expenditures to the value of the commodity, is an input or effort concept.

In terms of annual research units, we can note that exported crops had a much larger growth between 1960/69 and 1978/80 than domestic crops. The observed growth in research output is quite impressive for cocoa, soybeans and sugarcane. The cocoa result certainly reflects the creation of CEPEC - Center for Cocoa Research - in 1963 in the state of Bahia[1]. The sugarcane result may be, at least partially, the consequence of the creation of PLANALSUCAR in 1971, already mentioned. Also, coffee, citrus (oranges) and cotton showed a good growth in research results although much lower than that for the former three crops.

With respect to domestic crops, impressive growth can be observed for cassava, maize and to a lesser extent, for rice and edible beans, between average 1960/69 and 1978/80. Although the overall grouth for all domestic crops was about half that observed for exported crops, it is important to emphasize that maize and rice had for 1978/80 an annual research output at a level similar to the one for coffee and soybeans, the two most important Brazilian agricultural exports in value terms. This indicates an extraordinary improvement in relation to the past pattern of research investment[2] and no doubt reflects the creation of EMBRAPA and the development of the Brazilian research system, including

---

(1) (Penna and Monteiro, 1976). The estimated rate of return for cocoa research with CEPEC was 60-79 percent.

(2) In the average for the fifties, maize had a number of "research units" 27 percent that of coffee, and rice, 51 percent (Evenson, 1984, p. 249).

TABLE 6

BRAZILIAN ANNUAL AGRICULTURAL RESEARCH BY COMMODITIES, 1960/69 AND 1978/80

COMMODITY	RESEARCH UNITS			RESEARCH INTENSITIES		
	1960/69	1978/80	CHANGE(%)	1960/69	1978/80	CHANGE(%)
1. Exported Crops:	22.42	254.50	1,035	0.0015	0.0062	313
Coffee	7.66	32.60	326	0.0016	0.0032	100
Soybeans	1.73	35.30	1,940	0.0052	0.0044	-15
Sugarcane	4.23	82.40	1,848	0.0012	0.0115	858
Citrus	2.70	13.40	396	0.0032	0.0035	9
Cotton	4.26	18.90	344	0.0014	0.0061	336
Cocoa	0.45	50.60	11,144	0.0065	0.0158	143
Tobacco	-	-	-	0.0002	0.0002	-
Peanuts	0.99	2.90	193	0.0014	0.0070	400
Castor Beans	0.40	0.60	50	0.0022	0.0021	- 5
Rubber	-	17.80	-	-	-	-
2. Domestic Crops:	18.42	122.40	568	-	-	-
Maize	2.65	33.40	1,160	0.0007	0.0049	600
Rice	4.81	38.60	702	0.0013	0.0064	392
Cassava	0.41	10.70	2,510	0.0002	0.0024	1,100
Edible Beans	3.28	19.90	507	0.0017	0.0069	306
Potatoes	2.08	3.70	78	0.0026	0.0020	-13
Onion/Tomatoes	2.49	9.20	269	0.0036	0.0051	42
Tropical Fruits	2.60	6.90	165	0.0017	0.0020	18
3. Imported Crops:						
Wheat	0.92	16.20	1,661	0.0014	0.0060	329
4. Animal Products:	41.25	86.10	109	0.0030	0.0037	23
Cattle	-	-	-	0.0026	0.0031	19
Swine	-	-	-	0.0031	0.0071	129
Other	-	-	-	0.0059	0.0051	-14

Source: Evenson (1984, p. 249 and p. 251).

the national research centers in Goiânia for rice/edible beans and Sete Lagoas for maize.

Wheat, still an imported crop but having had a policy of import substitution for quite some time, had a large growth in research output from 1960/69 to 1978/80. However, its level in 1978/80 was still considerably below that for most exported crops as well as a few domestic ones. Finally, the growth in research output of animal products was relatively low. It is interesting to note that in 1978/80 the agregate research output of animal products was similar to that for only one single crop, sugarcane. Probably PLANALSUCAR and the alcohol program made considerable difference in the sugarcane case.

While this first indicator of Brazilian research, – research units – through the concept of a "standard" (weighted sum) publication, also reflects efforts or investments made in periods previous to the two considered (1960/69 and 1978/80), the second indicator – research intensity – is a current input measure, and as such better reflects intentions or priorities in research for different commodities. In examining the bottom half of Table 6 it is possible to note that, in terms of research intensity growth, maize, rice, cassava and edible beans, all domestic crops performed quite well as compared to exported crops. For the latter, again sugarcane performed best, followed by peanuts and cotton. It is worth mentioning that the research intensity of maize, rice and edible beans in 1978/80 was higher than that for coffee, soybeans and citrus, three extremely important export crops, and clearly less only than sugarcane and cocoa. Thus these three domestic food crops can be considered to have approximately the same research effort as cotton, peanuts, wheat, swine and other animal products.

The information reviewed so far allows us to say that considerable progress has been made in increasing overall research effort as well as in correcting the unbalanced pattern of technological innovation. If we take the data on research intensity during 1978/80 as evidence of research input or effort, and

consider the proper horizon for a research project, we can optimistically expect to witness a more balanced pattern of innovation in the future. However, the question of overall research investment remains, since a balanced pattern of innovation may occur at a low or at a high overall level. In Table 7 we present Evenson's findings for research and extension expenditures as percentages of total agricultural product. The increase in research from the first half of the seventies to 1978/80 is quite clear and coincides with the first few years of EMBRAPA. In fact, the budget data given by Alves (Alves, 1984, pp. 161-73) shows a considerable increase in EMBRAPA's expenditures during 1974/80 (in millions of dollars): 1974, 25.3; 1975, 56.0; 1976, 80.8; 1977, 98.1; 1978; 125.6; 1979, 154.1; 1980, 157.5; 1981, 183.0; 1982, 220.0. Immediately before the creation of EMBRAPA, the federal budget for agricultural and livestock was the following (million dollars): 1970, 10.6; 1971, 9.5; 1972, 8.8; 1973, 14.0 (Alves, 1984, p.53). Extension expenditures also increased from the first half of the seventies to 1978/80 but at a rate lower than the increase for research. However, despite this an increase in research expenditures, the data shown by Evenson indicates that Brazil still ranked low compared to other Latin American countries, leading him to conclude: "The EMBRAPA initiative has now partially restored this balance, but even now Brazil does not rank highly as an investor in public sector agricultural research" (Evenson, 1984, p. 252). As a result, the Brazilian pattern of technological innovation may in the future lead to more balance among crops but may still be at a relatively low overall level compared to other countries.

Finally, there should be a word about the budget of São Paulo's research institutions. In Table 08 we present the research budget for all institutions, as well as the budgets for extension during 1960/80, both of them coming entirely from the state government. We can then note a fairly reasonable growth in the research budget for all institutions in the state from the early sixties to the mid-seventies, after which it looks like

TABLE 7

RATIO OF RESEARCH AND EXTENSION EXPENDITURES TO VALUE OF AGRICULTURAL PRODUCT IN BRAZIL

YEAR	RESEARCH	EXTENSION
1959	0.30	0.57
1965	0.34	0.77
1971	0.41	0.83
1974	0.31	0.66
1978/80	0.87	1.13

Source: Evenson (1984, p. 252).

overall research investment remained constant until 1980. Practically the same pattern can be observed for the extension budget, with the distinction that in every year this budget was considerably larger than the one for research.

One of the possible reasons for the observed no-growth in São Paulo's research investment after the mid-seventies, could be thought to be the creation of EMBRAPA and the growth in its budget after 1974. That is, after being the leader in agricultural research in Brazil for quite some time, with benefits to São Paulo and neighboring states, the state might have voluntary began to adopt a policy aimed at benefiting, via externalities, from EMBRAPA's increasing research investment.

However, doubts arise with respect to that hypothesis when we note that São Paulo's extension budget had practically the same behavior after the mid-seventies, and that external benefits to São Paulo from larger extension budgets at the federal level (EMBRATER) would be minimal, if existent at all.

In addition, the participation of EMBRAPA in São Paulo's research budget, through grants was very small – 4.7 percent

TABLE 8

RESEARCH AND EXTENSION'S BUDGET IN THE STATE OF SÃO PAULO, 1966/80 (1977's Cr$)

YEAR	RESEARCH	EXTENSION
1960	97.6	155.4
1961	105.0	173.2
1962	115.5	219.4
1963	98.1	262.1
1964	94.8	236.9
1965	109.5	334.9
1966	128.2	404.4
1967	159.9	297.2
1968	130.1	277.9
1969	168.1	382.2
1970	183.5	356.8
1971	262.6	387.3
1972	279.7	402.6
1973	300.2	569.6
1974	272.1	653.3
1975	257.1	747.6
1976	266.7	602.7
1977	246.1	562.7
1978	347.3	477.1
1979	311.3	617.5
1980	265.9	516.9

Source: Peixoto da Silva (1983, p.72).

during 1978/80 (Evenson, 1984, p.253). We recall that the research system in São Paulo is not a part of EMBRAPA's national system at least in formal terms, as the result of a decision taken by the state government in the mid-seventies. In any case, given the importance of São Paulo's research centers, there is reason for concern about the behaviour of the research budgets from the mid-seventies, especially since the situation seems to have deteriorated since 1979. For instance, in 1983 the budget of Campinas' Agronomic Institute (IAC) was 58.6 percent of the one for 1979; for the Biological Institute, 59.6 percent and for the Zootechnology Institute,59.3 percent (Governo do Estado de São Paulo, 1984, p.31). Such a decline is quite serious, since Peixoto da Silva (1983, p.90) estimated a value of marginal product of 73-76 from an additional cruzeiro invested in research in São Paulo, as compared to one of 40 per additional dollar in the United States with a similar methodology.

Evenson (1984, p.254) had already detected such problems in São Paulo's program:"It appears, however, that São Paulo's exemplary program has not been the centerpiece of this expansion (EMBRAPA's).Indeed, the IAC budget has expanded little since the early 70s, and there are reports that it has lost some staff members...., few experiment stations in the world have produced more benefits per unit of investment than IAC". In the next chapter we will go in more detail about the relationship EMBRAPA - IAC.

2.4. Staff

One of the outstanding achievements of EMBRAPA since 1974 has been the upgrading of Brazilian research personnel through formal master and doctoral training. As pointed out by Pastore and Alves, in the federal research system that existed before EMBRAPA, "only 10 percent could be considered professionals with some kind of graduate training in research" (Pastore and Alves, 1984, p. 123). In December, 1983, ten years after EMBRAPA's creation, 79 percent of the research staff had either

the master or the doctoral degree. In Figure 1 we present the changes over time in the qualifications of EMBRAPA's researchers in which we can observe the strong growth in the proportion of masters holders, followed by those with doctoral degrees and the decline in the proportion of researchers with the B.S. level of training. In 1983, out of 1,613 researchers, 338 (21 percent) were at the B.S. level, 990 (61 percent) at the masters level and 285 (18 percent) at the doctoral level.

The staff structure of the NARS in 1983 (including the state institutions as well as EMBRAPA) was the following: 4,178 researchers, with 1,891 (45 percent) at the BS level, 1,777 (43 percent) at the master's level and 510 (12 percent) at the doctor's level. EMBRAPA, is leading in the current changes in qualification. If all EMBRAPA's researchers presently under training finish their degrees, the following distribution will prevail: 1,613 researchers in total with 195 (12 percent) at the BS level, 963 (60 percent) at the masters level and 455 (28 percent) at the doctor's level. If we apply the same assumption to the national research system, the following will result; 4,178 researchers in total with 1,545 (37 percent) at the BS level, 1,903 (46 percent) at the masters level and 730 (17 percent) at the doctor's level.

To achieve such a rapid qualification change in the research staff, EMBRAPA has invested a share of 15-30 percent of the overall budget during 1974/82. In dollar terms, that means annual values in the range 7.1 - 36.4 millions in the same period, including "salary indirect costs, substitution at a cost equal to salary and indirect costs, plus direct education expenses like scholarships, fees and transportation" (Alves, 1984). Such an improvement in the national sustem's qualification structure is an indication that more and better research results should be obtained in the future. We were not able, however, to breakdown this structure by commodity. If the same improvement can be assumed for domestic and exported goods, we could be still more optimistic that a more even pattern of technological

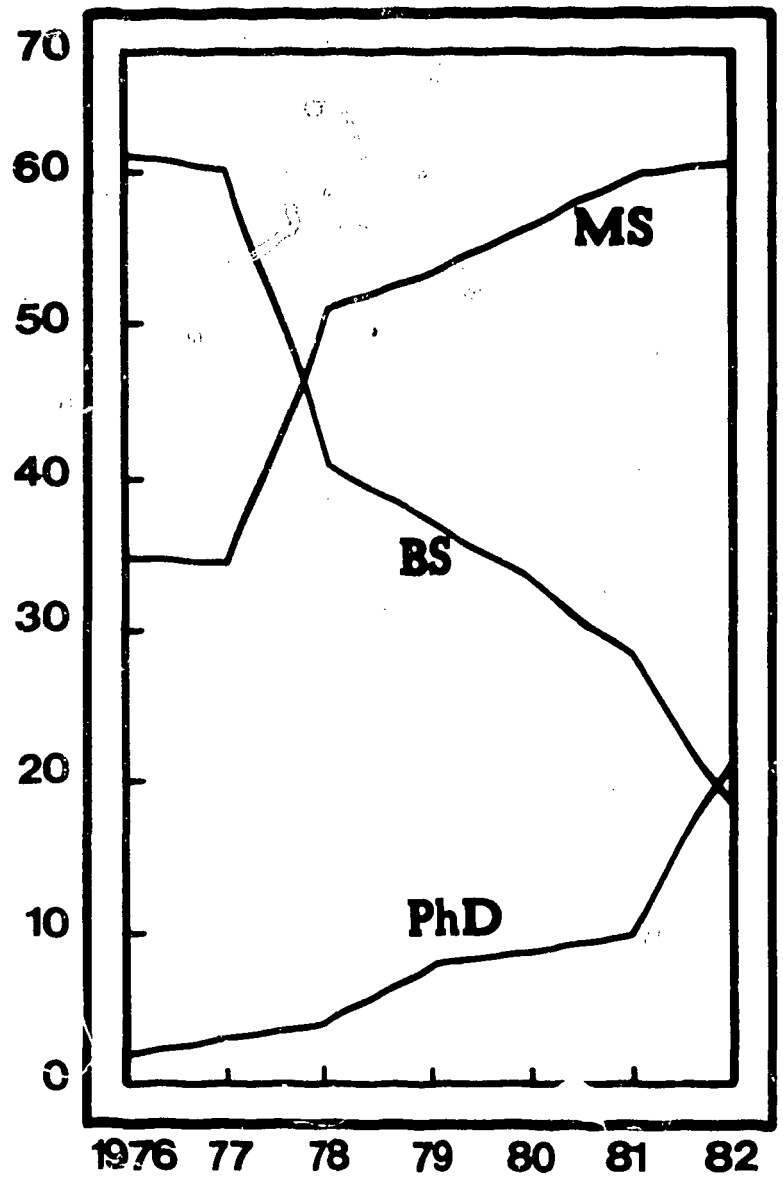


FIGURE 1: The changing qualifications of EMBRAPA researchers.

Source: Alves (1984, p. 173).

innovations will result in the future.

The data for IAC - Campinas' Agronomic Institute - is not as detailed as that for EMBRAPA. In 1983, IAC had a total of 250 researchers, of which 53 had training abroad, although the type was not specified. On the negative side, however, 33 researchers left the institution in the five years previous to 1983. The Biological Institute in São Paulo had 204 researchers in 1983, 44 with training abroad and a loss of four researchers in the last five years. In the Zootechnology Institute, there were 105 researchers in 1983, of which 13 with training abroad (Governo do Estado de São Paulo, 1984). The total number of researchers in IAPAR - Paraná's Agronomic Institute - evolved from 3 in 1972, 10 in 1973, 36 in 1974, 97 in 1975, 168 in 1976, 168 in 1977, 167 in 1979, 166 in 1980, 170 in 1981, 176 in 1982, 177 in 1983, to 176 in september 1984. Also, researchers at the masters or doctor's level evolved from 4 in 1973, 9 in 1974, 11 in 1975, 16 in 1976, 19 in 1977, 32 in 1978, 40 in 1979, 56 in 1980, 61 in 1981, 70 in 1982, 81 in 1983, and to 88 in September, 1984. Finally, IPAGRO, in Rio Grande do Sul, seems to be in the worst situation: with a total of 230 researchers in 1984, of which only one was at the doctor's level and 20 at the master's.

3. Impact of IARCs on the NARS

3.1. Introduction

As discussed in the previous chapter, the Brazilian agricultural research system has undergone quite important changes since the first half of the seventies. Even with a deficient federal research system before that time, the country, or more precisely, a part of it, had a set of successfull research cases and results. It is interesting to observe that most of the success stories of research in Brazil – coffee, cotton, citrus, sugarcane and soybeans – are commodities not covered by the IARCs even today. The exceptions are potatoes, because of CIP, and maize, with CIMMYT, although most of the research in these crops was completed prior to the creation of these two IARCs. The cases of cotton, maize, potatoes and soybeans illustrate the functioning of an informal mechanism for importing new knowledge as well as varieties, particulary from the United States and Europe, to be further used in crossing. The existence of relevant knowledge which can be transferred (a public good) should make it much easier and less costly to develop agricultural technology domestically.

When other countries, particularly the developed ones, do not have a substantial (and relevant) amount of knowledge to be transferred, research may be much more difficult as well as costlier for less developed countries. Previously, we mentioned the unbalanced pattern of technological innovation in Brazil with a bias against some critical domestic food crops, such as rice, cassava and edible beans. Mainly in the cases of cassava and edible beans, research effort by developed countries has not been of major significance, perhaps because they are not very important to them, in production or in consumption. The situation is mixed for rice. Irrigated rice has had significant technological developments, including those resulting from IRRI, but the same cannot be said for upland rice. As a result, and for

the moment leaving aside the more recent contributions of the IARCS for those crops (CIAT and IRRI), the domestic effort should have been much greater, in spite of being a more difficult one.

Since EMBRAPA and the national research system were created and implemented, research expenditures have been substantially increased, many research results have already been obtained and, as a result of all that, the country may be in the process of getting a more balanced pattern of technological change among crops - domestic and exported. In addition, EMBRAPA and the NARS have considerably improved the quality of their researchers, mainly through formal training at the masters and doctor's levels. On the negative side, however, IAC, our former most important research center, has experienced decline.

Even if no changes had also occurred in the international research scene, Brazil would still no doubt have realized gains from investing more in agricultural research, although through the "informal" transfer mechanism mentioned above, crops priveleged by research in developed countries would be more benefited by the process of knowledge transfer. However, things did not remain constant on the international scene, since the number and coverage of crops in the IARC system increased significantly. Recalling the crops with research deficiencies in Brazil, a mention of CIAT, with cassava, rice and edible beans, and IRRI with rice should be made, including the recent greater attention to upland rice. In addition, the creation of IITA and ICRISAT was a favorable development, given the prevalence in Brazil of tropical and semi-arid agriculture, mainly in the poorer regions of the country.

Reasoning somewhat differently, if those positive changes on the international scene had occurred without substantial improvement in Brazil's national research system, the occurrence of future benefits in terms of research results would not be so certain. However, as the national system actually improved, par-

ticularly in the area of researchers' qualifications, we think the present relationship IARCs - NARS, as well as the future one, is being/will be conducted much more productively. In other words, it is our opinion that an efficient national research system in Brazil, as elsewhere, is a precondition for a productive collaboration with the IARCs.

3.2. Research Organization

The structure of EMBRAPA, along with that of the rest of the NARS, has already been detailed in the previous chapter. We have also described how the system is implemented through national research programs, especially for the crops covered by EMBRAPA (which excludes coffee, sugarcane, and a few minor crops). Thus, as compared to the previous decentralized research system, whose main institution was IAC, supported entirely by the state of São Paulo, it can be seen that in establishing EMBRAPA, the federal government gained power in the decision-making process, and the state governments, at least in São Paulo, lost power as well as prestige.

The political complexity of implementing and administering the NARS's model in Brazil, must be recognized. The people involved in EMBRAPA's creation had a very clear vision of what the system should be, and in fact they tried to implement it. The system before EMBRAPA was identified as "the diffuse model of research", in the sense that "each research unit tries to diversify its activities, researching many different products and attempting to generate a wide array of technologies" (Pastore and Alves, 1984, pp. 120-21). On the other hand, "the development of EMBRAPA implies the concentration of relatively large financial and human research resources on a limited number of products. The challenge that this model presents is that of defining priorities and responding to changing circunstances (Pastore and Alves, 1984, p. 124). The definition of priorities involved not only the commodities to be researched but also the

number of production system prototypes to be developed. We could call this the "concentrated model of research", as opposed to the previous "diffuse model".

It seems clear to us that EMBRAPA's administrators began to implement this new research model/organization without discussing or debating it with all possible participants, which, given the already established and independent institutions, was bound to lead to conflict. It is of course possible that even if the concentrated model had been offered for a broad discussion with all parties, conflicts would still have occurred.

Based on a simple economic reasoning and given Brazilian agricultural conditions, as well as the scarcity of research resources, we see merits in EMBRAPA's concentrated model. In the real world, however, personal and institutional conflicts should be viewed with no surprise. The clearest case is that of IAC - Campinas' Agronomic Institute. IAC's usefulness had not been limited to São Paulo. Many innovations with origin at IAC, including varietal innovations, were adopted by farmers in other states, particulary the neighboring ones with similar ecological conditions. For instance, Evenson's result about external effects was that "transferability from São Paulo to the South is high (but less than one, of course) and significant" (Evenson, 1984, pp. 262-63). No transferability, however, was observed to the Northeast and a low one to the Center-West and Southeast regions of Brazil. In conclusion, even if IAC could not be considered a national research center, it at least had a considerable regional influence. Also, the technical assistance, personal or institutional, to other research centers in Brazil, including the Northeast (cotton, for instance) should not be neglected.

Although the collaboration of IAC with the IARCs has not been of great intensity, it nevertheless has existed in training, genetic materials, information and publications. In most of the interviews made at IAC it was felt there was a relationship problem between IAC and the IARCs involving EMBRAPA

in the middle. This problem appears to exist most intensively in the activities of training and genetic materials. The complaint from IAC is that, although its researchers can directly seek the collaboration from different IARCs, any final decision depends on EMBRAPA. This, according to Campinas' researchers, limits the institution's initiative, places it in subordination to EMBRAPA and, in some ciurcunstances, is quite humiliating. This last problem arises when the researcher in IAC feels he is professionally superior to the EMBRAPA analyst in a specific situation. Given the past quality of IAC's staff and research accomplishments, this may happen in some circunstances. For instance, quite a strong bias against EMBRAPA was found in IAC's edible bean sector, while there was none in the rice sector. Both rice researchers interviewed made the point that they have had no problems with EMBRAPA in terms of access to the rice germoplasm bank of that institution. The bean breeder interviewed, on the other hand, was highly critical of EMBRAPA: first, because of the poor quality of the beans' research staff in CNPAF-Goiânia; second, because of the difficulties in doing research supported by EMBRAPA; and third, regarding the collaboration with the IARCs, because of EMBRAPA's centralization of all decisions for the services provided. As a result, that bean breeder is not part of the national bean research program. He considers the participation rules for an independent research center like IAC too restrictive, mainly in terms of research procedures and limitations on the use, by IAC, of the results obtained in research.

The administration of IAPAR-Paranã's Agronomic Institute - in Londrina, would prefer to have, for all services, a direct relationship with the IARCs, rather than go through EMBRAPA. They think IAPAR would gain with such a change, mainly in the case of training, since its planning for the future would be improved. In IPAGRO - Rio Grande do Sul's Agronomic Institute -, most relations with the IARCs also have to go through EMBRAPA. One of IPAGRO's researchers stated the need for direct collaboration IPAGRO - CIMMYT, that is, without EMBRAPA's intermediation.

IPAGRO would gain from such a change since currently EMBRAPA's centralization slows the receipt of genetic materials. In IRGA - Rice (Cachoeirinha, Rio Grande do Sul) on the other hand, there is a direct relation of its researchers with CIAT's, a mechanism which is thought to best express needs to the IARCs.

From this evidence, we could conclude that independent research institutions in Brazil would prefer to have a direct relationship with the IARCs. The present system, however, is one where EMBRAPA's staff coordinates most aspects of the relationship and that is thought to be highly necessary. Although the "centralized" relationship with the IARCs may be more efficient in the short-run than the previous "diffuse" one, in the sense of getting a higher short-run return for an invested cruzeiro, it may block researchers and institutions initiative and, as a result, yield smaller returns in the long-run. Critical to solving this problem, we believe, would be the establishment of channels in the national commodity research programs where such problems could be openly discussed.

3.3. Services provided

As stated above, the provision of genetic materials and training are undoubtdely the most important services provided by the IARCs to the NARS. The opinion was often heard that the training at the IARCs was more important in the past than in the present, and that now the provision of genetic materials is the most important service. In our view, what explains such ranking today is the substantial improvement already obtained in the qualification of EMBRAPA's research staff, and to a lesser extent, in the entire national research system. Evidence of such improvement was presented in the previous chapter.

If that is true, the predominance of genetic materials in the relationship IARCs-Brazil will tend to be accentuated in the future since qualification improvement, through formal

master and doctoral programs, is a process still underway in EMBRAPA and at the NARS. Without a highly trained research staff, research related to breeding and varietal improvement should not be expected. Now, the human resource base has improved substantially, altering the nature of the relationship between the NARS and the IARCs. This relationship can be expect to continue changing in the future.

The head of the Human Resources Development of EMBRAPA expressed the opinion that the courses presently offered by the IARCs are not of great interest to EMBRAPA's people. Here we may have two possibilities: first, the IARCS have already completed their role in the type of training provided by the programs offered in the earlier years of EMBRAPA and the national system, and may shift their emphasis to other countries. Second, the traditional training should be only the first stage in a two or more stage training program. Given the present higher qualification of the research staff in Brazil, the program should evolve to more specific areas or to discussion of specific problems identified by the respective national commodity research programs. As a result, the contribution of the IARCs in terms of "research approaches or methodologies" would be a better one. It seems to me that presently, there is no mechanism for this type of evolutionary change in the relationship IARCs-NARS to ocur.

It is important to observe that in the opinion of those people interviewed, the formal training that Brazilian researchers have had abroad, in American and European universities, is considered as a complement rather than a substitute for IARC training. As a result, we believe the second possiblity — a change in the IARC's training programs for Brazilian researchers — should be pursued in the future.

In the following, specific comments made in our interviews will be listed with the origin indicated, but with no attempt to integrate them or to avoid overlapping.

a) EMBRAPA's headquarters: courses should consider well-defined areas and themes because of the increasing qualification of EMBRAPA's research staff: a better specification of the trainees' pre-requisites; more advance notice in programming courses to allow EMBRAPA to do its own planning.

b) CNPAF - Goiânia: the IARCs should give more attention to "scientific" training; decisions about which Brazilian researchers should be trained and in what subjects should lie with EMBRAPA.

c) IPAGRO - Rio Grande do Sul: training was ranked as the most important aspect of the collaboration[1]. Since IPAGRO is having serious funding difficulties for formal and long-time training, it suggested short courses as a possible "second best" solution.

d) CPAC - Cerrados - Brasília: training was the most important aspect in the beginning of the collaboration in 1978, but with the ensuing increase in the qualification of CPAC's staff, today the most important aspect is germoplasm material and research approaches /methodologies.

e) IAPAR - Londrina: there is a need for more training of longer duration in breeding.

With respect to the provision of genetic materials, we have a few comments before listing them. First, we have used information provided in the inteviews made in each research center, as well as in published material. Second, not all research centers provided us with a list of IARC's contributions to varietal developments. As a result, our list may be incomplete Lastly, there is almost no information about which areas are utilizing these new varieties. The crops given priority in our

(1) We recall from the previous chapter that IPAGRO, with 230 researchers had only one doctor and 20 masters.

field survey were rice, edible bean, maize and cassava.

RICE:

a) BR-2: upland rice, cultivar resulting from lineage IR 442-2-58, with origin in the crossing IR 95-31-4/ /Leb Mue Nahng. It was introduced in 1976 in Piauí (Northeast) by UEPAE-Terezina and CNPAF- Goiânia, through the International Rice Testing Program of IRRI. Characteristics: resitance to blast, "mancha parda", "escaldura" and to lodging; tolerant to dry periods in recommended areas (parts of Piauí).

b) BR-IRGA-409: cultivar of irrigated rice, developed in 1978 by EMBRAPA through UEPAE-Pelotas, the Federal University of Pelotas, and IRGA through Cachoeirinha's experiment station, from lineage P 790 of CIAT, resulting from the crossing of lineages IR 930-2 and IR 665-31-2-4 of IRRI. Intermediate reaction to blast, moderatly resistant to "helmintosporiose" and resistant to lodging. Recommended for the state of Rio Grande do Sul, excepting the southern coastal area. According to IRGA's people in Cachoeirinha, this cultivar occupied 350 thousand hectares in 1983 (50 percent of the state's total).

c) EMPASC 103: cultivar of irrigated rice developed in 1980 by EMPASC - Santa Catarina's Agricultural Research Corporation - from lineage P 791 - $-B_4-14$ and crossing IR 930-2/IR 665-31-5-8. Resistant to lodging and to blast in laboratory conditions.

d) CNA-4: irrigated rice, introduced from Indonesia by CNPAF in 1978 and corresponds to lineage B 54 1b-Pn--58-5-3-1, originating from the crossing PELITA I-1/ /IR 1082. Short size and recommended for irrigated areas of Ceará, Pernambuco and Paraíba (Northeast states).

e) CNA 7: introduced in Brazil in 1978 with the identification IET 2881, originating in India and resulting from the crossing T 141/IR 665-1-175-3. Short size irrigated rice, moderatly resistant to blast and recommended for irrigated areas of Ceará, Pernambuco and Paraíba (Northeast states).

f) CNA 1051: for humid lowland rice areas, originating from the crossing BG 90-2/4440/Colombia 1, made in CIAT and introduced in Brazil by CNPAF in 1981. Short size plant, resistant to blast and "escaldadura"; recommemded for Center-West, North and Northeast regions.

g) BR-IRGA 410: resulting from joint research EMBRAPA-IRGA (Cachoeirinha), introduced in 1981, originating in CIAT's material IR 930-53/IR 665-31-2-4, irrigated rice, indicated for the cooler regions of Rio Grande do Sul; in 1983 it occupied 100 thousand hectares in the state (15 percent of the total).

h) IAC 1278: irrigated rice coming from progeny P-1278 in "homozigose", from CIAT in 1976 and tested experimentally for five years by Campinas' Agronomic Institute: commercially available in June, 1982.

i) IAC 4440: IAC's denomination for the introduction of CICA 8, resistant to blast.

j) IR 665 and IR 841: in Campinas' Agronomic Institute.

k) CICA 8 and CICA 9, after 1977 in the state of Rio Grande do Sul, the former with low acceptance and the latter not working well.

EDIBLE BEANS:

a) CAUPI BEAN-MANAUS: lineage from IITA and developed by UEPAE/Manaus and CNPAF; resistant to "carvão" and "cercospora", and moderatly resistant to "mosaico"; recommended for the state of Amazonas (North).

b) CAPIXABA PRECOCE: edible beans, originating in CIAT (BAT 304) and resulting from the crossing Porrillo Sintetico (El Salvador)/Compuesto Chimaltenango (Guatemala). Selected by EMCAPA-Espírito Santo's Agricultural Research Corporation-in 1981/82 and commercially available in the state of Espírito Santo in 1983; resistant to "ferrugem" and tolerant to "antracnose", "bacteriose" and "mancha angular".

c) EMPASC 201-CHAPECÓ: edible bean (black), introduced in 1976 by IPAGRO-Rio Grande do Sul, as LINEA 38 from ICA- Colombia Agricultural Institute. In 1977 it was introduced in Santa Catarina by EMPASC; first recommendation for planting in Santa Catarina in 1983. Resistant to "ferrugem" (Uromyces phaseoli) and moderatly resistant to "antracnose" (Colletotrichium lindemuthianum), to "mancha angular" (Isariopsis griseola) and to "bacteriose" (Xanthomonas campestris pv phaseoli).

d) IAPAR 8-RIO NEGRO: obtained in IAPAR-Londrina, black edible bean, from the crossing RIO TIBAGI with segregating population originating from CIAT (FF 1322); resistant to "antracnose", "mosaico" and "ferrugem" and recommended for parts of Paraná state.

e) VITÓRIA: cultivar originating from CIAT (BAT 179) and resulting from the crossing 51052 (Turialba 4)/Beurre D Paulinat; selected by EMCAPA in 1981/82 and made commercially available in 1983; tolerant to "antracnose" and "bacteriose", but sensible to "ferrugem" and "mancha angular"; recommended for all the state of Espírito Santo (Southeast).

j) EMGOPA 201: coming from CIAT (A-295), developed by EMGOPA - Goiás' Agricultural Research Corporation -; in 1984 was distributed to farmers.

g) BR-1 POTY: caupi beans (Northeast), resulting from the crossing of cultivar PITIUBA and TVu 410 (Texas Purple Hull 49), this last one from IITA. It was obtained by CNPAF- Goiânia and UEPAE-Terezina(Piauí); resistant ro several "virus"; used for human consumption as well as for animals.

h) BR-3 - SERRANO: caupi bean obtained by CNPAF-Goiânia and EMPARN - Rio Grande do Norte's Agricultural Research Corporation - in 1983, originating from the crossing of PITIUBA and TVu-590 (IITA, Nigeria); tolerant to the main diseases and recommended for parts of the state of Rio Grande do Norte.

i) CNC 0434: cultivar of caupi bean originated in the selection made by CNPAF-Goiânia, with material coming from IITA in 1978; resistant to "mosaico" and made available in the state of Maranhão (Northeast).

MAIZE:

a) BR-5101: cultivar developed in 1978 by CPA-Humid Tropic (EMBRAPA, Belém) through selection in an original population synthesized at School of Agriculture - USP, Piracicaba, with maize coming mainly from race TUXPENO. When consulting Piracicaba's material, reference was made to its coming from CIMMYT. Recommended for the Amazon region.

b) BR-5102: cultivar developed in 1978 by CPA-Humid Tropic in Belém and CNPMS-National Research Center for Maize and Sorghum - in Sete Lagoas, Minas Gerais, both of EMBRAPA, from population 28 in CIMMYT's germplasm bank; moderatly resistant to lodging and recommended for low-land areas of the Amazon region.

c) CENTRALMEX NORDESTE: cultivar developed in 19[illegible] by EMBRAPA's Semid-Arid Research Centre (CPATSA, Petrolina, Pernambuco), from germplasm TUXPENO through

the crossing PIRAMEX/América Central made at Piracicaba's School of Agriculture; it was not selected to be resistant to dry periods and joint cultivation, but is recommended for the Northeast region.

d) BR 105: cultivar developed in the early eighties by CNPMS-Sete Lagoas (EMBRAPA) from a synthetic variety obtained from germplasm originated in the Caribbean, and selected in Thailand, by CIMMYT for resistance to "mildio"; tolerant to "helminthosporiose" and "ferrugem", with planting recommendations for the states of Minas Gerais, São Paulo, Goiás, Paraná and Mato Grosso do Sul.

e) BR 108: white cultivar developed in the early eighties by CNPMS-Sete Lagoas (EMBRAPA), from a synthetic variety obtained from a version of short-size quantitative of germplasm TUXPENO of Central America, originating in CIMMYT. It is a variety indicated for mixing with wheat flour in the food industry; tolerant to "helminthosporiose" and "ferrugem" but with sensitivity to "mildio"; recommended for the central region of Brazil, particulary for the states of Minas Gerais, São Paulo, North of Paraná and Mato Grosso do Sul.

f) BR 126: cultivar developed in the early eighties by CNPMS-Sete Lagoas (EMBRAPA), from a synthetic variety obtained with germplasm originating mainly in the race TUXPENO; moderatly resistant to lodging yellow, type and indicated for grain production as well as for green material. Tolerant to "helminthosporiose" and "ferrugem", but with sensitivity to "mildio" disease; recommended for the states of Minas Gerais, São Paulo, Goiás, Paraná, Espírito Santo and Mato Grosso do Sul.

g) BR 300: an intervarietal hybrid developed in 1983

and originating from crossing two short-size poligenic varieties with CIMMYT's basic material, obtained in CNPMS-Sete Lagoas (EMBRAPA); yellow type, resistant to lodging and tolerant to "helminthosporiose", "mildio" and "ferrugem" diseases; recommended for the states of Minas Gerais, São Paulo, Goiãs and Paranã.

h) BR 301: an intervarietal hybrid developed in 1983 by CNPMS - Sete Lagoas (EMBRAPA), originating from two short-size selected varieties based on poligenies, with basic material from CIMMYT. Yellow-orange color, resistant to lodging and tolerant to "helminthosporiose", "mildio" and "ferrugem" diseases. Recommended for the states of São Paulo, Minas Gerais and Paranã.

i) BR 302: a "top-cross" hybrid originating from crossing a short-size poligenic variety with a high-yield simple hybrid, obtained by CNPMS-Sete Lagoas (EMBRAPA) in 1983 with CIMMYT's material. Yellow-orange color, resistant to lodging and tolerant to the same diseases as BR-300 and BR-301. Recommended for the states of Minas Gerais, São Paulo, Goiãs and North of Paranã.

j) EMPASC 151 - CONDÃ: a cultivar originating from the population Amarillo del Bajio x Templados, coming from CIMMYT through EMBRAPA, and developed in 1983 by EMPASC - Santa Catarina's Agricultural Research Corporation - for conditions of average soil fertility. Yellow-orange color, with good resistance to the main pests and diseases. Recommended mainly for the western part of the state of Santa Catarina (Souht).

k) EMPASC 152-OESTE: a cultivar originating from the population SUWAN DMR (Caribbean region), improved

in Thailand and CIMMYT, and coming to Brazil, via EMBRAPA, to EMPASC-Santa Catarina. It has shown resistance to "mildio" (Sclerospora sorghi) and is recommended for the western parts of the state of Santa Catarina.

l) PIRANÃO: obtained in the late sixties by the School of Agriculture-Piracicaba, São Paulo, with origin in the crossing of PIRAMEX III and TUXPENO BRAQUÍTICO, from CIMMYT. Short-size plant with high resistance to lodging and good yields.

In general, all new varieties mentioned for rice, beans and maize are presented as having good yields as compared to older ones, but we were not able to have a reliable basis for an adequate comparison in terms of actual production conditions. On the other hand, no registry of varietal improvement was found for cassava, which was confirmed when visiting CNPMF - National Research Center for Cassava and Tropical Fruits - in Cruz das Almas, Bahia. With respect to pastures, it seems that CIAT's collaboration with CPAC - "Cerrados" Research Centre - in Brasília, has led to the development of: a) Andropogon goyanos (cv Planaltina) in 1979/80; b) Stylosantes guianensis (cv Bandeirante) in 1984; c) Stylosantes macrocephala (cv Pioneiro) in 1984; d) Brachiaria brizanta (cv Marandu) in 1983.

While wheat was not included in our priorities for field interviews, we were able to identify the following developments: a) ALONDRA 4546, cultivar obtained late in the seventies from the crossing D 6301-Nai 60 x Wq-RM/Cno$_2$-Chr, with CIMMYT's material and having the number CM 11683, with good resistance to diseases; it is recommended for parts of Paraná, Mato Grosso do Sul, São Paulo and the central part of Brazil; b) MONCHO BSB: cultivar obtained late in the seventies resulting from a lineage selected by CIMMYT; recommended for the central part of Brazil; c) BR 10-FORMOSA: cultivar obtained early in the eighties from reselecting Alondra Sib, in CPAC - "Cerrados" Research Centre in Brasília, with yields 15 percent higher than ALONDRA 4546; d)

BR 11: joint work of CIMMYT, CNPT-National Research Center for Wheat -, Passo Fundo, and recommended for the state of Mato Grosso do Sul.

4. Research Impacts on Agricultural Production

4.1. Important Innovations from Non-IARC Sources

In the previous chapter we listed, for rice, edible beans, maize, pastures and wheat, the varieties developed in the NARS with the contribution of the IARCs. For cassava no development was identified. However, we must remember that the IARCs do not cover many commodities in Brazilian agriculture and that some of the research work leading to the development of new varieties is independent of their services. Also, other international research institutions may have contributed to the process of technological change in Brazil. In this part of the paper we will review the new varieties of several agricultural commodities developed independently of the IARCs, mainly from the second half of the seventies, but with less individual details than in the previous chapter.

RICE:

a) CNA 104: from crossing IAC 47 and SR 2041 - 50-1 (with resistance to blast, South Korea) recommended for the state of Mato Grosso (upland rice), with moderate resistance to blast disease.

b) CNA 108: developed with the objective of being resistant to blast, from crossing IAC 47 and TOS 2578/ /7-4-2-3-B2 (introduced from Nigeria). High resistance to blast, yield 15-20 percent higher than IAC--47, upland rice.

c) CNA 790954: with genetic material from IRAT-Institute de Recherches Agronomiques Tropicales - in 1979; from crossing DOURADO PRECOCE and IRAT 13; short cycle and higher resistance to lodging and being mostly cultivated in the states of Goiãs and Maranhão.

d) CNA 791048: upland rice's cultivar selected by CNPAF - Goiânia, from crossing, in 1979, DOURADO PRECOCE and IAC 5544, with the objective of combining characteristics of grain quality and short-cycle of the first one with high yields of the second. Recommended for states/territories of Roraima, Amapá (North) and Piauí (Northeast).

e) CNA 796019: cultivar introduced in 1979 by CNPAF-Goiânia, with the identification IET 4094. it resulted from crossing BN1/CR 115 made in India. Recommended for the state of Piauí (Northeast).

f) IAPAR 9: cultivar of upland rice developed in IAPAR - Londrina, from crossing BATATAIS and lineage IAC F-3-7; recommended for the state of Paraná.

EDIBLE BEANS:

a) IPA - 1: cultivar developed by Pernambuco's Corporation of Agricultural Research (IPA), from crossing COSTA RICA and L_3-0-50.

b) IPA - 2: cultivar developed by Pernambuco's Corporation of Agricultural Research (IPA), from crossing COSTA RICA and L_3-0-50; with resistance to "ferrugem" but with sensitivity to "antracnose". Recommended for warm areas and low relative humidity.

c) IPA-74-19: cultivar developed by Pernambuco's Corporation of Agricultural Research (IPA), from crossing COSTA RICA and L_3-0-50; resistant to "ferrugem" but with sensitivity to other diseases. Recommended for warm areas and low relative humidity.

d) GUATEIAN 6662: cultivar of black beans, introduced by the joint program DNPEA-IPAGRO (Rio Grande do Sul), originally selected by IIAC - Interamerican Institute of Agrarian Sciences - of Costa Rica. Recommended for bean areas of the state of Rio Grande do Sul.

e) TURRIALBA 4: cultivar of black beans, pure line selected from and indigenous population in Guatemala by IIAC; introduced in Brazil by IPAGRO - Rio Grande do Sul in 1969.

MAIZE:

a) SAVE 342: cultivar of double hybrid developed by IPAGRO - Rio Grande do Sul. Yellow color, indicated for feed as well as for flour. Recommended for the state of Rio Grande do Sul.

b) SAVE 345: cultivar of double hybrid developed by IPAGRO - Rio Grande od Sul. Yellow color, indicated for feed as well as for flour; short-cycle and recommended for the state of Rio Grande do Sul.

c) EMGOPA 501: cultivar obtained by EMGOPA - Goiás' Corporation of Agricultural Research, from population COMPOSTO DENTADO, synthesized in the Genetic's Department, School of Agriculture, Piracicaba, São Paulo; resistant to "mildio" and "helminthosporiose".

d) SINTÉTICO: cultivar obtained by PESAGRO - Rio de Janeiro's Corporation of Agricultural Research, from the original material SINTÉTICO IPEACS III. IPEACS was, before EMBRAPA, the research center for the Center-South region. Recommended for the northean part of Rio de Janeiro's state.

e) BR 125: cultivar developed in CNPMS - Sete Lagoas, from a synthetic variety obtained from germplasm originating in breeding programs of Brazil, Colombia and Mexico. Low resistance to lodging, tolerant to "helminthosporiose" and "ferrugem", and with sensitivity to "mildio".

f) BR 126: cultivar developed in CNPMS - Sete Lagoas, from a synthetic variety obtained from germplasm

originating in the race TUXPENO. Moderatly resistant to lodging, tolerant to "ferrugem" and "helminthosporiose" and with sensitivity to "mildio". Recommended for states of Minas Gerais, São Paulo, Goiãs, Paranã, Espírito Santo and Mato Grosso do Sul.

g) BR 427: cultivar of sweet corn developed by CNPMS - Sete Lagoas, from a synthetic variety obtained in germplasm from Haway. Tolerant to "ferrugem" and "helminthosporiose", but with sensitivity to "mildio". Recommended for the states of São Paulo, Minas Gerais, Rio de Janeiro, Mato Grosso do Sul, and south of Goiãs.

POTATOES:

a) BR - 1: cultivar resulting from crossing BNTJE (The Netherlands) and BARONESA, and developed by UEPAE - Cascata, Rio Grande do Sul. Resistant to "esverdeamento" and recommended for the states of Rio Grande do Sul and Santa Catarina.

b) CHIQUITA: cultivar developed by EPAMIG - Minas Gerais' Corporation of Agricultural Research - and EMBRAPA, from "clone" 0010 resulting from crossing DELTA and PAMIR 9in 1971); yield was 29 percent higher than those of imported cultivars. Recommended for the Center-South region of Brazil.

c) MANTIQUEIRA: cultivar developed by EPAMIG - Minas Gerais - and EMBRAPA, from "clone" 0113 resulting from crossing COSINA and HYDRA (in 1971); yield was 34 percent higher than those of imported cultivars. Recommended for the Center-South region of Brazil.

d) MINEIRA: cultivar developed by EPAMIG - Minas Gerais - and EMBRAPA, from "clone" 0196 resulting from crossing COSIMA and TONDRA (in 1971). Yield was

26 percent higher than imported cultivars and recommended for the Center-South region of Brazil.

WHEAT:

a) BR - 1: cultivar developed by the joint program CNPT - Passo Fundo (EMBRAPA) - and Federal University of Pelotas (Rio Grande do Sul), derived from crossing IAS 20 and IAS 50, in the late seventies; resistant to the majority of "ferrugem"'s races and to "crestamento". Short-cycle and recommended for the western parts of Paranã's state.

b) BR 2: cultivar developed by the joint program CNPT-Passo Fundo (EMBRAPA) - and the Federal University of Pelotas (Rio Grande do Sul), derived from crossing IAS-50/4/IAS-46/3/VILELA SOL 4/EGYPT NA 101/TIMSTEIN, in the late seventies. Short-cycle, tall size, recommended for the western part of Paranã's state.

c) BR 3: cultivar developed in the late seventies by DNPEA-Pelotas (before EMBRAPA), CNPT - Passo Fundo (EMBRAPA) - and the Federal University of Pelotas (Rio Grande do Sul), from crossing IAS 50/4/IAS 46/ /3/VILELA SOL 4/EGYPT 101/TIMSTEIN; average cycle, tall size, recommended for the state of Rio Grande do Sul.

d) BR 4: cultivar developed in the late seventies by CNPT - Passo Fundo (EMBRAPA) - and the Federal University of Pelotas (Rio Grande do Sul), from crossing IAS 20*3/SINVALOCHO GAMA. Average cycle, tall size, recommended for the state of Rio Grande do Sul.

e) ACEGUÃ: cultivar developed in the late seventies by IPAGRO - Rio Grande do Sul, from crossing IAS 50 and B 8; average cycle, tall size, recommended for the areas of Bagé and Herval in Rio Grande do Sul.

f) BR 5: cultivar developed in the late seventies by CNPT - Passo Fundo (EMBRAPA), from crossing IAS 59/ /IAS 52/GASTA; short cycle, tall size and recommended for the wheat regions of the state of Rio Grande do Sul.

g) BR 6: cultivar developed by DNPEA - Pelotas (before EMBRAPA), CNPT - Passo Fundo (EMBRAPA) and the Federal University of Pelotas (Rio Grande do Sul) in the late seventies, from crossing IAS-20-IASSUL/ /TOROPI. Long cycle, tall size and recommended for all wheat regions of Rio Grande do Sul.

h) TIFTON: cultivar developed by IPAGRO - Rio Grande do Sul, by selection from the same lineage existent in Georgia, United States; highly resistant to "oídio", average cycle, short size and recommended for all wheat regions of Rio Grande do Sul and southern Paranã.

i) BR 7: cultivar developed in the early eighties by CNPT - Passo Fundo (EMBRAPA) from crossing IAS 20- -IASSUL and TOROPI; average cycle, tall size, resistant to all races of "ferrugem" (Puccina graminis tritici) and recommended for parts of Paranã's state.

j) IAPAR 3-ARACATU: cultivar developed in the early eighties by IAPAR - Londrina, unknown crossing, short to average cycle, average to tall size, recommended for the region of Dourados, Mato Grosso do Sul.

k) BR 8: cultivar developed in the early eighties by DNPEA - Pelotas (before EMBRAPA) and CNPT - Passo Fundo (EMBRAPA), from crossing IAS 20/TOROPI/PF 70100; short-cycle, tall size, resistant to "ferrugem" and recommended for Rio Grande do Sul, Minas Gerais, Goiãs and the Federal District.

l) BR 9 - CERRADOS: cultivar developed in the early

eighties by CPAC - Brasília (EMBRAPA, cerrados) and resulting from crossing BH 1146 and IRN 595-71. Recommended for upland cultivation in the central region of Brazil.

m) CANDEIAS: introduced in Brazil by OCEPAR - Organization of Paranä's Cooperatives - as lineage E 75168 of Dekalb Seed Co. (Argentina), resulting from crossing CARDENOL x SONORA 64-KLEIN RENDIDOR, and evaluated by the national research system of EMBRAPA; short-cycle, low size and recommended for Minas Gerais, Goiãs, Mato Grosso and the Federal District.

n) MINUANO 82: cultivar originating in the crossing 571 x S 473. A_3A_2 made in FECOTRIGO's experimental centre. FECOTRIGO is Federation of wheat Cooperatives in Rio Grande do Sul. Recommended for soils with more than 5 percent of aluminum saturation in the states of Rio Grande do Sul and Paranã.

o) RS 1 - FENIX: cultivar developed by IPAGRO - Rio Grande do Sul - in the early eighties, from the crossing PF 70100/J 115157-69, short cycle and recommended for all the state of Rio Grande do Sul.

p) RS 2 - SANTA MARIA: cultivar developed by IPAGRO - Rio Grande do Sul - in the early eighties from the crossing S45/KAVKAZ, short-cycle and recommended for all Rio Grande do Sul.

q) RS 3 - PALMEIRA: cultivar developed by IPAGRO - Rio Grande do Sul - in the early eighties, from the crossing S45/KAVKAZ (made in 1972), short-cycle and recommended for all Rio Grande do Sul.

r) RS 4 - UBIRAIARAS: cultivar developed by IPAGRO - Rio Grande do Sul - from the crossing MARINGÃ/S 76. Recommended for all Rio Grande do Sul, except regions of Bagë and São Gabriel.

COTTON:

a) BR 1: cultivar developed late in the seventies by the CNP - Campina Grande, Paraíba (EMBRAPA), resulting from the crossing ALLEN 333/57 x ALBURN 56; resistant to "murcha" of Verticillium, short-cycle, recommended for parts of Pernambuco, Alagoas, Sergipe, Minas Gerais and Goiás.

b) IAPAR 4-PARANÃ 1: cultivar developed by IAPAR-Londrina in the late seventies, with selection in African variety REBA B-50 (beginning in 1973). Short-size, good resistance to dry periods, tolerant to "bacteriose" and "ramulose" and recommended for parts of Paranã and southern Ceará (Northeast).

c) CNPA 2 H: cultivar developed by CNPA - Campina Grande, Paraíba (EMBRAPA) in the early eighties, resulting from individual selection in the African variety REBA B-50. Tolerant to "bacteriose" and recommended for states of Ceará and Bahia (Northeast).

d) CNPA 2 M: cultivar developed by CNPA - Campina Grande, Paraíba (EMBRAPA) in the early eighties; it is a compound with genotypes of VELUDO C 71, C 74 and PB 117-20-8, with sensitivity to "bacteriose" and "fusariose" and recommended for the states of Piauí, Ceará, Rio Grande do Norte, Paraíba and Pernambuco.

SOYBEANS:

a) BR - 4: cultivar developed in the late seventies by CNPS-Londrina (EMBRAPA) and CNPT - Passo Fundo (EMBRAPA), resulting from crossing HILL and HOOD. Yields were 10 percent higher than BRAGG's and 15 percent higher than DAVIS's (see Table 1). Recommended for all areas of Rio Grande do Sul.

b) DOKKO: cultivar developed jointly by IAC - Campinas.

IAPAR - Londrina and CNPS - Londrina (EMBRAPA), from population RB 72-1, in the late seventies. Yields were 5-15 percent higher than that of UFV-1 and 19 percent higher than that of IAC-2 (see Table 1). Recommended for the states of Minas Gerais, Goiãs, Mato Grosso and the Federal District, the central part of Brazil.

c) IVAÍ: cultivar developed in the late seventies by IPAGRO - Rio Grande do Sul - from the crossing MAJOS x HOOD (in 1967). Yields were 9 percent higher than those of BOSSIER and HARDEE and 3 percent higher than that of BRAGG. Resistant to diseases and recommended for Rio Grande do Sul.

d) BR 05: cultivar developed in the early eighties by CNPS - Londrina (EMBRAPA) and made available by UEPAE - Dourados, Mato Grosso do Sul, resulting from crossing HILL and HOOD (in 1976). It has the same yield as BRAGG and DAVIS but is superior in terms of plant height and insertion of the first pods. Recommended for soils of high fertility in the southern part of Mato Grosso do Sul.

e) EMGOPA 301: cultivar developed in the early eighties by EMGOPA - Goiãs' Agricultural Research Corporation -, from the crossing IAC 4 and JÚPTER (in 1973/74). Recommended for the southern part of Goiãs, between 16^{o} - 19^{o} latitude, in soils from low to average fertility (partially or totally improved "cerrados").

f) DOURADOS: cultivar developed in the early eighties by UEPAE - Dourados, Mato Grosso do Sul (EMBRAPA), resulting from selection in cultivar ANDREWS (in 1973), selection made by OCEPAR - Organization of Paranã's Cooperatives. Yields were 9 percent higher than SANTA ROSA's and 5 percent higher than VIÇOJA's.

Recommended for the southern part of Mato Grosso do Sul.

g) NUMBAIRA: cultivar developed in the early eighties as a result of the work of several institutions: IAC - Campinas, IAPAR - Londrina, CNPS - Londrina (EMBRAPA), CPAC - Brasília, cerrados (EMBRAPA), EMGOPA - Goiás' Agricultural Research Corporation-, EPAMIG - Minas Gerais' Agricultural Research Corporation - and UNESP - São Paulo's State University - in Ilha Solteira. Yields were 6 percent higher than UFV-1 and 19 percent higher than IAC-2 (see Table 1). Recommended for Goiás, Mato Grosso, Minas Gerais and the Federal District, all in central Brazil.

h) TROPICAL: cultivar developed in the early eighties with the contribution of several institutions: IAC-Campinas, IAPAR - Londrina, EMBRAPA (UEPAE - Terezina, Piauí; UEPAT - Porto Velho, Rondônia; CPAC-Brasília, cerrados; CNPS - Londrina), EMAPA - Maranhão's Agricultural Research Corporation-, EMGOPA - Goiás' Agricultural Research Corporation-, and EPABA - Bahia's Agricultural Research Corporation. It is a progeny selected from the crossing HAMPTON and E 70-51 (in 1969/70), and it was the first soybean variety available for planting in latitudes below 15^{o} which includes the Amazon and the Northeast. Recommended for Maranhão, Piauí, Rio Grande do Norte, Amazonas, north of Goiás, north of Bahia and territory of Rondônia.

i) BR 6: cultivar made available in 1981 by CNPS -Londrina (EMBRAPA), selected as a progeny F from the crossing BRAGG (3) and SANTA ROSA. Resistant to several diseases and recommended for the state of Paranã.

j) TIARAJU: cultivar developed in the early eighties by IPAGRO - Rio Grande do Sul, from the crossing INDUSTRIAL x ASOMUSUME. It was tested by UEPAE-DOURADOS, Mato Grosso do Sul (EMBRAPA) and it is recommended for the region of Dourados in Mato Grosso do Sul.

k) BR 8 - PELOTAS: cultivar made available in 1983 by UEPAE - Pelotas, Rio Grande od Sul (EMBRAPA), resulting from a selection made in 1975 in generation F_5 of crossing BIENVILLE x HAMPTON. Resistant to several diseases and recommended for the wheat regions of Cruz Alta, Colonial de Santa Rosa and Lagoa dos Patos in Rio Grande do Sul.

l) BR 9 - SAVANA: cultivar developed in the early eighties by CPAC - Brasília, cerrados (EMBRAPA) -, with contributions from several institutions: CNPS-Londrina (EMBRAPA), IAC - Campinas, EPAMIG - Minas Gerais, EMGOPA - Goiãs and EMPAER - Mato Grosso do Sul's Agricultural Research Corporation. It resulted from an individual selection in the population ("bulk") LoB 74-2 in F_4. The crossings involved DAVIS x SANTA ROSA and lineages IAC 73-481, IAC 73--1075 and F67-5221. Recommended for the "cerrados" region of Brazil, mostly located in the central part of the country.

m) BR 10 - TERESINA: cultivar made available in 1983 by CNPS - Londrina (EMBRAPA); it is a progeny F_6 from the crossing UFV 1 x IAC 73-2736-10. It is recommended for regions North and Northeast of Brazil with latitudes bellow 15^{o}. It has a cycle 10 days longer than TROPICAL which allows a better distribution of planting and harvesting.

n) BR 11 - CARAJÃS: cultivar made available in 1983 by

the crossing UFV x IAC 73-2736-10, being resistant to some diseases. It is recommended for planting in regions North and Northeast, below 15^{0} latitude.

o) CEP 10: cultivar made available in the early eighties by FECOTRIGO - Federation of Wheat Cooperatives in Rio Grande do Sul -, resulting from the crossing IAS 2 x D 70-3185 (in 1974). Yields were 7 percent higher than those of BOSSIER, BR 3 and IVAÍ.

4.2. Production Effects

Brazil has, whithout doubt, substantially improved its agricultural research system since the first half of the seventies. First, EMBRAPA's overall budget has considerably increased. Second, the quality of Brazilian researchers has been significantly upgraded. Third, at the end of the seventies a more balanced pattern of research investment emerged between domestic and exported crops. Fourth, the contribution of the IARCs has been relevant and the list of new varieties resulting from such a collaboration, as given in chapter 3, is an impressive one. Fifthly, also impressive is the list of new crop varieties developed in the NARS - Brazil, without the direct collaboration of the IARCs.

There still remain some relevant questions. The first one is whether or not Brazil is investing the proper – in economic terms – amount in agricultural research in the aggregate and in important segments. The second one is whether or not the unbalanced pattern of technological innovations – domestic vs.exported crops – is actually being corrected. We already noted that in terms of effort (investment) a change towards a more balanced pattern could be detected during 1978/80. Was that translated into actual results, that is, increasing the rate of technological change for domestic crops relative to exported ones, including the

in the remainder of this section we will make some attempts to discuss the production effects of technological change. The first question will not be dealt with further here.

In reviewing the new varieties developed in the NARS, with and without the collaboration of the IARCs, the first impression is that the balance if innovation among crops is good. While we certainly cannot go very deep in analysing this problem using as the only evidence the list of new varieties, when considering the respective numbers and geographical distribution of new varieties, for each crop it looks like rice, edible beans and maize (among the domestic crops) and soybeans and cotton (among the exported ones), as well as wheat, had a good performance. Of course, we must recall that several exported crops, such as coffee, oranges, sugarcane, peanuts and tobacco, were not included in our survey since they are not part of EMBRAPA's research system. On the other hand, cassava, among the domestic crops, was the negative part of the review, since not a single new variety was identified as being developed in the recent past. As for soybeans a proper evaluation of the impact of all the varieties previously listed would require much more time and effort than we were able to give to the present research.

To make some progress in answering the basic question as to whether or not Brazil now has a more balanced pattern of varietal (yield improving) innovations among crops, we will use a different methodology. Consistent with our analysis in Table 2, we will look at the annual rates of yield growth for several crops, domestic and exported, in the states of Brazil's Center-South region for the period 1977/83. Following that, we will examine the annual rates of acreage growth for the same crops and states, for the period 1977/84.

It is not necessary to repeat the economic reasoning supporting such a procedure, since that was a good part of chapter 1. The main point was that a pattern of innovations favoring exported

through substitution in production, could bring acreage declines for domestic crops. In Table 9 we present the annual rates of yield growth and in Table 10 the annual rates of acreage growth both for domestic and exported crops in Brazil' Center-South region. We must make it clear that our test is only a first attempt to tackle the problem and that perhaps only a rough pattern in both tables could be expected.

First, let us compare Table 9 with Table 1, in terms of number of events – defined as individual crop yield growth above 2 percent per year – during 1960/69, 1967/76 (both in Table 1) and 1977/83 (in Table 9) and in the same group of states. Since there are 8 events during 1960/69, 16 during 1967/76 and 24 during 1977/83, it looks like yield-improving technological change has been increasing. This agrees with the observed increase in investment for agricultural research since the establishment of EMBRAPA in 1974.

Looking at the distribution of these events among domestic, exported crops and wheat, for the same crops and states in both Tables, in the three periods, we note that both groups of crops experienced expansion in the number of events at about the same rate between the first and third periods. However, the expansion was larger for exported crops when only the second and third periods are compared. In addition, in Table 9 four cases of negative yield growth for domestic crops can be noted, two for beans (Paranã and Mato Grosso), one for cassava (Minas Gerais) and one for potatoes (Rio Grande do Sul), while there are none for exported crops.

Also, an important change in the mix of technological innovations for domestic crops occurred during 1977/83 as compared to 1967/76 (Table 1): in this earlier period, of eight events, one was for rice, three were for potatoes and four for maize. During 1977/83, in nine events, two were for rice, only one for potatoes and six for maize. In addition, in two states

TABLE 9

ANNUAL GROWTH RATES IN YIELDS, SELECTED CROPS AND STATES, BRAZIL, 1977/83[a] (%)

CROPS	SP	PR	RGS	MT	GO	MG	BRAZIL
1. DOMESTICS:							
Rice	8.19	zero	1.67	1.72	zero	3.72	2.00
Beans	zero	-2.32	zero	-9.49	zero	zero	-1.40
Maize	4.15	4.40	5.58	3.63	4.75	3.93	3.88
Cassava	zero	zero	zero	zero	zero	-1.90	-1.22
Potatoes	-	zero	-1.49	-	-	8.13	3.24
2. EXPORTED:							
Cotton	zero	5.50	-	4.01	7.99	8.18	5.81
Peanuts	zero	zero	-	zero	-	-	zero
Coffee	zero	15.61	-	-	-	4.12	5.50
Soybeans	3.83	zero	zero	6.57	4.32	5.69	2.84
Oranges	2.67	-	2.89	-	-	zero	2.15
Sugarcane	-	5.36	zero	zero	6.70	5.45	2.82
Tobbaco	-	-	2.83	-	-	0.76	1.85
3. WHEAT:	-	3.42	zero	8.94	-	-	-

Source: Basic data, FIBGE.

(a) Three-year moving average. The letters for the states mean: SP, São Paulo; PR, Paraná; RGS, Rio Grande do Sul; MT, Mato Grosso do Sul and Mato Grosso (together); GO, Goiás; MG, Minas Gerais. Significance test at 5 percent level, the same as in Table 2.

TABLE 10

ANNUAL GROWTH RATES IN CULTIVATED ACREAGE, SELECTED CROPS AND STATES, BRAZIL, 1977/84 (%) (a)

CROPS	SP	PR	RGS	MT	GO	MG
1. DOMESTICS:						
Rice	zero	-14.25	3.70	-8.02	zero	zero
Beans	4.71	zero	zero	zero	zero	zero
Maize	2.97	2.63	1.61	8.41	zero	-2.20
Cassava	zero	zero	-9.75	-6.71	zero	-4.44
Potatoes	-	- 4.75	-5.32	-	-	zero
2. EXPORTED:						
Cotton	zero	4.13	-	-4.70	zero	zero
Peanuts	zero	-16.14	-	-33.62	-	-
Coffee	zero	- 8.31	-	-	-	6.64
Soybeans	zero	zero	zero	19.16	28.72	17.51
Oranges	7.81	-	-3.13	-	-	5.11
Sugarcane	11.24	16.29	zero	29.60	19.11	5.25
Tobbacco	-	-	zero	-	-	-11.89
3. WHEAT:	-	- 7.59	-11.81	19.19	-	-

Source: Basic data, FIBGE.

(a) The letters for the states mean: SP, São Paulo; PR, Paranã; RGS, Rio Grande do Sul; MT, Mato Grosso and Mato Grosso do Sul (together); GO, Goiãs; MG, Minas Gerais. Significance test at 5 percent level.

Mato Grosso), in spite of being below the 2 percent dividing rate. The mix of technological change in 1977/83 – more concentrated on maize and rice – should bring more benefits to producers and consumers, especially since potatoes has only a minor importance for either group.

Another point giving greater confidence to these results, is the spread of positive rates of yield growth over the Center-South region of Brazil. Maize is the best example, with very impressive rates for all six states considered. During 1967/76 (Table 1) maize had rates above 2 percent in four states. Including rates which were positive but below 2 percent, rice showed increases in four states of Brazil's Center-South region during 1977/83 (Table 9). For exported crops, cotton had four events out of a possible five during 1977/83, soybeans had four out of six, oranges two out of three, and sugarcane, three out of five. Finally, in terms of aggregate national yield increases we can also note considerable progress during 1977/83 (Table 9) as compared to 1967/76 (Table 1). Only potatoes and soybeans did not show improvement in yields.

Our test indicates that Brazil had more technical change during 1977/83 than in previous periods. However, the questions still remains of an balanced distribution between crops – of such technical change. First, in the aggregate, exported ones still had a higher rate than domestic ones, mainly because rates for edible beans and cassava were negative. However, in the southern region, domestic crops gained relatively over exported crops, in terms of yield growth, especially maize and rice, as compared to soybeans and cotton. For this region, at least, the bias favoring exportables in the crop mix during 1967/76 was not repeated during 1977/83. The opposite result occurred in Brazil's central region, where exported crops gained relatively over domestic ones, in spite of the fact that yield growth rates in those states, for maize and rice in particular, were positive. As a result, Brazil's central region may now be repeating the pat-

anced pattern of technical change, which could lead to unbalanced agricultural growth as between domestic and exported crops.

In Table 10, giving the annual rates of acreage growth during 1977/83 for the same crops and states, the following can be noted. First, in the Southern region soybean acreage did not grow; we recall that the extraordinary expansion of this crop beginning in mid-sixties was a major reason for changes in crop mix against domestic products. Also, we note a consistent area growth of maize in the three Southern states and that of irrigated rice in Rio Grande do Sul. Here the case is not that of rice-soybeans competition, but should be interpreted as a favorable impact of the development of new rice varieties as earlier reviewed (mainly BR-IRGA 409 and 410). Cotton acreage increased only in Paranã.

In second place, when turning our attention to the three central states, an opposite pattern of agricultural growth was observed during 1977/83. Soybean acreage grew substantially in these three states – more than two million hectares between 1977 and 1984 – while rice area declined in Mato Grosso and stagnated in Goiãs and Minas Gerais. For maize, there was high area growth in Mato Grosso, stagnation in Goiãs and decline in Minas Gerais. For beans, there was stagnation and for cassava, declines in two states and stagnation in one. For maize and rice, at least, we had indications of technical innovations in the central region, as well as positive rates of yield growth during 1977/83. Our explanation is that soybean innovation is dominating that in rice and, to a lesser extent in maize, since all three are substitute crops in production. Thus, it seems that the development of soybean varieties for the central region of Brazil, including its "cerrados" area and that with latitudes below 15^{o}S, is having a strong impact on the composition of agricultural growth in that part of the country. Finally, the strong growth of the sugarcane acreage, in practically all states in the Center-South region, should be interpreted more as a result of the alcohol program

5. Conclusions

With the information provided in this study, it can be concluded that today the IARCs are collaborating with a much better research system in Brazil than previously. The country, however, lost quite some time before deciding to invest in agricultural research. The major policy change occurred in the first half of the seventies with the creation of EMBRAPA. By all reasonable criteria of performance, the achievements of EMBRAPA and more broadly the NARS, can be considered as close to extraordinary. A few reasons will justify such an evaluation.

First, Brazil could not be considered as having, up to the first half of the seventies, a national research system with the minimal conditions of size and quality to serve its different regions, crops and producers. In fact, up to that time, a favorable word could be said only about São Paulo's agricultural research system, which developed several yield-improving varieties. IAC - Campinas' Agronomic Institute -, the best example, made important innovations in coffee, cotton, oranges, sugarcane, soybeans, maize and potatoes.

A consequence of that situation, in which research was very poor at the federal level, was an underinvestment in agricultural research, which was particularly serious when analyzed on a crop by crop basis. The underinvestment was greatest for certain critical food commodities. In consequence, the country experienced the developemnt of a segmented agricultural system with one sector open to external transactions and competitive in the international market, and another without regular competitiveness in that market because of unfavorable domestic cost conditions.

In terms of production performance, things became much more complicated after the mid-sixties, with technological innovations for soybeans, high international prices and a better exchange rate policy. A drastic change in crop mix occurred in

favor of exported commodities and "per capita" production of domestic foods declined significantly. EMBRAPA and the NARS were created and the collaboration with the IARCs was intensified in the middle of this process. In addition, in 1973/74, Brazil, like many other countries, was facing the extremely adverse effects of the first oil "shock", in its external accounts. In light of these three developments, it is possible to understand the social "demands" as well as EMBRAPA's responsibilities in the mid-seventies.

Also, from that situation and the difficulties related to human and financial resources, it is possible to understand EMBRAPA's preoccupation in defining research priorities, including crops to be emphasized in the research program. That will take us to the second reason for our extremelly good evaluation of EMBRAPA, the resources invested in the research program. Overall EMBRAPA's budget grew by a multiple of ten in dollar terms from 1974 to 1982 and total research expenditure as a proportion of the value of agricultural product almost doubled between 1974 and average 1978/80. The period's negative point, however, was the deterioration observed in IAC - Campinas, formerly our principal research institution, a high quality one even by international standards.

In addition to its greater budgets EMBRAPA was able to make substantial investments in human resources. From an initial situation where the minority of researchers was really qualified, ten years later EMBRAPA had succeeded in a major quality change in its research staff, with a large majority at the master's or doctor's level of training. In this period, also important for the quality of Brazilian researchers, was the training offered by the IARCs. However, with the quality improvement experienced by the research staff, it looks like presently the type of training provided by the IARCs will have to change.

The third reason to justify our good evaluation of EMBRAPA-NARS is related to the problem of a previous unbalanced

pattern of technological innovation. The evidence we were able to gather indicated that a change had already occurred by the end of the seventies towards a more balanced pattern of research investment between domestic and exported crops. Certainlly, that was an indication of effort and not practical results. However, it is important to observe that in this effort the IARCs had much to give, since CIMMYT, IRRI and CIAT, were concerned with exactly those domestic crops for which Brazil had a problem, maize, rice, edible beans and cassava, and IITA and ICRISAT were relevant to Brazil's agro-climatic conditions.

Evaluating research results obtained since the creation of EMBRAPA-NARS, it was noted that the contribution of the IARCs has been relevant, mainly in the provision of genetic materials to Brazil. The list of new varieties resulting from such a collaboration, given in chapter 3, is impressive, mainly in the cases of maize, rice, edible beans and wheat. Also impressive is the list of new crop varieties developed by EMBRAPA-NARS without the direct collaboration of the IARCs. By the criteria we developed in this study to measure the amount of technological change occurring over time, we concluded that an increase did take place from 1960/69, 1967/76 and 1977/83. This is in agreement with the overall increase in investment for agricultural research after the implementation of EMBRAPA in 1974. When considering domestic and exported crops, it was noted that the amount of technological change increased similarly for both groups from the first to the third period, although the increase was larger for exported crops when comparing the second and third periods. Within domestic crops, the mix of technological change is now more concentrated in maize-rice as against maize-potatoes, with the present mix being more important for producers and consumers.

When considering the question of technological change in regional terms, we noted that domestic crops made relative gains over exported crops in the Southern region, with yield growth as indicator, during 1977/83, especially maize and rice, as compared to soybeans and cotton. However, the opposite hap-

pened in Brazil's central region, where exported crops made relative gains over domestic ones. In this region now, as it was in the Southern region during part of the sixties and the seventies, soybeans is in the first place, with several new varieties for the area of "cerrados" as well as those for low latitudes.

With all that in mind, it seems important to me that the collaboration EMBRAPA-NARS-IARCs should be maintained or even increased. The IARCs work with the "right" crops with respect to Brazil's needs. In terms of priorities, we would say that an increased collaboration would be necessary for cassava, edible beans and upland rice. Such a collaboration, however, should take into account that presently the quality of Brazilian researchers is much higher than it was ten years ago. As a result, the basis for a continuing successful collaboration, be it in training, genetic materials, research approaches or methodologies, etc., does exist today in Brazil and, probably, in better terms than in mid-seventies. The favorable effects to be still obtained in the future, related to gains in income, welfare and nutrition, justify the continuation of the interchange Brazil - IARCs.

REFERENCES

Abbott, P.C., "Modelling International Grain Trade with Government Controlled Markets", American Journal of Agricultural Economics 61(1979): 22-31.

Alves, E.R., "Brazil's Program for Development of Agricultural Researchers", In: Yeganiantz, L. (ed.), Brazilian Agriculture and Agricultural Research, EMBRAPA - Department of Diffusion of Technology, 1984, pp. 161-74.

Alves, E.R., "Making Agricultural Research a Priority for Public Investment". In: Yeganiantz, L. (ed.), Brazilian Agriculture and Agricultural Research. Brasília, EMBRAPA - Department of Diffusion of Technology, 1984, pp. 175-90.

Alves, E.R. et al, "Demographic Aspects of Agricultural Development: Brazil, 1950-1974". In: Yeganiantz, L. (ed.), Brazilian Agriculture and Agricultural Research, EMBRAPA, 1984, pp. 9-73.

Alves, E.R. and A.C. Pastore, "Import Substitution and Implicit Taxation of Agriculture in Brazil", American Journal of Agricultural Economics 60(5): 865-71, 1978.

Alves, E.R. and J.L. Vieira, "Evolução do Padrão Alimentar da População da Cidade de São Paulo", Seminário A Economia da Tecnologia, Fundação Instituto de Pesquisas Econômicas, São Paulo, 1978.

Ayer, H.W. and G.E. Schuh, "Social Rates of Return and Other Aspects of Agricultural Research: The Case of Cotton Research in São Paulo, Brazil", American Journal of Agricultural Economics 54(4): 557-69, 1972.

Baer, W., Industrialization and Economic Development in Brazil. Richard D. Irwin, Homewood, Illinois, 1965.

Baer, W., The Brazilian Economy: Growth and Development. New York, Praeger Publishers, 1983, second edition.

Baer, W. and A.V.Villela, "Industrial Growth and Industrialization: Revisions in the Stages of Brazil's Economic Development", The Journal of Developing Areas 7(January 1973): 217-34.

Bacha, E., "Uma Proposta para a Retomada do Crescimento Econômico", Economia em Perspectiva - Carta de Conjuntura, nº 3, June 1984.

Bergsman, J. and A.Candau, "Industrialization: Past Successes and Future Problems", In: Ellis, H.S. (ed.), The Economy of Brazil, University of California Press, 1969, pp.29-72.

Biswanger, H.P., "Measuring the Impact of Economic Factors on the Direction of Technical Change". In: T.M. Arndt et al (eds.), Resource Allocation and Productivity, 1977, pp. 526-50.

Brown, L.R., "Putting Food on the World's Table". Environment 26(4): 16-43, May 1984.

Castro, J.P.R., "An Economic Model for Establishing Priorities for Agricultural Research and a Test for the Brazilian Economy". PhD dissertation, Purdue University, 1974.

Castro, J.P.R. and G.E. Schuh, "An Empirical Test of an Economic Model for Establishing Research Priorities: A Brazil Case Study". In: T.M.Arndt et allii (eds.), Resource Allocation and Productivity, 1977, pp. 498-525.

De Janvry, A., "Inducement of Technological and Institutional Innovations: An Interpretative Framework", In: T. M. Arndt et allii (eds.), Resource Allocation and Productivity, University of Minnesota Press, Minneapolis, 1977, pp. 551-66.

Dias, G.L.S., Agricultura e Crescimento Extensivo, Thesis of "livre-docência", Department of Economics, University of São Paulo, 1978.

Evenson, R.E., "Observations on Brazilian Agricultural Research and Productivity". In: Veganiantz, L.(ed.), Brazilian Agriculture and Agricultural Research, Brasília, EMBRAPA-Department of Diffusion of Technology, 1984, pp. 247-76.

Fava, V.L., Urbanização, Custo de Vida e Pobreza no Brasil. PhD dissertation, Department of Economics, University of São Paulo, 1984.

Food and Agriculture Organization, "Expert Consultation on Agricultural Price Policies". Rome, 29 November - 02 December, 1983.

Fundação Cargill, A Soja no Brasil, 1977.

Furtado, C., Diagnosis of the Brazilian Crisis. University of California Press, Berkeley, 1965.

Governo do Estado de São Paulo, "A Situação dos Institutos de Pesquisa de Administração Direta das Secretarias da Saúde e de Agricultura", São Paulo, 1984, p.31.

Guttman, J.M., "Interest Groups and the Demand for Agricultural Research", The Journal of Political Economy 86 (June 1978): 467-84.

Hayami, Y. and V.W.Ruttan, Agricultural Development: An International Perspective. The Johns Hopkins Press., Baltimore, 1971.

Hinshaw, R., "Non-Traded Goods and the Balance of Payments: Further Reflections", Journal of Economic Literature 13: 475-78, 1975.

Hirschman, A.O., "The Political Economy of Import-Substituting Industrialization in Latin America", Quarterly Journal of Economics 82: 1-32, February 1968.

Hoffman, R. and J.F. Graziano da Silva, "A Estrutura Agrária Brasileira", In: C.R., Contador (ed.) Tecnologia e Desenvolvimento Agrícola, Instituto de Planejamento Econômico e Social, Rio de Janeiro, 1975, pp. 233-265.

Homem de Melo, F., "Produtividade da Terra: Os Casos de Milho e Algodão no Estado de São Paulo". In: Mendonça de Barros, J.R. and D.H. Graham (eds.), Estudos sobre a Modernização da Agricultura Brasileira, Monografia nº 9, Instituto de Pesquisas Econômicas, Universidade de São Paulo, 1977, pp.57-106.

Homem de Melo, F., Agricultura Brasileira: Incerteza e Disponibilidade de Tecnologia. Tese de livre-docência, Faculdade de Economia e Administração, Universidade de São Paulo, 1978.

Homem de Melo, F., "Padrões de Instabilidade entre Culturas da Agricultura Brasileira", Pesquisa e Planejamento Econômico, 9(3): 819-44, 1979.

Homem de Melo, F. and E.G.Fonseca, Proálcool, Energia e Transportes. Editora Pioneira, São Paulo, 1981.

Homem de Melo, F., "Abertura ao Exterior e Estabilidade de Preços Agrícolas", Revista Brasileira de Economia 35(2): 189-205, 1981.

Homem de Melo, F., "Políticas de Estabilização para o Setor Agrícola", unpublished research report, Instituto de Pesquisas Econômicas, 1982.

Homem de Melo, F., O Problema Alimentar no Brasil: A Importância dos Desequilíbrios Tecnológicos. Editora Paz e Terra, São Paulo, 1983.

Homem de Melo, F., "Trade Policy, Technology and Food Prices in Brazil", Quarterly Review of Economics and Business 23 (1): 58-78, 1983.

Homem de Melo, F., "O Trigo e a Questão do Subsídio a Alimentos", Gazeta Mercantil, October 19th, 1984, p.04.

Homem de Melo, F., "Technological Change and Income Distribution: the Case of a Semi-Open Less Developed Economy", unpublished paper, 1984.

Homem de Melo, F., "A Necessidade de uma Política Alimentar Diferenciada", mimeo, 1984.

Homem de Melo, F. and E.R. Pelin, Soluções Energéticas e a Economia Brasileira. Editora HUCITEC, São Paulo, 1984.

Homem de Melo, F. and J.H. Accarini, A Política Econômica e o Setor Agrícola no Brasil do Pós-Guerra. Instituto de Pesquisas Econômicas, Universidade de São Paulo, São Paulo, Relatórios de Pesquisa nº 03, 1979.

Knight, P.T., "Substituição de Importações na Agricultura Brasileira: A Produção de Trigo no Rio Grande do Sul", Estu-

dos Econômicos 1(3): 71-102, 1971.

Krasner, S.D., "Manipulating International Commodity Markets: Brazilian Coffee Policy, 1906 to 1962". Public Policy 21(4): 493-523, Fall 1973.

Kuznets, S., "Innovations and Adjustments in Economic Growth", The Swedish Journal of Economics 74: 431-51, 1972.

Mendonça de Barros, J.R., "Política de Desenvolvimento Agrícola no Brasil". Paper presented at the 10º Encontro Nacional de Economia, Águas de São Pedro, São Paulo, December 1982.

Myint, H., "Agriculture and Economic Development in the Open Economy". In: L.G. Reynolds (ed.), Agriculture in Development Theory, Yale University Press, New Haven, 1975, pp. 327-54.

Paiva, R.M., O Setor Agrícola no Brasil. São Paulo, Secretaria da Agricultura, 1973.

Pastore, A.C., "A Inovação Induzida e os Limites à Modernização na Agricultura Brasileira". Trabalho para Discussão Interna nº 25, Instituto de Pesquisas Econômicas, Universidade de São Paulo, 1974.

Pastore, J., "Condicionantes da Produtividade da Pesquisa Agrícola no Brasil", Estudos Econômicos 6(3): 147-182, 1976.

Peixoto da Silva, G.L., Evolução e Determinantes da Produtividade Agrícola: O Caso da Pesquisa e da Extensão Rural em São Paulo. Doctoral's thesis, Instutituto de Pesquisas Econômicas, Universidade de São Paulo, 1983.

Penna, J.A. and A.Monteiro, "A Taxa Interna de Retorno da Pesquisa e Extensão Agrícola do Cacau Brasileiro", Estudos Econômicos 6(2): 51-82, 1976.

Perrin, R. and D. Winkelman, "Impediments to Technical Progress on Small vs. Large Farms", American Journal of Agricultural Economics 58(5): 888-94, 1976.

Peterson, W.L., "International Farm Prices and the Social Cost of Cheap Food Policies", American Journal of Agricultural Economics 61(1): 12-21, 1979.

Pinstrup-Andersen, P. and H.Alderman, "The Effectiveness of Consumer Food Subsidies in Reaching Rationing and Income Transfer Goals". Paper presented at IFPRI Conference on Consumer-Oriented Food Subsidies, Chiang Mai, Thailand, November 1984.

Prebish, R., "Commercial Policy in the Underdeveloped Countries". American Economic Review (May 1959): 251-69.

Pastore, J. and E.R. Alves, "Reforming the Brazilian Agricultural Research System". In: L. Yeganiantz (ed.), Brazilian Agriculture and Agricultural Research. Brasília, EMBRAPA - Department of Diffusion of Technology, 1984, pp. 117-28.

Schuh, G.E., "The New Macroeconomics of Agriculture", American Journal of Agricultural Economics 58(1976): 795-801.

Scobie, G.M., "The Demand for Agricultural Research: A Colombian Illustration", American Journal of Agricultural Economics 61(3): 540-45, 1979.

Schuh, G.E. and E.R. Alves, O Desenvolvimento da Agricultura no Brasil. APEC Editora, Rio de Janeiro, 1971.

Silva, G.S., "Investimento na Geração de Tecnologia Agrícola no Brasil", mimeo, Instituto de Economia Agrícola, São Paulo, 1979.

Smith, G., "Brazilian Agricultural Policy, 1950-1967", In: H.S. Ellis (ed.), The Economy of Brazil, University of California Press, 1969, pp. 213-65.

Szmrecsányi, T., O Planejamento da Agroindústria Canavieira do Brasil (1930-1975), Editora HUCITEC, São Paulo, 1979.

Zockun, M.H., A Agricultura e a Política Comercial Brasileira. Instituto de Pesquisas Econômicas, Universidade de São Paulo, São Paulo, Monografia nº 8, 1976.

Zockun, M.H., A Expansão da Soja no Brasil: Alguns Aspectos da Produção. Ensaios Econômicos nº 4, Instituto de Pesquisas Econômicas, Universidade de São Paulo, São Paulo, 1980.

Williamson, J.G., "Strategic Wage Goods, Prices and Inequality", American Economic Review 67(2): 29-41, 1977.

Wionczek, M.S., "Latin America Growth and Trade Strategies in the Post-War Period". Development and Change 5(1): 1--35, 1973.