Consultative Group on International Agricultural Research

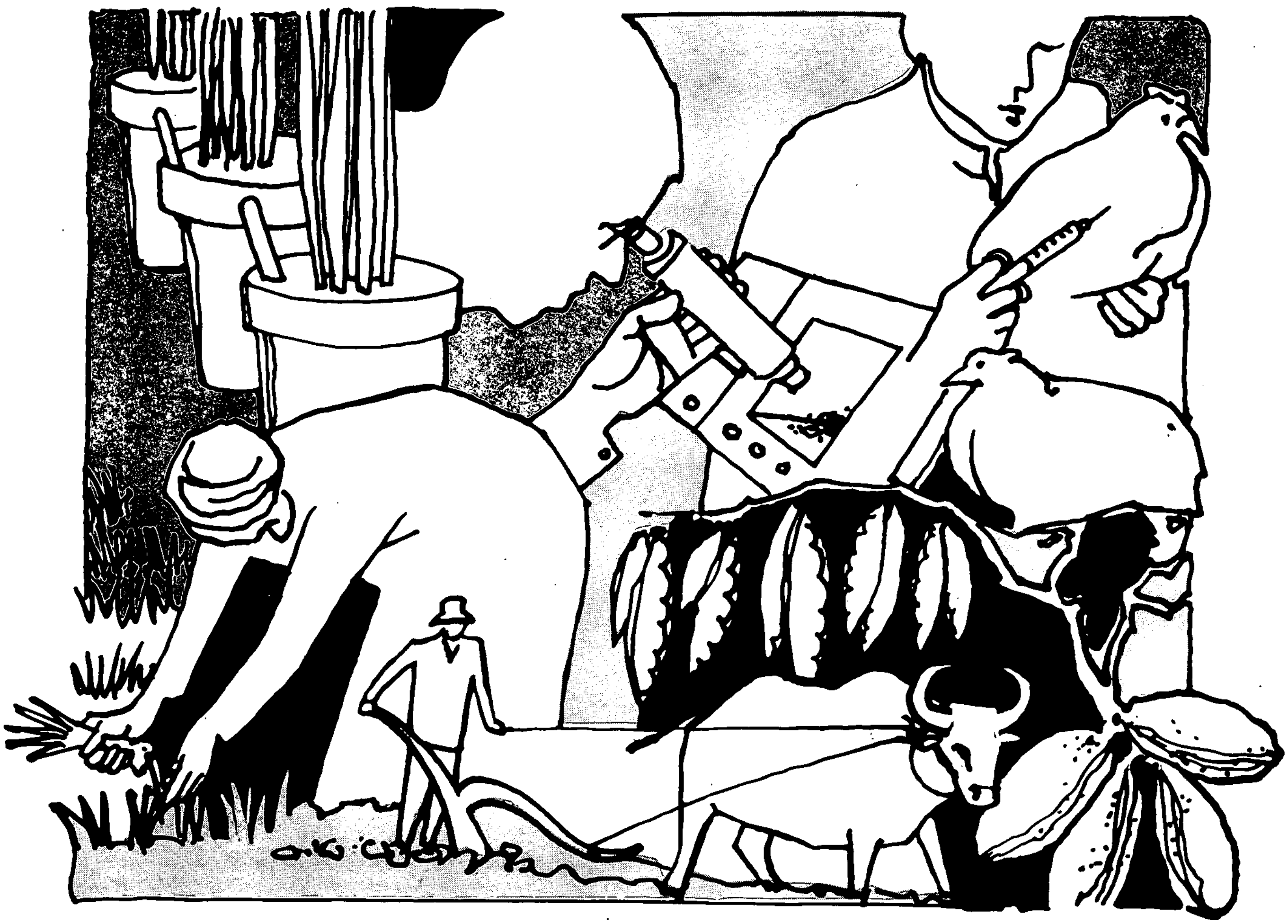
CGIAR

Study Paper Number 14

Cuba and the CGIAR Centers

A Study of Their Collaboration in Agricultural Research

Pedro A. Sanchez
Grant M. Scobie



Cuba and the CGIAR Centers

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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.

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Summary

This report describes a two-week study of the collaboration between international agricultural research centers and the national agricultural research system of Cuba, a project that was conducted by the authors as part of the worldwide CGIAR impact study. Cuba straddles the Tropic of Cancer and has a total area of 11 million ha and a population of 10 million. The significant monthly temperature variation permits the growth of many temperate and most tropical crop and animal species. Land resources in Cuba are about the best among developing countries: 80 percent of the land is flat to gently undulating, and there are more than 2.5 million ha of fertile red Alfisols, which combine superior physical and chemical properties with smooth topography.

Cuba has undergone major economic and social transformations since 1959, and these have led to the establishment of a socialist state. In the agrarian sector, the principal changes were a series of land reforms, the establishment of state farm enterprises, and a nationwide food rationing and delivery system. Per-capita food production fell during the sixties, but economic growth in recent years has been comparable to that of Latin America as a whole. Income distribution, however, is vastly more equitable. Substantial investments have been made in human capital, and there is widespread access to health and education services throughout the country. Life expectancy, infant mortality and school enrollment rates are among the best of all the middle-income developing countries in the world.

Cuba's economy is still dominated by the production and export of sugar. Allocation of land for food crop production is second in priority to land for sugarcane production. Food production per capita, after falling in the 1960s, has recently recovered, but current levels are no higher now than in 1959.

However, food consumption per capita has increased markedly. To meet such an increase in demand, Cuba depends heavily on imported foods and feedstuffs. In 1983, 37 percent of the rice and 80 percent of the beans were imported. There has also been a rapid rise in wheat imports. Of its basic food crops, Cuba is self-sufficient in root crops and vegetables. Almost half of the milk equivalents are imported, as is 81 percent of the corn, most of which is used for livestock feed. Because Cuba receives favorable prices for its sugar exports to socialist countries, it has specialized in sugar production and devotes fewer resources to food production. This, combined with a policy to expand consumption of animal products, has meant depending heavily on food and feed imports.

Before 1959, Cuba had only a modest agricultural research and extension system. Because many professionals had left the country, the stock of agricultural scientists was badly depleted. A substantial effort was made to rebuild the research system, and today there are 1,053 research scientists in the Ministry of Agriculture (MINAG) and some 700 in other agencies. The total research budget of MINAG was estimated at 31 million pesos in 1983, or 1.8 percent of the total value of non-sugar agriculture. This gives Cuba one of the highest ratios of investment in agricultural research to the value of crop production in Latin America. The research system is decentralized, with 17 institutes and a network of research stations and substations throughout the country. Furthermore, neither the research budgets nor the staffing suffers from the volatility and high turnover which characterize so many national research programs. Because of its centrally planned system, the research-extension-production link is strong and direct.

Collaboration between MINAG and the CGIAR system started with IRRI in 1967, with CIAT in 1977, with CIP in 1981 and with CIMMYT in 1982. Germplasm exchange, training and visits are the main activities. Collaboration is considered mature with IRRI

and CIAT on rice, and with CIAT on beans, cassava and pastures. Collaboration is considered developing with CIP on potatoes and CIMMYT on maize, and incipient with ICRISAT on sorghum, IITA on malanga and CIP on sweet potatoes.

CIAT has built up an extensive system of contacts in Cuba in all four of its programs. It also facilitates the operations of other CGIAR institutes. About 90 Cuban scientists have had training at CGIAR centers; with the low rate of turnover, most remain at their respective institutes.

In the "mature" group of crops a significant share of the total area sown in Cuba involves the use of germplasm and technology which are products of CGIAR collaboration. It is estimated that the production of rice, beans and cassava is a respective 73, 21 and 224 percent higher than it would be in the absence of these innovations. The annual flow of benefits from the extra production is US$40 million, US$3 million and US$11 million, respectively. The internal rates of return to the Cuban research program were calculated as 54, 29 and 48 percent per year, respectively.

Cuban researchers value their collaborative links with the CGIAR centers, which they view as their main window to tropical agricultural technology. Some of the CGIAR technologies have been adapted for other crops, such as malanga. The main constraints to collaboration are communications difficulties, MINAG budget constraints for overseas travel, and the difficulty in starting major initiatives in the middle of a five-year plan. These constraints are balanced by the seriousness and dedication of Cuban scientists, the continuity of programs and staff, and the direct link between research, extension and producers. The desirability of continuing and expanding CGIAR collaboration was clearly expressed in all places visited. In addition to the present efforts, Cuban scientists wish to start collaboration with CIP on sweet potatoes, IITA on plantains, AVRDC on

vegetables, and ICRISAT on peanuts and chickpeas. Interest was also expressed for collaboration in factor-oriented research, such as fertilizer efficiency with IFDC, soil management with IBSRAM, irrigation and drainage with IIMI and agroforestry with ICRAF.

Major issues for Cuba's agricultural strategy include: (1) attaining sustained self-sufficiency in rice, beans and maize; (2) decreasing dependency on imported feedstuff for livestock production by increasing soybean, maize and sorghum production, by incorporating cassava as animal feed and by adopting low-input pasture technology for marginal soils; (3) maintaining self-sufficiency in potatoes, cassava, plantains and malanga; (4) increasing the efficiency of input use, particularly given the depletion of the irrigation aquifer under certain Matanzas soil areas and the subsequent intrusion of saline water. Attention should also be given to the modification of cropping sequences in order to eliminate the idle period during summer months on such prime land.

Contents

Abbreviations and Acronyms

ACC	Academia de Ciencias de Cuba
ANAP	Asociación Nacional de Agricultores Pequeños
AVRDC	Asian Vegetable Research and Development Center
CEDIC	Centro para el Desarrollo Integrado de la Caña de Azúcar
CEMSA	Centro Experimental de Mejoramiento de Semillas Agámicas
CENSA	Centro Nacional de Sanidad Agropecuaria
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIP	Centro Internacional de la Papa
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
ERB	Ensayos Regionales "B" (Pastos)
FAO	Food and Agriculture Organization of the United Nations
GMP	Gross Material Product
GSP	Global Social Product
IBSRAM	International Board for Soils Research and Management
IBYAN	International Bean Yield and Adaptation Nursery
ICA	Instituto de Ciencia Animal
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIDCA	Instituto Cubano de Investigación en Derivados de la Caña
ICINAZ	Instituto Cubano de Investigaciones Azucareras
ICRAF	International Council for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IICA	Instituto de Investigacion de Caña de Azucar

IIMI	International Irrigation Management Institute
IITA	International Institute of Tropical Agriculture
INCA	Instituto de Ciencia Agrícola
INIFAT	Instituto Nacional de Investigaciones Fundamentales en Agricultura Tropical
INSFFER	International Network on Soil Fertility and Fertilizer Efficiency in Rice
ISCAH	Instituto Superior de Ciencias Agrícolas de La Habana
JUCEPLAN	Junta Central de Planificación
MES	Ministerio de Educación Superior
MIC	Middle Income Countries
MINAG	Ministerio de la Agricultura
MINAZ	Ministerio de la Industria Azucarera
NMT	Net Material Product
PCCMA	Programa Cooperativo Centro-americano de Mejoramiento Agrícola
PPE	Problema Principal Estatal
PR	Problema Ramal
PRECODEPA	Programa Regional Cooperativo de Experimentacion en Papas
TMP	Total Material Production
Unesco	United Nations Educational, Scientific and Cultural Organization

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1 Background

This study, part of the CGIAR global impact study, was conducted during February 1985, following the terms of reference developed by the CGIAR and approved by the Cuban Ministry of Agriculture. Following the background, this report consists of four chapters: the agricultural sector, the national agricultural research systems, collaboration with the centers, and an impact analysis and conclusions.

1.1 The Natural Setting

Cuba is the largest island in the Caribbean with a total land area of about 11 million ha and a population of 10 million. Straddling the Tropic of Cancer, Cuba's climate and land resources are considerably better than those of many developing countries. The temperature regime borders on the sub-tropical, with significant variation between winter and summer. This permits a highly diversified tropical and subtropical agriculture. Potatoes, winter vegetables and dairy cattle thrive along with most tropical crop and animal species.

1.1.1 Climate

The rainfall regime is subhumid seasonal, with a hot rainy season from May to November and a cool dry season from December to April. Annual rainfall ranges from 1,100 to 1,500 mm throughout most of the country. Exceptions occur around the Sierra Maestra range in Oriente, where the windward side around Bayamo has a humid tropical climate with high annual rainfall of 2,000 mm, while the rain shadow on the southern side creates a semiarid climate with 700 mm annual rainfall around Guantánamo. Table 1.1 shows representative climatological data. Eastern trade winds provide pleasant breezes, which minimize potential air pollution problems.

Table 1.1 Monthly Climatic Summary for Ciudad Habana, (23°9'N, 82°22'W); Long-Term Averages

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean temperature (°C)	21.8	22.1	23.1	24.0	25.6	26.5	26.9	27.2	26.8	25.4	23.6	22.3	24.6
Solar radiation (langleys/days)	370	430	500	580	600	540	590	520	490	430	400	340	483
Precipitation (mm)	62	39	50	52	104	146	105	108	150	184	84	52	1136
Potential evaporation (mm)	105	111	147	170	188	167	190	169	152	134	115	98	1745
Precipitation deficit (mm)	43	72	97	118	84	21	85	61	2	-50	31	46	609
Dependable precipitation (mm)	29	10	19	21	64	100	65	68	103	131	48	21	
Wet or dry months[a]	DRY	DRY	DRY	DRY	WET	WET	WET	WET	WET	WET	WET	DRY	

Note: [a] Moisture availability index greater than 0.33 for wet months.

Source: Hancock et al., 1979.

1.1.2 Topography

Cuba's topography is also eminently favorable for agriculture. Most of the island is an uplifted limestone plateau interspersed with three mountainous regions, the Sierra de los Organos to the west, the Escambray Mountains in the center, and the Sierra Maestra to the east. These mountain regions, however, occupy a small proportion of the country. Calculations based on FAO's World Soil Map (FAO-Unesco, 1975) and local observations indicate that 79 percent of the land is flat to gently undulating, 6 percent is rolling and 15 percent is rolling to steep. About 6.9 million ha, or 66 percent of the country, has topography suitable for mechanized agriculture with well-drained soils.

1.1.3 Soils

Cuba's soil resources are also above average quality. The most extensive soils are red Alfisols of the Matanzas series, similar to the Terra Roxa soils of southern Brazil. These soils occupy about 2.5 million ha and combine excellent physical properties with high base status and smooth topography. Alfisols cover about 23 percent of Cuba; the Inceptisols cover 19 percent, Ultisols 16 percent, Vertisols 14 percent and smaller percentages of Histosols, Mollisols, Entisols and Oxisols (Table 1.2). Soil textural profiles are also very favorable, with only 8 percent organic and 5 percent sandy.

An analysis of the main soil-related constraints shown in Table 1.3 indicates that the most widespread one is dry season (90 percent). The second most widespread constraint is limited depth of soil volume caused by the presence of limestone bedrock within 50 cm of the surface, or a large proportion of calcareous stones that impede normal tillage. This condition occurs in 29 percent of the country, half of it in the mountains but the other half in 1.5 million ha of flat land that otherwise would be prime agricultural land. Included in the estimate is one-third of the Matanzas clay-type Alfisols and 70 percent of the Mollisols.

Table 1.2 Distribution of Soils Based on the FAO World Soil Map (FAO-Unesco 1975) and Authors' Modifications

Soil	Thousand Hectares	Percent of Country
Alifsols (Matanzas-type)	2,467	23
Inceptisols		
Eutropepts	1,529	
Aquepts	539	
Total	2,068	19
Ultisols		
Ustults	1,056	
Aquults	682	
Total	1,738	16
Vertisols	1,518	15
Mollisols		
Ustolls	275	
Rendolls	616	
Total	894	9
Histosols	847	8
Entisols		
Lithic groups	165	
Psamments	484	
Total	649	6
Oxisols	407	4
Total	10,585	100

Table 1.3 Main Soil-Related Constraints

Constraint	Thousand Hectares	Percent of Country
Drought stress	9,523	90
Shallow to rock	3,040	29
Acid, low native fertility	2,145	20
Saline	2,145	20
Poor drainage	2,068	20
Calcareous	2,057	19
Vertic (cracking clays)	1,606	15
No major limitation (except drought)	1,628	15
High erodibility	1,562	15
Peat and bogs	847	8
High leaching potential	484	5
High phosphorus fixation	407	4

Other widespread constraints are acid infertile soils; soils with basic reaction (pH above 7.3) which often leads to zinc and iron deficiencies; poor drainage, mainly along the southeastern coast, and salinity, often induced by poor irrigation management. Each of these constraints is found in 20 to 23 percent of the country, respectively. Other less extensive constraints are high erodibility because of steep slopes (15 percent) and vertic, cracking clays (15 percent). High phosphorus fixation, a widespread constraint in the tropics, occupies only 4 percent of the country.

In summary, Cuba has an excellent land resource base, with a considerable proportion of first class soils and most favorable topography. The main soil constraints are physical rather than chemical.

1.1.4 Land use

The most extensive form of land use is annual crops and cultivated pastures. Each occupies 22 percent of the country, followed by 6 percent in perennial crops (other than sugarcane) and 14 percent in forests and woodlands (Table 1.4). This table includes a remarkably high proportion of the land not in use. Much of this is actually native pastures on marginal, usually shallow soils.

Land use is dominated by sugarcane, which accounts for 55 percent of the area in annual crops. Sugar is harvested once a year in Cuba and is considered an annual crop although ratooning for four years is practiced. Sugarcane is grown throughout the country mainly on Alfisols, Vertisols, Inceptisols and Ultisols. The crops that follow (rice and citrus) each occupy about one-tenth of the area under sugarcane. Other major food crops which include maize, beans, cassava, plantains, sweet potatoes, malanga (Colocasia esculenta - malanga isleña and Xanthosoma mafaffa - malanga morada) and potatoes, all of which occupy rather small areas (Table 1.5). There are no significant areas of crops such as soybeans, sorghum and peanuts, commonly grown in other countries with similar land and climatic conditions.

1.1.5 Farming systems

The main farming systems of interest to the CGIAR are sugarcane, rice, cassava, "cultivos varios" and cattle production. Sugarcane land is being replanted more frequently since the introduction of mechanical harvesting which involves burning, a factor that considerably shortens the ratooning ability of this crop. Before replanting cane, state farms may plant one crop of beans, maize, pastures or rice.

Most of the rice, however, is grown on eight state farms (Empresas de Producción de Arroz), located on poorly drained Ultisols and Vertisols along the southern coast. All rice is irrigated and major efforts to water-level the fields have been

Table 1.4 Land Use in 1982

Land Use	Thousand Hectares	Percent
Annual crops	2,540	22
Perennial crops	675	6
Cultivated pastures	2,500	22
Forests and woodlands	1,900	17
Other*	3,817	33
Total	11,452	100

Note: * Includes natural pastures.
Source: FAO Production Yearbook 1983, 1984.

made. Most state rice farms have water reservoirs and extensive irrigation systems. However, salinity is becoming a major concern in rice lands because of inadequate drainage systems. Rice is rotated with beans, pastures and other crops, and only about 10 percent of rice land is planted to two rice crops a year.

A third noteworthy farming system is the intensive management of tuberous, grain and horticultural crops on Matanzas clay soils with irrigation. Plantings are totally mechanized, including the direct seeding of vegetable crops. Fertilization and pesticide use is intensive and irrigation is often done by center pivot systems or similar USSR and Eastern European moving systems. The rotations involve two crops a year. During the cool dry season, crops occupy the land from November to March. These include potatoes, beans, tomatoes, onion, garlic, bell peppers, cabbage, and lettuce. After harvesting, the land is rapidly planted to the spring crops, which grow from March to

May, which include sweet potato, cucumbers and squash. Most of the land then lies idle from June to October when temperatures, rainfall and solar radiation are at their optimum for tropical crops (Table 1.1). Although there are no firm figures on the extent of idle prime land during the summer, a rough calculation suggests it may be as much as 200,000 ha every year.

Table 1.5 Area, Yield and Production of Principal Crops: 1983

Crop	Area (000 ha)	Yield (t/ha)	Production (kt)
Sugarcane	1,230	53.6	66,000
Rice (paddy)	140	3.5	490
Citrus	109[ab]	7.4	619
Sweet potatoes	83	4.0	332
Maize	77	1.2	96
Coffee (green)	50	0.5	26
Cassava	50	6.7	335
Tobacco	42	0.9	37
Beans	35	0.8	27
Plantains	33[c]	2.8	92
Tomatoes	30	7.4	222
Potatoes	13	17.0	222
Malanga	8[a]	30.0[d]	240

Notes: [a] From Cuba (1984).
[b] 84,000 of which were in production.
[c] This contrasts with the data provided by the National Research Program of 34,000 ha with an average yield of 11.6 t/ha.
[d] Supplied by the National Research Program.

Source: FAO Production Yearbook 1983, 1984.

Another important system is that of cassava production which occupies a wider range of soils than the other cropping systems. Cassava is planted from November to February 15, during the dry season. Bacterial diseases preclude plantings during the rainy season (June to October). Planting is now done on ridges, except on very sandy or drought-prone soils. Two or three irrigation applications are given to assure sprouting. Fertilization is according to soil test recommendations ("cartograma") and at high rates of 1 to 1.3 t/ha of a complete fertilizer. Harvesting is semi-mechanized, and 90 percent of the fresh roots are marketed through the "acopio" or state collection system. In spite of the heavy fertilization and often excellent soils, cassava is viewed as a nutrient depleting crop and is thus rotated with sweet potatoes, corn or vegetable crops. The present "norma estatal" (production law) is to plant cassava every third year.

Cattle raising constitutes a major activity in Cuba with approximately 7 million ha under pastures of which about 2.5 million are cultivated, and the rest is natural pastures. Approximately 1.2 million ha are intensively managed fertilized pastures, many of them sprinkle-irrigated. Feed supplementation is the rule rather than the exception. However, Cuba is not self-sufficient in dairy products. The cultivated pasture area is rapidly rising at the rate of 200,000 ha of new seedings per year. Of these, 70,000 ha are land cleared of secondary forest or brush (manigua) and the rest is reseeding of degraded pastures.

1.2 Historical and Political Setting

The island was one of the first points of the New World reached by Columbus on October 17, 1492. The first Spanish settlement was established in 1511 by Diego Velásquez on the eastern end at Baracoa, the first capital. Land was granted under the encomienda system to the conquistadores according to their rank and role in the conquest. Indians were assigned to

work on the land, but despite laws for their protection they received brutal treatment and were eventually wiped out.

Havana developed as an important port for servicing Spanish ships carrying gold and silver from Mexico and Peru, and became the capital in 1598. In response to pirate attacks impressive fortifications were built and still stand at the mouth of the harbor. During the sixteenth and seventeenth centuries cattle raising and some limited sugar and tobacco growing were the main agricultural activities.

Tobacco assumed importance during the eighteenth century as the demand in Europe grew, although the Spanish crown maintained a monopoly on its trade. The British occupied Havana in 1762 for 10 months, and close trade was established with British colonies in North America. After the American Revolution, and a relaxation of trade controls from Spain, Cuba established trade links with North America.

Haiti had become the principal supplier of sugar to Europe but after slave uprisings destroyed its industry, the Cuban sugar industry expanded rapidly responding to a surge in world prices. Slave imports began in large numbers in the late 1700s. The extensive livestock holdings were divided up into sugar plantations. In 1750 there were 200 sugar mills; by 1800 there were over 500 mills and both Spanish and US capital was being invested in the expansion. By 1846 the population was 1.5 million of which 660,000 were slaves and another 220,000 were free blacks and mulattoes. Sugar had become the main industry; slavery was abolished in 1886.

Cuba's independence from Spain came much later than in other colonies. Wars of independence started in 1865, and thirty years later under the leadership of Jose Martí, the final guerilla thrust began. Although Spanish resistance was strong they were finally defeated by a combination of Cuban and American

troops during the Spanish-American War. The United States established a military government in Cuba in 1898, and finally ended its occupation in 1902 after the establishment of a constitution, independence, and the election of José Estrada Palma as the first president.

The US established trade treaties with Cuba and gave preferential treatment to Cuban sugar imports. US investment in Cuba was significant; by 1914 Cuba was the sixth largest export market for the US.

A series of elected presidents and military dictators characterized Cuba's politics for the next 40 years, with Fulgencio Batista as the effective military leader from 1940. In January 1959 the government was overthrown by the revolutionary forces led by Fidel Castro. Within a year, the country became a socialist state. In February 1960, the first treaty for trade and economic assistance was signed with the Soviet Union, signaling the start of an important series of political, economic and military links with other socialist states. Government operations are run according to five-year plans, approved by the Communist Party Congress.

1.3 Economic Setting

Very substantial US investment in sugar, communications, transport and energy took place up until the 1920s. In the period after World War II, further investment occurred in petroleum refining, industry and mining. Sugar, however, had always dominated the island's economy. Cuba produced over 25 percent of the world's total supply in the 1920s.

Sugar earned almost all the foreign exchange and allowed for rapid growth in the economy. However, it left the economy vulnerable to variations in both seasonal conditions and world markets. Pro sugar policies slowed down the diversification of

agriculture, created seasonal unemployment and limited the expansion of manufacturing during the 1930s and 1940s. In the 1950s, sugar production represented about 30 percent of the national income (Ritter, 1974).

After World War II, together with the expansion of manufacturing, there was some diversification of agriculture. The production of non-sugar crops grew at 5.5 percent per year from 1949 to 1958, although livestock growth was only 1 percent annually. Imports of agricultural products fell both as a proportion of total imports from 24 to 17 percent between 1950 and 1956, and also in absolute terms.

"In summary, during the decade prior to the Revolution the Cuban economy showed a small rate of real economic growth per capita; however, the rate of investment was increasing. Even though development in the non-sugar sector occurred, sugar monoculture still dominated the economy. Cuba was heavily dependent on the United States for both capital and trade, and the latter resulted in a deficit against Cuba. Both unemployment and underemployment were high and apparently worsening. The economic growth that occurred largely benefited capital and employed labor, as well as the urban sector, at the expense of the unemployed and the rural sector. All of which resulted in significant inequalities in living standards" (Mesa-Lago, 1981).

1.4 Social Setting

1.4.1 Population

At mid-1983, the total population of Cuba was estimated to be 9,858,000. The age distribution of the population is fairly balanced, unlike most developing countries (Table 1.6). One-half of the population has been born since the revolution in 1959. Almost 2 million people live in Havana, the capital; the other 80 percent are distributed rather evenly across the remaining 13 provinces, each having between 4 and 9 percent of the total

population. The population growth rate is currently about 1 percent per annum, less than half the average of 47 middle income countries (MICs) of which Cuba is one (Table 1.7).

Table 1.6 Age Distribution of Cuba's Population in Mid-1983

Age Range (Years)	Percent
0-04	7.2
5-14	21.5
15-24	21.2
25-39	20.9
40-59	18.2
60+	11.0
Total	100.0

Table 1.7 Population Growth Rates (Percent per Year)

Countries	1960-1970	1970-1982	1980-2000 (Projected)
Cuba	2.1	1.1	1.0
Average of 47 MICs	2.6	2.4	2.2

Source: World Bank, 1984.

1.4.2 Urban-rural balance

The uniform distribution reflects both the physical characteristics of Cuba, and the economic and social development policies. These have been deliberately chosen to provide employment and social amenities to all provinces and avoid excesses of rural to urban migration, characteristic of many developing countries. The urban population has fallen from one-half to one-third of the total since 1960 (Table 1.8), and Cuba has a much higher proportion of its population in rural areas than do other middle income third world countries (Table 1.8). A series of policies control movement of people. Each individual's ration card is only good at a particular store. Permission is needed to apply for a change in location.

Table 1.8 Urbanization

Countries	Urban Population as Percent of Total		Annual Average Growth Rate of Urban Population	
	1960	1982	1960-1970	1970-1982
Cuba	55	33	2.9	2.1
Average of 47 MICs	68	46	4.4	4.2

Source: World Bank, 1984.

1.4.3 Health

Since 1960, the birth rate has been cut almost in half and is now 16 per 1,000. The crude death rate is 60 percent of the average rate for MICs (Table 1.9). Life expectancy at birth (Table 1.10) is the highest of all MICs and has continued to improve since 1960, although no faster than the improvement in other MICs. In other words the margin of superiority is the same now as it was in 1960. Infant and child mortalities are the

lowest of all MICs (Table 1.11), reflecting important investments in pre- and neonatal care, nutrition and health services. There was one physician for every 710 people in 1980 compared to 1 to 554 in industrialized countries, and 1 to 5,414 for the average of the middle income countries.

Table 1.9 Crude Birth and Death Rates per 1,000 of Total Population

Countries	Birth Rate			Death Rate		
	1960	1982	% Change	1960	1982	% Change
Cuba	31	16	-47	9	6	-37
Average of 47 MICs	43	35	-22	17	10	-40

Source: World Bank, 1984.

Table 1.10 Life Expectancy at Birth

Countries	Male		Female	
	1960	1982	1960	1982
Cuba	62	73	65	77
Average of 47 MICs	49	58	52	62

Source: World Bank, 1984.

Table 1.11 Infant and Child Mortality: Deaths per 1,000

Countries	Infants Less Than 1 Year 1960	Infants Less Than 1 Year 1982	Children 1-4 Years 1960	Children 1-4 Years 1982
Cuba	35	17	2	1
Average of 47 MICs	126	76	23	10

Source: World Bank, 1984.

1.4.4 Education

In 1979, 65 percent of the population had completed at least 6 years of school and 23 percent had completed secondary school or university, compared with 5 percent at this education level prior to 1959. Illiteracy had fallen from 30 percent in 1953 to 6 percent of the population over 14 years old in 1979. Enrollments in secondary and tertiary schooling are twice the levels of average MICs (Table 1.12). In 1982/83, 1,687 university graduates received degrees in agricultural science (about 10 percent of the total number of graduates). In addition 370,000 people attended agricultural courses for workers and technicians. Sixty percent of secondary school students attend Basic Rural Schools (Escuelas Secundarias Básicas), located in rural areas in which basic agricultural skills and knowledge are acquired through a work-study program (Gillette 1972; Gelman 1981).

1.4.5 Human capital

Cuba has made major investments in human capital. Education and health services are accessible and free. This access has been gained by both the rural and urban population and is more uniformly available than historically was the case. Brundenius (1984) has constructed a series on real basic needs expenditures per capita for Cuba since 1959. This index was built up from quantity data from food, clothing, housing, education and health

Table 1.12 Enrollment in Schools as a Percentage of Population of Relevant Age by Levels

Countries	Primary 1960	Primary 1981	Secondary 1960	Secondary 1981	Tertiary 1960	Tertiary 1981
Cuba	109	107	14	75	3	20
Average of 47 MICs	75	102	14	41	3	11
Industrialized	114	101	64	90	16	

Source: World Bank, 1984.

services. In the first decade after the Revolution there were some slight gains in the average per-capita index, but by 1970, the index was only 3 percent above the prerevolutionary level. Changing the distribution rather than the absolute amounts had been the main focus of the social policy in the 1960s.

Between 1970 and 1980 per-capita basic needs expenditure rose 60 percent, an average rate of improvement of nearly 5 percent per year. Over the entire period from 1959 to 1980 the annual average rate of improvement was 2.3 percent, almost the same as the growth in per-capita income. Therefore, real income growth has been matched by an equal rate of increase in basic needs expenditures.

1.5 The Economy

At the outset, it should be stressed that there is some evidence that the usual problems of the adequacy of statistical data may be more marked in the case of Cuba (Mesa-Lago, 1969 and 1979). In part this stems from the reorganization and rebuilding of the statistical services after the Revolution, a feature characterizing many Cuban institutions. However, it also stems

from the fact that Cuba, as a socialist state, uses a different system of national accounting (Brundenius, 1984; Mesa-Lago 1981).

The socialist accounting system distinguishes between:

(a) Material Production Sphere comprising (i) material goods - the value of output of agriculture, fishing, industry and construction defined as Total Material Production (TMP); and (ii) material services - the value of transport, communication and trade which when added to TMP gives Global Social Product (GSP).

(b) Non-Material Sphere which is "non-productive" (finance, health, sports, education, defense, housing, public administration), and is not counted in GSP.

By subtracting intermediate inputs from GSP, Gross Material Product (GMP) is obtained which after subtracting depreciation gives Net Material Product. Note also that Gross Social Product does not include foreign trade. Adding imports to GMP gives Global Supply, and then subtracting exports gives Disposable Product. An estimate of Gross Domestic Product can then be formed by adding the non-material sphere to Gross Material Product. These are presented in Table 1.13.

1.5.1 Per-capita income

Following the revolution there was a decade of relatively slow growth in material output, as emphasis was placed on redistribution (Barkin, 1972). By 1970, per-capita income was no higher than before the revolution. Since 1970, national output (both goods and services) and especially non-material services, has risen dramatically. Between 1980 and 1982 per-capita income grew at 2.7 percent per year, the same rate as in the rest of Latin America (Table 1.14). Presently, Cuba has a per-capita income equal to the average of the rest of Latin America,

although this figure is 50 percent higher than the average for Central America and the Caribbean.

1.5.2 Income distribution

It is the change in the distribution rather than the level of income which has been the remarkable feature of Cuban economic and social development in the last 25 years. "The development strategy has stressed the elimination of poverty through a marked reduction in inequality. The degree of equality in Cuba is probably unique in the world" (Seers, 1976).

Table 1.13 Estimates of Cuban Gross Domestic Product

Year	Total Material Production	Gross Material Product[a]	Non-Material Services[b]	Gross Domestic Product[c]	GDP per Capita[d]
	million pesos[e]				US$ 1980
1958	2,116	3,480	678	4,158	866
1960	2,240	3,685	742	4,427	887
1965	2,520	4,138	967	5,105	921
1970	2,976	4,204	1,060	5,264	867
1975	4,576	5,708	1,967	7,675	1,158
1981	6,525	8,040	2,947	10,989	1,579

Notes: [a] Total material production (value added of primary industry, mining, manufacturing, electricity, construction) plus value added of transportation, communication and services (the non-material production).

[b] Including health, education, administration.

[c] Gross material product plus non-material services.

[d] Converted at US$ 1980 at (US$1 = 0.71 pesos).

[e] Constant 1965 Cuban pesos.

Source: Brundenius, 1984.

Table 1.14 GDP per Capita: Cuba and Selected Countries

Countries	1960	1970	1982	Growth Rate 1960-82 (Percent)
	US$ 1980			
Cuba	887	867	1,600	2.7
Brazil	651	924	1,527	3.9
Peru	910	1,142	1,268	1.5
Mexico	975	1,376	1,897	3.0
Argentina	1,371	1,767	1,686	0.9
Caribbean[a]	595	784	959	2.2
Latin America[a]	836	1,128	1,504	2.7

Notes: [a] Excluding Cuba.
Source: Brundenius, 1984.

The evolution of income distribution is shown in Tables 1.15 and 1.16. Prior to 1959, the poorest 40 percent of the population had a per-capita income of about one-fifth of the national average, and earned 6 percent of the total income. By 1978, their share had risen to a quarter of the total income, their per-capita income had risen nearly fivefold, to about 60 percent of the national average (Table 1.15).

In 1960, the income of the lowest 40 percent was similar to that in other Latin American countries; today it is very much higher. Both the share and the average income of the richest in Cuba fell drastically, especially in the 1960s. Today the richest 5 percent receive less than 10 percent of the income compared to receiving 30-40 percent, which is typical of much of the rest of Latin America (Table 1.16).

Table 1.15 Estimated Income Distribution

Decile Group	1953	1962	1973
		(Percentage of Income)	
0-10	0.6	2.8	2.9
10-20	1.5	4.9	4.9
20-30	1.9	5.3	5.4
30-40	2.2	7.0	7.1
40-50	4.6	8.5	8.7
50-60	6.4	9.8	10.5
60-70	10.8	10.2	12.0
70-80	12.0	13.7	13.5
80-90	21.5	15.8	15.1
90-100	38.5	22.0	19.9
(Top 5%)	(28.0)	(11.0)	(9.5)

Source: Brundenius, 1984.

1.5.3 Structure

The structure of the economy for 1983 is depicted in Table 1.17. While agriculture appears to contribute a relatively small share, a significant part of the material product of industry and of the trade services is related to the agricultural production, processing and distribution. The entire value of sugar, rice and milk production is included as industrial output in the national statistics because these products enter the food processing industry. The output under "agriculture" is largely limited to products consumed directly without further processing such as beans, vegetables and fruits. It is true, however, that agriculture's share has been declining (Table 1.18). Within the total agricultural sector (including fishing, forestry and livestock) the role of the sugar industry has fallen since the Revolution as increased attention has been given to other activities.

Table 1.16 Levels and Distribution of Per-Capita Income

Country	Year	Poorest 40%		Richest 5%	
		Per Capita Income[a]	Share of Total Income	Per Capita Income[a]	Share of Total Income
		US$	Percent	US$	Percent
Cuba	1958	182	6.5	5,947	26.5
	1973	506	20.3	1,892	9.5
	1978	865	24.8	3,068	11.0
Peru	1961	232	10.0	4,810	26.0
	1972	334	9.0	6,578	33.0
	1979	197	8.2	7,255	37.0
Brazil	1960	197	11.5	3,788	27.7
	1970	233	10.1	6,450	34.9
	1980	401	9.9	11,298	34.2

Note: [a] In US$ 1980.
Source: Brundenius, 1984.

1.5.4 Labor force

In 1982, the total state civilian labor force was 2.88 million, of which 35 percent were women. Twenty-two percent of the value of the material product was generated in agriculture (Table 1.18) and 22 percent of the work force is employed in agriculture (Table 1.19). This share has fallen from 37 percent in 1958. Average agricultural wages are over 90 percent of the average industrial wage. Workers are rewarded with material incentives (bonuses, access to durable goods, housing, vacations) for superior output and productivity (Mesa-Lago, 1968, 1981). Male unemployment rates have been between 2 and 3 percent; however, in spite of the rapid rise in female labor force participation (from 25 to 50 percent over the last decade) female unemployment rates have been much higher.

Table 1.17 Structure of the Cuban Economy, 1983

Sector	Million Current Pesos	Percent
Agriculture	3,443	14
Industry	10,640	44
Forestry	105	neg
Construction	1,995	8
Other	125	neg
Total Material Product	16,308	66
Transport	1,678	7
Communications	204	neg
Trade	6,426	27
Global Social Product	24,616	100

Source: Cuba, 1984.

The composition of the work force between the state and non-state sectors for 1980 is given in Table 1.20. The state employs 94 percent of the total labor force. About 10 percent of the state labor force are in the military, but they perform a wide range of civilian tasks in construction, transport and agriculture. The agricultural sector accounts for most of those not working directly for the state.

Table 1.18 Percent Share of Major Sectors in Total Material Production

Sector	1950	1960	1965	1970	1975	1980
Agriculture	48	42	33	32	22	22
Sugarcane	57	55	40	51	36	32
Non-Sugar	n.a.	n.a.	26	22	31	34
Livestock	n.a.	n.a.	31	22	25	24
Mining	1	1	3	2	2	1
Manufacturing	42	47	47	53	53	49
Electricity and Construction	9	10	17	13	23	28
Total	100	100	100	100	100	100

Source: Brudenius, 1984.

Table 1.19 Distribution of Labor Force by Sector

Sector	1958	1970	1979	1982
		(Percent)		
Agriculture	37	30	22	22
Industry	21	26	28	26
Transport and Communications	4	6	6	7
Services	25	24	29	30
Other Commerce	13	12	8	11
Other	-	2	7	6
Total	100	100	100	100

Source: Brudenius, 1984 and Cuba, 1984.

Table 1.20 Structure of Employment, 1980

	'000	Percent
Labor Force	3,527	100
Unemployed	146	4
Employed	3,381	96
State	3,168	94
Civilian	2,849	94
Military	319	10
Non-State	213	6
Agriculture	172	81
Other	41	19

Source: Brundenius, 1984.

1.5.5 Output growth

Data for the overall pattern of growth of the economy are sketchy especially if one is interested in a long-time series. In Table 1.21 output growth rates of Total Material Products are given for the three main sectors. It is apparent that manufacturing output has grown faster than agriculture. In fact, the output growth rates for agriculture, both sugar and non-sugar, are quite low and have fallen since 1959. However, agricultural growth has accelerated remarkably in the last few years (Table 1.22). Part of this difference is due to price rises, and part due to increased use of material services in agriculture. A more disaggregated analysis for agriculture is presented in the next section. Based on data for components of GNP (United States, 1984) real agricultural output grew at an average annual rate of 3.5 percent between 1971 and 1982, compared to 3.6 percent for industry and 5.2 percent for "non-productive services" (housing, health, education, culture, recreation, administration, etc.).

Table 1.21 Annual Average Rates of Growth of Total Material Product at Factor Cost

Sector	1946-61	1968-73	1974-80
		(Percent)	
Agriculture	2.3	0.7	1.1
Sugarcane	3.7	0.2	1.2
Non-Sugar	n.a.	-0.6	1.1
Livestock	n.a.	1.3	1.1
Fishing	n.a.	13.3	6.1
Mining	-2.8	1.6	2.1
Manufacturing	4.1	9.2	4.0
Total Material Product	3.5	7.4	5.1

Source: Brundenius, 1984.

Table 1.22 Growth of Output, 1975-83

Year	Industry	Agriculture	Total GSP[a]
1975	100	100	100
1979	118	123	121
1980	121	128	124
1982	150	213	165
1983	158	216	175
	Annual Average Rate of Growth		
1975-80	3.9	5.1	4.4
1980-83	1.7	19.1	12.2

Notes: [a] Gross Serial Product.

Source: Cuba, 1984.

1.5.6 Public expenditure

Because of the role of the state in both ownership of assets and direct control of production, the western notion of government expenditures has little relevance. However, some data are available on public expenditure (Table 1.23). The proportion of the budget dedicated to development (public investment) and social services has been over 70 percent for the last decade. In 1978, social service expenditure was US$400 per capita. The estimate of total basic needs expenditures, which includes some private as well as public expenditure, was US$600 (from Brundenius, 1984). Social services continue to be the major item of public expenditure. Total foreign debt (in hard currency) is about $3.3 billion (Gutierrez Muñoz, et al. 1984) and represents about one-half of current export receipts.

1.5.7 Foreign trade

Trade has always been a vital element of the Cuban economy. Exports continue to be dominated by sugar and there are relatively few other export crops. In 1983, the breakdown of total export earnings was: sugar (74 percent), nickel (6 percent), tobacco (2 percent), and citrus (2 percent). Trade is closely tied with the communist countries. In 1983, they bought 86 percent of Cuba's exports and provided 87 percent of imports. Over 80 percent of the trade with the communist countries is accounted for by the USSR. However, trade with a number of western countries is important (particularly Spain, U.K., Japan, Canada, West Germany and France), and has been as high as 30 percent of total trade in some years.

The three major categories of imports are capital goods, fuels and food. In 1982, these accounted for 32, 27 and 15 percent of total imports respectively. Food imports per capita have been rising and have probably doubled in real terms since 1970 (Table 1.24).

Table 1.23 Public Expenditure

Item	1957 (US$m)	1957 (%)	1965 (US$m)	1965 (%)	1978 (US$m)	1978 (%)	1984 (US$m)	1984 (%)
Development	20	6	878	35	5,355	48	4,101	31
Social Services	130	39	832	32	4,003	33	5,688	44
Public Administration	89	27	137	6	718	6	764	6
Defense and Order	55	17	213	8	1,043	9	1,355	10
Other[a]	36	11	476	19	1,099	8	1,141	9

Note: [a] Including reserves, debt servicing and other activities.

Source: United States, 1984.

Table 1.24 Food Imports[a]

Year	Total Imports (US$m)	Food Imports: Total[a] (US$m)	Food Imports: Per Capita (US$)	Food Imports: Proportion of Total Imports (Percent)
1965	866	205	26	24
1970	1,310	263	31	20
1975	3,766	718	76	19
1980	6,409	1,093	112	17
1981	6,546	1,117	113	17
1982	6,645	1,001	101	15

Note: [a] SITC Categories 0, 1, 4: food and live animals, beverages, tobacco, oils and fats.

Source: United States, 1984.

The Soviet Union provides substantial economic aid to Cuba. About three-quarters of the total aid of US$4.16 billion in 1983 was in the form of trade subsidies. The Soviet Union has long-term agreements for the purchase of sugar at above the world price (Radell, 1983). The price paid by the Soviets has only been below the world price on three occasions (Table 1.25). This subsidy was valued at $2.8 billion in 1983. In addition to the sugar subsidies, Cuba receives prices above the world market for its nickel exports and pays less than the world price for its petroleum imports. Hence to get a more accurate reflection of the foreign trade sector it is necessary to reduce export earnings and increase import payments by the amount of the subsidies.

While food imports have only been 15 percent of total import costs recently, they represent a much larger share of Cuba's total command over foreign goods and services when valued at world prices (Table 1.26). In fact they have been as high as 40 percent, and over the past decade have averaged 32 percent, showing no tendency to decline.

Table 1.25 Amount by Which Prices Paid by Soviet Union for Cuban Sugar Exceed the World Price

Period	Cents/Pound
1960-64	0.06
1965-69	3.82
1970-74	-0.85
1975-79	20.06
1980-82	21.83

Source: Radell, 1983.

Table 1.26 Food Imports as a Proportion of Adjusted Export Earnings[a]

Year	Total Food Imports (US$ million)	As a Proportion of Adjusted Export Earnings (Percent)
1971	316	40.3
1972	324	39.6
1973	411	32.8
1974	684	22.2
1975	718	24.2
1976	723	31.8
1977	736	36.5
1978	861	40.7
1979	865	33.4
1980	1,093	24.6
1981	1,117	27.6
1982	1,001	29.9
Annual Average	1971 - 1975	31.8
	1977 - 1982	32.1

Note: [a] Adjusted for the nickel and sugar subsidies.
Source: United States, 1984.

2 The Agricultural Sector

2.1 Structure

2.1.1 Land tenure

Prior to 1959 Cuban agriculture was characterized by an uneven distribution of land ownership. The majority of the land was held in large estates; 70 percent of the land was occupied by less than 10 percent of the farms. The 40 largest cattle farms had nearly 1 million ha or 10 percent of the land and 28 sugar companies owned or leased 20 percent of the land (MacEwan, 1980, 1981, 1982).

The structure of land holding was drastically changed by two agrarian reform laws (1959 and 1963). After the second reform about 70 percent of the land was owned by the State, and 30 percent by private farmers. The State's share has risen to 79 percent as small farmers have sold their land to the State or incorporated it in state run cooperatives. The remaining 21 percent of the land is held by 140,000 private farmers. A breakdown of the agricultural labor force is given in Table 2.1.

The majority of the land held by the private sector is organized through the National Small Farmers Association (ANAP), and its cooperatives (either for credit and inputs alone, or through complete agricultural production cooperatives). In 1985, there were 1,437 of these "full" cooperatives with over 83,000 members farming 1.5 million hectares.

The importance of the private sector varies widely according to the crop. About 16 percent of sugar production comes from the private sector; other crop estimates for 1976 were rice, 6.7 percent; citrus, 34 percent; beans, 58 percent; cassava, 61 percent; malanga, 76 percent; sweet potatoes, 40 percent; coffee 48 percent; and tobacco, 82 percent (Forster, 1982). These estimates refer to deliveries to the state harvest collection

centers (acopio). Private farmers participate in production plans and must sell an agreed amount of their production to the State at fixed prices. In effect private farms are subject to the same planning goals that characterize the state sector. Since 1980, farmers' markets have been introduced and some of the production is sold at freely determined prices in these markets, but the total proportion of the output marketed this way is quite small. A major part of agricultural output comes directly from the state farms and enters the state distribution system.

Table 2.1 Employment in Agriculture, Fishing and Forestry

Sector	1970 (000)	1979 (000)	Percent
State	495	546	76
Private	24	9	1
Small Farmers	231	143	21
Self Employed	6	10	1
Family Workers	34	8	1

Source: Brundenius, 1984.

About 80 percent of the agricultural land is now in state enterprises. There are 152 sugarcane units with an average area of 15,000 ha each, an average of 9,000 ha of which is in cane. These are under the control of the Ministry for the Sugar Industry (MINAZ). The remaining state agricultural enterprises are the responsibility of MINAG. The following is a summary of the state farm structure.

Crops

Large: 8 for rice (average area 17,500 ha)
12 for citrus (average area 12,000 ha)

Medium: 61 for vegetables, grains, roots and tubers (3,000-5,000 ha each)

Small: 16 for coffee
13 for tobacco

Livestock

120 cattle farms (beef and dairy)
43 poultry and pig farms

Forestry

31 state forest enterprises

Animal Feed Enterprises

11 units preparing animal feeds

There is considerable debate (Forster, 1982; Eckstein, 1983) as to whether productivity is lower in the state farm sector as compared to private production. While the evidence is far from complete it appears that for roots, tubers, beans and some horticultural crops small, labor intensive private production may achieve higher yields. In other cases it is possible that the state overestimated the efficiency gains from large-scale capital intensive farming; so that while yields are comparable, state farms use much higher levels of inputs.

2.1.2 The importance of sugar

Sugar has dominated Cuban agriculture for nearly two centuries. Cuba has supplied up to 30 percent of total world output (Brunner, 1977). It used to be the world's single largest producer and now ranks fourth after Brazil, India and USSR. Sugar is of overwhelming importance in all aspects of the agricultural sector. It competes for land, labor, machinery, irrigation, fertilizer and transport facilities with other crops.

This competition is reflected in the relative rates of growth of sugar and non-sugar agriculture (Table 2.2). Whenever there is a surge of sugar production there is a corresponding decline in non-sugar output. In fact the correlation coefficient between rates of growth of sugar and non-sugar agriculture was -0.67 between 1969 and 1983. During this period the average annual change in sugar was 2.6 percent; for non-sugar agriculture it was 4.4 percent suggesting that non-sugar has been favored relative to sugar. To some extent this is true for the period since 1970. Table 2.3 examines the relative importance of sugar over a 35-year period. In the period immediately following the revolution there was an attempt to reduce the importance of sugar, in part reflecting the desire to break the dependency on a monoculture. From an annual average of 1.4 million ha in sugarcane in 1960 and 1961 the average fell to 1 million ha from 1962-68. However in the mid-1960s it was felt that sugar exports were needed to allow greater economic development and a target of 10 Mt was set for 1970; production actually reached 8.5 Mt (Table 2.4). In 1970, the output of non-sugar agriculture fell to less than one-half the output of sugar, but has since recovered, and by 1980, the TMP of non-sugar agriculture again exceeded that of sugar (Table 1.18). However, it is clear that any expansion of other crops is in part limited by the policy of maintaining the area under sugarcane at least at its present levels.

As a way to maintain output and still release some resources from sugar to other crops, improved sugarcane varieties are being introduced, water control and agronomic practices improved, and very significantly the harvesting is being mechanized (Edquist, 1983). Currently over 60 percent of the crop is mechanically harvested (Table 2.4). It is not as if the production were confined to any one area so that expansion of other crops might occur in the non-sugar areas. In fact, every province produces some sugar, and the production is relatively evenly spread across much of the country although the yields vary substantially between provinces (Table 2.5). Cuba receives prices which are

Table 2.2 Annual Average Rates of Growth of Total Material Production (TMP) in Sugar vs. Non-Sugar Agriculture

Year	Sugarcane	Non-Sugar Agriculture
1955	-11.4	3.6
1956	6.4	6.9
1957	20.7	4.5
1958	2.2	-4.7
1959	5.1	4.2
1960	-1.1	5.4
1969	10.3	-10.0
1970	33.9	-7.0
1971	-24.5	2.7
1972	-12.6	13.0
1973	3.8	4.3
1974	3.1	15.6
1975	3.7	3.2
1976	2.2	7.9
1977	14.4	-5.7
1978	15.2	4.4
1979	0.8	3.0
1980	-18.3	27.3
1982	4.2	7.0
1983	0.0	7.4

Source: Brundenius, 1984.

Table 2.3 Relative Importance of Non-Sugar Agriculture and Livestock[a]

Year	Non-Sugar Agriculture: Sugar	Livestock: Non-Sugar Agriculture
1946	1.02	n.a.
1950	0.77	n.a.
1955	1.03	n.a.
1960	0.68	0.85
1965	0.64	1.19
1970	0.43	0.99
1975	0.85	0.80
1980	1.07	0.71

Note: [a] Ratio of contributions to Total Material Product at factor cost.

Source: Brundenius, 1984.

both more stable and currently very much higher than the world price for sugar. In 1983, Cuban sugar exports of 6.79 Mt earned US$6,416 million. This is an average price of US$944/ton or 43 cents per pound. The world price in 1983 was 8.5 cents per pound (and in January 1985 was 3.6 cents per pound). With an area harvest of 1.327 million ha in 1983, Cuba generated foreign earnings equivalent to US$4,835 per hectare. Although from this figure processing cost must be subtracted, sugar sold to the Soviet Union is a highly lucrative enterprise. At current yield levels, it does not appear possible to generate foreign exchange savings of this magnitude by increasing the domestic production of foods that are currently imported (e.g., rice, beans).

The use of the sugar price as a mechanism for transferring Soviet aid to Cuba distorts the pattern of agricultural production encouraging higher sugar output and lower production of other crops than would prevail at world prices (Eckstein, 1981; Scobie, 1985). As a consequence Cuba's food imports are higher than they would be under an alternative aid mechanism.

Table 2.4 Sugar: Milling, Production and Exports

Year	Area Harvested (000 ha)	Cane Yield (t/ha)	Share Mechanically Harvested (Percent)	Sugar Content (Percent)	Total Sugar Production (Mt)	Exports (Mt)
1957	1,264	35	0	12.8	5.7	5.3
1965	1,054	49	n.a.	12.1	6.2	5.3
1970	1,460	56	n.a.	10.7	8.5	6.9
1975	1,180	44	26	12.4	6.3	5.7
1976	1,124	44	33	11.8	6.2	5.8
1977	1,137	53	35	11.5	6.5	6.2
1978	1,237	56	39	11.0	7.4	7.2
1979	1,313	59	45	10.9	8.0	7.3
1980	1,392	46	50	10.8	6.7	6.2
1981	1,209	55	55	11.1	7.4	7.1
1982	1,327	55	60	11.2	8.2	7.7
1983	n.a.	n.a.	n.a.	10.5	7.2	6.8

Source: United States, 1984.

Table 2.5 Sugar Production by Provinces in 1979-80

Province	Percentage of National Output	Yield of Cane (t/ha)
Pinar del Rio	2	55
La Habana	9	58
Mantanzas	13	57
Villa Clara	8	36
Cienfuegos	6	38
Sancti Spiritus	6	42
Ciego de Avila	12	49
Camaguey	11	42
Las Tunas	9	40
Holguin	11	50
Granma	6	43
Santiago de Cuba	6	54
Guantanamo	2	46

Source: Cuba, 1981.

2.2 Food and Agricultural Output

While Cuba has devoted substantial resources to agriculture the performance of the sector judged by output alone has been disappointing (Table 2.6). In the decade following the revolution, total agricultural and food output were virtually unchanged, but in per-capita terms they fell substantially because of population growth. In that decade however, the whole structure of agriculture was reorganized; input use, labor relations, delivery, planning and investment were all restructured. Massive investments were made in rural literacy, health and education, so that despite the slow growth in output the real welfare of much of the rural population seems to have

been improved significantly during that decade. But the gains came largely from redistribution rather than new output (MacEwan, 1981).

In interpreting the performance of Cuban food production the importance of sugar must be repeatedly emphasized. In the early 1960s the development strategy de-emphasized sugar production and concentrated on agricultural diversification and greatly increased industrial output. In fact between 1962 and 1976 industrial output per capita rose by 73 percent while agricultural output per capita fell by 12 percent.

By the late 1960s the policy was reversed and it was agreed that Cuba had to concentrate on the production of sugar, in which lay its greatest comparative advantage. However, the record output of 1970 came at a very high cost, and could not be sustained. The 1970s have seen a very much more balanced pattern of gross agricultural growth, as well as a marked improvement in per-capita performance compared with the stagnation of the 1960s (Barkin, 1977; Dumont, 1970, 1974). This is especially true of the latter part of the 1970s and the 1980s (Table 2.7). However, emphasis has been given to certain parts of the agricultural sector (in particular livestock and citrus production) and this has implications for the crops of interest to the international centers. The output of those crops over the last three decades is given in Table 2.8.

2.3 Agricultural Inputs

2.3.1 Mechanization

Not only has the sugar harvesting been mechanized to a high degree, but the strategy is to mechanize all agricultural production to the extent possible. The absolute labor input in agriculture has been constant for a long period and agricultural workers now comprise only just over 22 percent of the work force. The number of tractors rose from 7,200 in 1959 to 70,000 in 1985,

and 80 percent of the land is now cultivated with machinery. In all crops the development of varieties and agronomic practices is centered on making cultivation, seeding, weeding, spraying, and irrigating and harvesting as fully mechanized as possible. Agriculture is viewed as a source of labor for other sectors, not for its potential to provide employment. With a slow rate of growth in the total labor force (around 1 percent per year) and a continued emphasis on industrial development it seems inevitable that the efforts to mechanize agriculture and release labor will continue. The international centers need to be fully cognizant of this policy in their collaborative efforts.

Table 2.6 Trends in Agriculture and Food Production

Year	Total Production			Per Capita	
	Agriculture	Food	Ratio of Food to Agriculture	Agriculture	Food
1959	100	100	100	100	100
1960-64	92	96	107	87	89
1965-69	94	102	109	79	84
1970-74	103	108	105	79	87
1975-79	121	121	100	85	91
1980-83	136	130	96	93	97

Source: Based on data from Mesa-Lago (1981); Forster and Hendelman (1982). Both these draw on FAO data which were used to update the series to 1983, and recalculated to a base of 1959 = 100.

Table 2.7 Recent Trends in Per-Capita Production

Year	Agriculture	Food	Crops	Livestock	Cereals
			1974-76 = 100		
1972	97	97	87	108	77
1974	101	101	99	100	100
1976	101	100	101	104	100
1978	118	121	119	118	100
1980	113	118	113	125	103
1981	123	124	121	131	98
1982	123	125	125	132	109
1983	120	122	118	137	103

Source: FAO Production Yearbook 1983, 1984.

Table 2.8 Production of Major Food Crops (thousand ton): Selected Years

Crop	1957	1961	1965	1980	1983
Sugar	5,672	6,767	6,051	8,529	7,200
Rice	167	213	82	299	490
Maize	245	198	50	291	96
Total	412	411	132	590	586
Potatoes	94	90	84	77	222
Cassava	186	255	62	22	335
Sweet Potato	161	117	81	22	332
Malanga	91	257	47	12	240
Total	532	719	274	133	1,029
Beans	36	55	11	5	27

Source: 1957-70 from Ritter, 1974; 1983 from FAO Production Yearbook 1983, 1984, except malanga for which estimates were supplied by national research program.

2.3.2 Fertilizer

The quinquennial production of ammonium nitrate and urea rose from 21 kt in 1966-70 to 1,067 kt in 1976-80 (Cuba, 1982). Production of complete fertilizers rose from 3.4 Mt to 4.5 Mt in the same period. Sugarcane receives the largest share of total fertilizer use (Table 2.9). A major portion of the nitrogenous fertilizer is used on cultivated pastures and forage crops. In 1980, sugarcane received 214 kg/ha and pastures 150 kg/ha of nitrogenous fertilizer.

Table 2.9 Fertilizer Use by Crops in State Sector: 1980

Crop	Fertilizer Applied	
	Balanced (kt)	Nitrogenous (kt)
Sugarcane	454	214
Rice	32	37
Vegetables	30	1
Roots and tubers	47	5
Citrus	52	11
Plantain	23	4
Coffee	47	13
Pastures	164	150

Source: Cuba, 1982.

Cuba depends heavily on imported fertilizers (Table 2.10). Total fertilizer use per hectare has been rising dramatically since the mid-1970s as part of the effort to raise agricultural output. Per hectare applications have been rising at 7 percent per year and will have nearly doubled over a decade (Table 2.11). There is considerable current concern about the cost of this

strategy (and about in fact the cost of all chemical inputs) and efforts are underway to see if these rates can be reduced, by improving the efficiency of fertilizer use.

2.3.3 Irrigation

The total irrigated area was 450,000 ha in 1980 in the state sector. Sugar, rice, citrus and pastures (in that order) accounted for the majority of this area.

2.3.4 Agrochemicals

Pesticide and herbicide use expanded rapidly from 18.4 kt in 1975 to 27.5 kt in 1980, the latest available data.

Table 2.10 Production and Import of Fertilizer: 1982-83

Source	Nitrogenous (kt)	Phosphate (kt)	Potash (kt)
Production	96	4	0
Imports	179	77	198

Source: <u>FAO Fertilizer Yearbook 1983</u>, 1984.

Table 2.11 Consumption of Fertilizer per Hectare of Arable Land and Permanent Crops

Year	Type of Fertilizer Nitrogenous	Phosphate	Potash	Total
		(kg/ha)		
1974-76	52	19	36	107
1978	71	19	53	142
1980	84	23	59	166
1982	86	25	62	173

Source: FAO Fertilizer Yearbook 1983, 1984.

2.4 Food Production and Imports

In this section attention is focused principally on the crops of interest to international centers.

2.4.1 Wheat

Cuba does not produce wheat; however, imported wheat is an important part of total food imports. Wheat imports have risen substantially from 319 kt in 1960-62 to 1,442 kt in 1983. The cost of wheat imports was US$261 million in 1983. Interest has been expressed in the possible use of locally produced flours based principally on cassava to substitute for some of the imported wheat.

2.4.2 Rice

The area in rice has declined since 1960 but with higher yields output has nearly doubled (Table 2.12). The degree of self-sufficiency has risen slowly and the stated goals are:

- to eliminate imports over the next 10 years
- to do this through "vertical" (yield) rather than

"horizontal" (area) expansion, a philosophy espoused for many crops in Cuba

If domestic demand grows at 3 percent annually (1 percent population growth plus 2 percent growth in per-capita consumption) then domestic production in 1995 would need to be 0.75 Mt of milled rice or about 1 Mt of paddy rice. This will mean a national average yield of 7.5 t/ha, an extremely ambitious target if the planted area were to remain at about 140,000 hectares. Improvements in water control and agronomic practices are to play an important role in this strategy and continued productive relations with IRRI and CIAT will be necessary in order to provide a range of suitable genetic material. The possibility is being explored, of incorporating short cycle rices into sugarcane land as it is renovated; if this was followed, it would lower the target yield. Nevertheless, the "vertical" strategy implies doubling rice yields from the present national average of 3.8 t/ha in 10 years; at this point this possibility appears highly improbable. If the area devoted to rice does not expand, some imports will almost certainly be required to sustain a growth in domestic consumption.

Table 2.12 Rice: Production and Imports

Year	Area (000 ha)	Yield (t/ha)	Production (rough rice) (kt)	Imports (milled rice) (kt)	Import Dependency[a] (Percent)
1960-62	158	1.6	255	181	49
1970-72	172	2.0	346	245	49
1980-82	146	3.3	486	208	37
1983	140	3.5	490	207	37

Note: [a] Imports as a share of production plus imports converted to rough rice equivalents.

Source: FAO Production and Trade Yearbooks.

2.4.3 Maize

Virtually all maize is used in animal feeds. Yields are low and production has dropped considerably since the early 1960s (Table 2.13). Meanwhile imports have grown at an annual rate of 10 percent, and production now meets less than 20 percent of domestic requirements. Imports per capita rose from 18 kg in 1961-65 to 53 kg in 1980-82.

Table 2.13 Maize: Production and Imports

Year	Area (000 ha)	Yield (t/ha)	Production (kt)	Imports (kt)	Import Dependency (Percent)
1960-62	168	1.0	175	54	24
1970-72	112	0.8	87	165	66
1980-82	77	1.2	95	515	84
1983	77	1.2	96	402	81

Source: <u>FAO Production and Trade Yearbooks</u>.

2.4.4 Sorghum and soybeans

Production of these two crops is very low in Cuba, in contrast with other countries with comparable climate and land resources. Virtually no sorghum is produced (less than 1 kt) and there are some modest imports. There is interest in expanding sorghum production to substitute for increasing imports of feed grains. Little soybean production exists while large amounts of soybean meal are imported. There is also interest in increasing soybean production.

2.4.5 Potatoes

Potatoes are an important food in Cuba and considerable

emphasis is given to their production. Yields have risen with new varieties and cultural practices allowing an increase in domestic consumption (Table 2.14). There is some interseasonal trade with the Soviet Union, but most imports appear to be seed potatoes largely from the Netherlands and Canada.

2.4.6 Beans

Data for the area and production of common beans (*Phaseolus vulgaris*) seem less reliable than for most other crops. Much of the production comes from the private sector and some (probably unrecorded) is retained for home consumption. The FAO data are shown in Table 2.15. Cuban data (Cuba, 1981) report 39,500 ha were sown in 1980 producing 9.74 kt (implying an unrealistically low yield of 0.25 t/ha). The area sown in 1970 was only 1,920 ha. In 1983, Cuban statistics report 12.5 kt were harvested from 38,300 ha with a yield of 0.33 t/ha (Cuba, 1984), again unrealistically low considering the high level of inputs used in state farm bean production. In any event there appears to have been a substantial decline from production levels of over 50 kt in the early 1960s (Ritter, 1974). Import dependency is over 80 percent and has remained stagnant.

In 1982 per-capita distribution was 0.94 kg/month or a total of 110.5 kt. This agrees with imports of 119.2 kt that year as some would go into the "free" market.

2.4.7 Cassava

Cuba is placing a major emphasis on the production of *viandas* (vegetatively reproduced tropical starchy food crops). This includes cassava, malanga, sweet potato (boniato), plantain (plátano vianda) and yams (ñame). The FAO estimates for cassava are given in Table 2.16. Production of malanga, sweet potato and plantain has grown from 59 kt in 1970 to 480 kt in 1980 (Cuba, 1981). The country is entirely self-sufficient in these crops. They are the brightest spot in food production increases.

Table 2.14 Potatoes: Production and Imports

Year	Area (000 ha)	Yield (t/ha)	Production (kt)	Imports (kt)	Import Dependency[a] (Percent)
1960-62	11	10.7	103	36	26
1970-72	7	11.0	76	39	34
1980-82	14	18.4	257	27	9
1983	13	17.1	222	26	10

Note: [a] Mainly seed potatoes in the later years.
Source: FAO Production and Trade Yearbooks.

Table 2.15 Beans: Production and Imports

Year	Area (000 ha)	Yield (t/ha)	Production (kt)	Imports (kt)	Import Dependency (Percent)
1960-62	35	0.6	22	73	77
1970-72	35	0.7	24	99	81
1980-82	35	0.8	26	103	80
1983	35	0.8	27	107	80

Source: FAO Production and Trade Yearbooks.

Table 2.16 Cassava Production

Year	Area (000 ha)	Yield (t/ha)	Production (kt)	Imports (kt)	Import Dependency (Percent)
1960-62	24	6.7	162	0	0
1970-72	33	6.6	217	0	0
1980-82	48	6.9	330	0	0
1983	50	6.7	335	0	0

Source: FAO Production Yearbooks.

2.4.8 Citrus

This is an important expanding sector which receives very high priority in the overall plans for the agricultural sector. In 1960 total citrus production was about 100 kt. Today production is now over 500 kt and exports have grown from 255 kt in 1981 to 383 kt in 1983 with an export value of US$140 million. Furthermore, the rate of planting has been very rapid, so greatly expanded areas will come into production in the future. Based on current plantings, the World Bank expects exports to be over 1 Mt in 1990 and nearly 2 Mt in 1995. At an average price of $350/t this implies earnings from citrus of $700 million, signalling a significant diversification of production and export revenue. This is a major element of current Cuban agricultural policy.

2.4.9 Milk

Intensive, irrigated, highly fertilized tropical pastures and forages combined with genetic improvement, artificial insemination and capital investment have led to a major expansion in milk production from 0.6 Mt in 1960-62 to 1.25 Mt in 1983. Yields on state farms increased from 1,339 kg/cow/yr (3.7 kg/cow/day) in 1970 to 2,235 kg/cow/year (6.1 kg/cow/day) in

1980. Almost all milk produced on state farms comes from milk breeds. Holstein-Brahma F1 and F2 crosses account for 68 percent of the production of milk breeders. The production for 1980 is shown in Table 2.17. In 1983, 0.5 Mt of dry milk powder, and condensed and evaporated milk were imported together with 22 kt of butter and cheese. These are approximately equivalent to 0.5 Mt and 0.59 Mt respectively of fluid milk equivalents. (Data are based on conversion factors supplied by Dr. William L. Johnson, Department of Animal Science, North Carolina State University, Raleigh, NC.) Consequently, Cuba produces only about 45 percent of its total consumption of milk products.

Table 2.17 Milk Production - 1980

Breed	Milk (kt)	Kg/cow/day
From Milk Breeds:		
Holstein and crosses	688	7.2
Brown Swiss and crosses	117	4.5
Other	17	7.4
From Meat Breeds	57	2.8
Total	889	6.1

Source: Cuba, 1982.

2.4.10 Poultry

Meat production has doubled in the last decade to over 90 kt at present, and another 20 kt are imported. Egg production rose from 118 per capita in 1965 to 237 in 1980. Breeding and

management have raised egg output per laying hen from 206 in 1971 to 245 in 1980. In 1980, poultry production used 200 kt of feed grains with a conversion efficiency of 2.85 kg feed per kg meat; another 330 kt of feed were used in egg production, at a rate of 161 gm/egg. In addition to over 500 kt of maize imports, oilseed cake meal imports rose from 150 to 200 kt between 1981 and 1983.

Poultry and egg consumption have been rising at least 10 percent per year for the last decade. Consider the implications of a similar rate of growth in consumption from 1985 to 1995:

	Estimated Output		Feed Grain Requirements in 1995	
	1985	1995	Conversion	Total (kt)
Chicken (kt)	100	260	2.5 kg/kg meat	650
Eggs (m units)	2,500	6,500	150 gm/egg	975

In total some 1.6 Mt of feed grains would be needed for egg and poultry meat production alone. Additional feedstuffs are used in milk and pork production; the latter was 72 kt in 1983. This suggests that there exists a substantial demand for domestically produced cassava, maize, sorghum and soybeans in order to meet future feed grain requirements and lessen the demand for imported feed grains.

2.4.11 Beef

In 1983, total beef and veal production reached 155 kt from a slaughter of 910,000 head. The total cattle population was about 6.3 million head. It appears to have grown very little over 20 years (Mesa-Lago, 1981). Per-capita distribution of beef has declined, an outcome consistent with stagnant production. Emphasis appears to have been given principally to cattle for milk production and to the production of pork and especially poultry, for meat.

It would appear that there is a significant latent demand for beef. In 1970, state collection was approximately 40 kg of liveweight per capita. If that rate had been maintained, then in 1982 it would have required a collection of 392 kt instead of the recorded collection of 267 kt i.e., almost a 50 percent increase. This allows for no growth at all in beef demand, which is quite inconsistent with rising real incomes. The implication is that there must be a major potential for expanding beef production for local consumption. This will presumably have to come from the more marginal lands and extensive beef grazing systems in the drier, hilly areas of the country. It implies a significant potential demand for new pasture species to achieve this, if in fact that was to be the plan.

2.5 Food Consumption and Distribution

The trends in per-capita consumption of major foods is given in Table 2.18. This evidence closely mimics the general pattern of agricultural development, and in particular the commodity emphasis that Cuba has followed. In general following the stagnation and decline of production, average per-capita consumption of many commodities fell between 1960 and 1970; it must be stressed however, that their distribution became much more even. Exceptions were eggs and fresh milk; from the outset the government placed considerable emphasis on these products. Their rate of growth slowed in the 1970s as emphasis shifted to poultry, meat, roots and tubers. Rice consumption has remained fairly static with the increased domestic production replacing imports. Consumption of wheat products has increased notably.

Data on the pattern of consumption expenditures were examined for the period 1960-80. Somewhat surprisingly there have been no substantial changes. The major category is livestock products (34 percent of food and beverage expenditures) followed by cereals (19 percent) and fish, roots and tubers, oils

and fats (5 percent each). The information serves to underline the importance of livestock products.

Table 2.18 Per-Capita Consumption of Selected Foods

Food	1963	1970	1975	1980
		(kg/yr)		
Livestock Products:				
Beef	8.5	11.4	6.4	8.3
Poultry	4.2	1.8	7.2	8.8
Pork	0.2	0.6	1.0	2.4
Eggs (units)	101.0	160.0	186.0	212.0
Fluid Milk	19.5	55.2	65.1	72.2
Legumes:				
Beans	9.4	9.4	10.3	12.5
Roots and Tubers:				
Potatoes	15.4	12.5	13.5	22.3
Malanga	5.6	1.3	3.6	12.2
Sweet Potatoes	11.1	2.4	8.7	9.5
Cassava	8.4	2.4	8.0	8.5
Cereals:				
Rice	36.8	41.7	44.6	42.2
Wheat, Bread, Spaghetti	34.5	59.1	56.4	64.6

Source: Brundenius, 1984.

2.5.1 Nutrition

FAO estimates show that per-capita daily caloric supplies are over 2,700, having risen from 2,400 in the 1960s. Protein availability is at 70 gm/day with one-half coming from animal sources. These average figures suggest no serious nutritional

problems, given the uniform nature of food distribution. This is in contrast to a World Bank report in the 1950s which reported 30 to 40 percent of Cuba's urban population and 60 percent of the rural populace to be undernourished "as manifested in small bone structure ... general physical weakness, anemia and low resistance to disease." (World Bank, 1981). Nevertheless nutritional levels in Cuba were superior to other comparable developing countries before the revolution (Gordon, 1983; Handelman, 1983). The extent of the subsequent improvement has been widely debated (Handelman, 1982; Forster and Handelman, 1982, 1984).

2.5.2 Rationing

Cuba has a universal ration card system for food and other items including cigars, cigarettes, soap, detergents, clothing and shoes. It covers a wide range of foods (a selection is shown in Table 2.19) and the prices are fixed at low levels. Rations vary with age. These currently provide each person with 2,000-2,300 calories per day, with the balance coming from meals in cafeterias (on state farms, in schools and factories). In addition since 1980, a higher priced "free market" has been established in which many ration items, sometimes of higher quality, are available. Table 2.20 shows a comparison of rationed and open market prices in Havana during February 1985.

This parallel or free market accounts for 10 percent of total retail sales (Gutierrez Muñoz, et al., 1984). Some food is also sold in farmers' markets (mercados campesinos) whose operation has been greatly liberalized since 1980. The State provides the infrastructure for these markets but prices are freely determined. Nevertheless, government food distribution through the various official channels seems to account for a very large share of total consumption. Estimates for 1982 suggest that 73 percent of rice and 83 percent of bean consumption come through public distribution.

Table 2.19 Per-Capita Monthly Ration Allowances: Selected Items for Adults (in kilograms)

Commodity	1965	1975	1985
Beans	0.82	0.82	0.91
Rice	3.45	3.72	4.55
Beef	-	0.54	0.68
Other Meats	-	1.36	1.36
Sugar	3.95	2.59	3.64
Coffee	0.27	0.23	0.17

Source: 1965 and 1975: Anuario Estadistico de Cuba, 1985: Data collected by Georgina Sanchez McEwan.

Table 2.20 Prices of Ration and Open Market Prices in Havana, February 1985 (in pesos)

Commodity	Ration	Open Market
Rice (lb)	0.28	2.5
Beans (lb)	0.30	1.68-3.00
Potatoes or Other Viandas (lb)	0.15	0.15
Sugar (lb)	0.25	1.50
Condensed Milk (can)	0.30	1.00
Coffee (6 oz)	0.24	3.00
Chicken (lb)	0.74	2.50

Source: Data collected by Georgina Sanchez McEwan.

2.5.3 State collection

The output of the state farms goes directly into the collection and distribution system (acopio) of the Ministry of Internal Commerce, while the cooperatives and private farms deliver predetermined quotas. The broad pattern of delivery is given in Table 2.21. Apart from beans, coffee and tobacco the state collects over 70 percent of total output of other products, much of it directly from state farms. In 1980 almost all the horticultural crops entered the state collection system although only 38 percent came from state farms, the rest came from the private sector. Two developments have changed this in recent years. The expansion of very large state farms means that a higher share of production comes from them; but with the evolution of farmers' markets, a somewhat smaller share of total output enters the state collection system. It is interesting to note that it is horticultural crops, coffee and tobacco where a large share of the output comes from the private sector. Together with beans these represent highly labor intensive crops less amenable to the large-scale mechanized production that characterizes rice, potatoes, milk and poultry production. Finally, in Table 2.22 a more detailed breakdown of the state collection is given for those crops of particular concern to the international centers, together with the two provinces having the largest contribution to the total collection of the respective crops.

2.5.4 Import dependency

It is of interest to note that the strongest growth in food consumption has depended on imported foodstuffs. The big increase in livestock products (except beef), higher bean consumption and greatly expanded wheat consumption all depend directly on imports.

The Cuban dependence on imported food has consequences for its non-farm sector. During the years 1979 and 1980 a severe austerity program reduced imports of capital goods and industrial

raw materials to save foreign currency for essential food imports. This is a common feature among developing countries dependent on imported goods to sustain a food subsidy scheme (Scobie, 1983).

The distortion in the terms of trade facing Cuban agriculture results in more sugar and less food crops being produced; this results in more imports (especially of rice and beans). At the same time the food rationing system lowers the price of staples and raises the consumption levels, further adding to import requirements. Finally the emphasis on livestock products and wheat consumption greatly increases food imports. Table 2.23 shows the major agricultural imports and exports for 1982. Imports of all major food groups are substantial. The dependency on imports is summarized in Table 2.24.

If this strategy of relying heavily on imported food is continued, the demand for new technology from the centers in maize, sorghum, cassava, beans and rice will be limited. However, increasing concern for the cost of food imports is likely to stimulate greater interest in domestic production for rice and beans. Potatoes have been designated a priority crop, and any effort to expand beef production will require relevant pasture technology for more marginal areas. Finally the non-sugar sector of agriculture will continue to be driven by the demand for livestock products and this will mean either very much higher feed imports or greater domestic output of cassava for use as a feedstuff, and for maize, soybeans and sorghum. Cassava also has possibilities for use as a wheat flour substitute to reduce in part the high dependence on wheat imports. In short all the crops of concern to the international centers have a crucial role in the food economy of Cuba, and their importance can only increase over time.

Table 2.21 State Collection (Acopio) of Major Crops: 1980

Product	Total Production (kt)	Total Production (kt)	Proportion of: Total Collection to Total Production (Percent)	Total Collection from State Production (Percent)
Cereals	573	368	72	92
Roots and Tubers	737	597	81	70
Beans	9	5	56	60
Horticultural Crops	446	443	99	38
Fruits	876	689	79	64
Coffee	23	11	48	53
Tobacco	8	5	63	45
Milk	889	725	82	98
Eggs (millions)	2,151	1,819	85	100

Source: Cuba, 1984.

Table 2.22 State Collection (Acopio) of Selected Foods and Major Collection Areas

Product	Total State Collection (kt)	Proportion from State Farms (Percent)	Major Provinces (Percent of Total Collection)
Potatoes	209	80	La Habana (55); Matanzas (16)
Sweet Potatoes	195	70	La Habana (11); Holguín (9)
Cassava (fresh)	87	49	Pinar del Rio (16); Holguín (15)
Rice	352	94	Granma (32); Pinar del Rio (24)
Maize			
Grain	2	17	Granma (20); Ciego de Avila (18)
Fresh	14	56	La Habana (19); Pinar del Rio (17)
Beans	4	70	Pinar del Rio (20); Ciego de Avila

Source: Cuba, 1981.

Table 2.23 Value of Selected Agricultural Imports and Exports: 1982

Category	Imports (US$ million)	Exports (US$ million)
FOOD		
Meat and Meat Products	119	-
Dairy Products	74	-
Cereals	470	-
Fruits and Vegetables	78	125
Sugar	-	4,484
Coffee, Tea and Cocoa	9	45
Feedstuffs	61	
Miscellaneous	53	
BEVERAGES and TOBACCO		
Beverages	7	31
Tobacco	5	122
FATS and OILS		
Animal Fats	15	-
Vegetable Oils	41	-
FISH and FISH PRODUCTS	47	115
INPUTS		
Fertilizer	135	-
Pesticides	23	-
Machinery	113	-

Source: FAO Trade Yearbook 1983, 1984.

Table 2.24 Import Dependency for Major Agricultural Products: 1983

Product	Domestic Production (kt)	Imports (kt)	Import Dependency[a] (Percent)
Maize	96	402	81
Rice (milled)	353	207	37
Milk Products[b]	889	1,090	55
Beans	27	107	80
Wheat and Flour	0	144	100
Poultry Meat	90	21	23
Canned Meat[c]	227	44	19

Notes: [a] Imports as a share of domestic production plus imports.

[b] In milk equivalents.

[c] Total production of beef, veal and pork.

Source: FAO Production and Trade Yearbooks 1983, 1984.

3 The National Agricultural Research System

3.1 Overall Framework

The Cuban Academy of Sciences, established in 1861 was restructured in 1962 and plays the major role in the planning and coordination of all scientific research. The Academy has a total staff of 5,000 including 1,000 professionals. In 1983, its budget was about 100 million pesos, one-third devoted to agriculture. There are 117 research institutions which fall under the responsibility of 21 ministries or central agencies. Of these the principal groups are:

(1) 22 Institutes in the Academy of Sciences which work in five major areas: biology and chemistry; physical sciences and engineering; earth sciences; agricultural sciences; and social sciences.

(2) 23 Institutes under the Ministry of Higher Education (MES) including the National Centre for Scientific Research with 1,000 research staff including 300 "candidatos" (PhD-equivalents) and an annual budget of 7 million pesos which covers biomedical, bioengineering, chemistry, metallurgy and electronic research. ("Candidato a Doctor en Ciencias" is the degree offered in many socialist countries that resembles the PhD level. The degree of "Doctor en Ciencias" is attained later in life as professional recognition. It is probably equivalent to a "fellow" in western professional societies.); and the Higher Institute for Agricultural Sciences of Havana (ISCAH), formerly the Faculty of Agriculture of the University of Havana;

(3) 17 Institutes under the Ministry of Agriculture (MINAG); and

(4) 15 Institutes in Public Health, 57 in Industry and 24 in Construction.

In 1977, the total Cuban scientific research establishment consisted of 4,959 scientists and engineers, 6,075 technical

staff and 8,625 support staff, with an annual budget of 74 million pesos (Unesco, 1979). The number of scientists and engineers has increased rapidly (Casas, 1984). Projections suggest a doubling of scientists and engineers from 1980 to 1990 with the share devoted to agriculture to increase from 17 to 23 percent (Table 2.24).

3.2 Agricultural Research Institutions

Before 1959 there were three relatively small agricultural experiment stations for sugarcane, two for tobacco and one for general crops at Santiago de las Vegas. Since that time a major effort has been made to expand agricultural research. The institutions involved in agricultural research are the Ministry of Agriculture (MINAG), the Ministry of Higher Education (MES), the Ministry of Sugar Industry (MINAZ) and the Cuban Academy of Sciences (ACC).

3.2.1 The Ministry of Higher Education

MES has responsibility for universities, teaching institutions and research centers. Those most closely linked with the agricultural sector are:

Centro Universitario de Pinar del Rio "Hermanos Saiz" - Research areas: tobacco, forestry, horticulture, rice, plantain

Centro Universitario de Matanzas - Research areas: sugarcane, beans, tomatoes, potatoes

Universidad Central de Las Villas - Research areas: soybeans, potatoes, tomatoes, rice, beans, and sugarcane; animal diseases

Universidad de Camagüey - Research areas: animal science

Instituto Superior Agrícola de Ciego de Avila - Research areas: livestock, mechanization and irrigation

Instituto Superior de Ciencas Agropecuarias de la Habana (ISCAH) - Research centers: Centro Nacional de Sanidad Agropecuaria (CENSA); Centro de Mecanizacion Agropecuaria

(CEMA); Instituto de Ciencia Agricola (INCA); Instituto de Ciencia Animal (ICA): animal genetics, milk chemistry, pasture research, rhizobiology

Estación Experimental de Pastos y Forrages "Indio Hatuey" in Perico, Matanzas

Estación de Fertilización de Pastos, Barajagua, Cienfuegos: pasture fertilization research

Estación Experimental Los Palacios, Pinar del Rio: rice research

Many of these are closely linked to production research, and work closely together with the MINAG institutes.

3.2.2 Ministry of Agriculture

Agricultural research in MINAG is organized into 17 central institutes and coordinated by its Directorate for Science and Technology. Each institute has a separate headquarters (usually the "flagship" experiment station for that crop or input), and there are in total 69 experiment stations, substations and laboratories covering the entire country.

The 17 institutes can be grouped into commodity centers (either crops or livestock) and support (or input) centers. It is the first four of these institutes that have developed collaborative linkages with the international centers.

Commodity Research Institutes

1. Research Institute for Tropical Starchy Crops (Viandas), Santo Domingo, Villa Clara Prov. Lead responsibility for plantain, banana, sweet potato, cassava, malanga, and yams. Formerly known as the Crop Breeding Center for Vegetatively Reproduced Tropical Starchy Staples (CEMSA).
2. Rice Research Institute, Bauta, Habana Prov.
3. Research Institute for Horticulture, Grains, Potatoes and Fibers "Liliana Dimitrova", Quivicán, Habana Prov. Responsible for horticulture: tomato, pepper, cabbage,

garlic, green beans, carrots; grains: beans, sorghum, soybeans, maize (El Tomeguín Station); potatoes: (La Katuca Station); and fibers: kenaf and sisal.

4. Research Institute for Pastures and Forage Crops "Niña Bonita", Cangrejeros, Bauta, Habana, Prov.
5. Research Institute for Citrus and Other Fruits
6. National Tobacco Research Network
7. Forestry Research Center
8. Research Network for Coffee and Cocoa
9. Research Institute for Beekeeping
10. Animal Improvement Research Center
11. Pork Research Institute
12. Poultry Research Institute

Support Research Institutes

13. Research Institute for Irrigation and Drainage
14. Research Institute for Crop Protection
15. Institute for Agrochemical Research
16. Research and Development Institute for Mechanization and Electrification of Agricultural Production
17. Agricultural Economic Studies Unit

3.2.3 Ministry of the Sugar Industry (MINAZ)

In 1963, the Institute for Sugar Cane Research (IICA) was created by the Academy of Sciences. More recently within the Ministry, there were created the Cuban Institute for Research on Sugar Cane (ICINAZ) and the Cuban Institute for Research on Sugarcane Derivatives (ICIDCA). In 1981, the Center for Integrated Development on Sugarcane (CEDIC) was created at Pablo Noriega near Havana with research facilities for three institutes. In 1982, ICINAZ took over the leadership role from IICA for coordinating sugar research.

3.2.4 The Academy of Sciences

As well as its overall role in the planning and coordination of research, the Academy has a Division of Agricultural Sciences. The two participating institutes with direct relation to the

crops of interest are: the Institute for Agricultural Research "Jorge Dimitrov" in Oriente, and the Institute for Fundamental Research in Tropical Agriculture "Alejandro von Humboldt" (INIFAT) at Santiago de las Vegas, Habana, where the experiment station used to be. It is understood that the primary role of the Academy is to undertake basic research. While it is connected to other agencies where applied research takes place, it has no direct collaborative links with the international centers. While this may be an avenue which the centers may wish to explore in the future (say to initiate research on a very specific problem of a basic nature in some particular crop) it seems that the appropriate links with the centers should continue to be through the MINAG institutes oriented to crop and livestock production.

3.2.5 Planning and coordination

The research strategy is developed as an integral part of the national five-year plan approved for each quinquennium. This planning is an iterative process between MINAG, other institutions and the Central Planning Board (JUCEPLAN). The plans for 1986-90 are currently being developed. Clear priorities are established, and crops are designated as having first or second priority. First priority crops are assigned the "Problema Principal Estatal" (PPE) status. Second priorities are "Problemas Ramales" (PR) i.e. problems specific to the agricultural sector, not to the nation. The research plan for a commodity is then structured at three levels: first, either as Principal State Problems (PPE) or Sector Problem (PR); second, within these there are themes or branches; and finally a series of tasks (roughly equivalent to experiments) are planned for each theme. Year to year modifications are made in a revision of annual plans. Throughout, considerable attention is given to the fulfillment of the plan, and the ratio of completed to planned tasks is used to measure performance. Overfulfillment of planned tasks seems to be the rule rather than the exception.

3.3 Research Resources

3.3.1 Personnel

MINAG currently has 1,053 professional research scientists. These include 100 veterinarians and 25 economists. There is a well-established professional ranking for all research staff.

Level	Number	Title	Description
I	104	Investigador Titular	This is the highest category and requires the academic rank of "Candidato a Doctor en Ciencias" (equivalent to a PhD degree), and extensive publications
II	160	Investigador Auxilar	Senior researchers, many of whom will be preparing research for Candidato theses
III	211	Investigador Agregado	Must have at least 2 years research experience and language proficiency (in English, Russian or German)
IV	510	Investigador Aspirante	Entering level with a university degree in Agricultural Science; a grade of at least 80 percent (B) in university studies is needed to enter this category
V	68	Not categorized	

Of the total number in the Investigador Titular class, 60 percent have been foreign trained. In the next quinquennium it is expected that 90 percent will be trained in Cuba and only 10 percent trained overseas in specialized fields not offered in Cuba. In 1984, a total of 199 MINAG research staff were undertaking further studies.

Because of the rapid growth in total Cuban scientific staff (Table 3.1) there are many young scientists. Overall, the average number of years of research experience is about five. Individual performance evaluations are conducted every two years, but the financial rewards from promotion are limited by the relatively small steps in the salary scale. The beginning level (Class IV) research salaries are 305 pesos per month (farm workers receive 180 pesos per month) plus a premium of 75 pesos per month for administrative responsibilities. However, the prestige of a scientific career, technical missions and study opportunities in foreign countries, and personal use of official cars for senior scientists add to the real rewards (Casas, 1984).

Estimates of the number of scientists in agricultural research in MINAG are given in Table 3.2, which also shows a breakdown for the main commodity groups of concern to the CGIAR. The total staff of the research institutes of MINAG has been estimated as 6,630 and this figure was used as the basis for estimating the total research budget of MINAG.

Table 3.1 Table and Projected Staff/Research Scientists and Engineers in Cuba

Year	Persons	Percent in Agricultural Research
1970	1,500	15
1975	5,800	16
1980	11,400	17
1985*	17,060	20
1990*	23,480	23

Note: * Projected

Source: Casas, 1984.

Table 3.2 Staffing of MINAG Research Institutes: 1984

Research Institute	Professional Research Staff[a]						Technical Staff	Administration Support Staff Farm Workers	Total
	I	II	III	IV	Other	Total			
Viandas	1	3	5	16	12	37	28	214	279
Rice	2	8	10	16	12	38	75	116	230
Horticulture, Grains, Potatoes and Fibers	3	6	na	na	na	47	58	141	246
Pastures and Forages	2	15	na	na	na	48	73	201[b]	322[b]
13 Other Institutes	na	na	na	na	na	882	1,207[b]	3,464[b]	5,533[b]
Total	104	160	211	510	68	1,053	1,441	4,136	6,630[b]

Notes: [a] I: Investigador Titular (PhD-equivalent); II: Investigador Auxiliar, III: Investigador Agregado, IV: Investigador Aspirante.

[b] These numbers are estimated by assuming the ratio of technical or support staff to professional staff are the same in those institutes as in the first four listed for which data were available.

Source: Data provided by MINAG staff members and MINAG, 1984.

3.3.2 Research expenditures

The Rice Research Institute provided an estimate of an average annual cost of about 4,500 Cuban pesos per staff member regardless of the rank. This includes salaries, operating expenses and some capital improvement costs. Assuming the costs are similar for all other research centers then the total research budget would have been $30 million pesos in 1984. To this must be added an allowance for the central administration costs in the MINAG. If these were 5 percent of the total costs then the estimated research budget would be 31.3 million pesos. In fact a totally independent estimate of 27 million pesos is given by Casas (1984).

The size of a country's research budget is often expressed as a percentage of the value of its agricultural output. In 1983, the GSP of the agricultural sector was 3,444 million pesos (Cuba, 1984). If it is assumed that sugar represents about one-half of the GSP (as it does of Total Material Production) then the GSP of non-sugar agriculture would be 1,722 million pesos. This gives an estimate of the research expenditures as a share of value of output of 1.8 percent.

The 1980 figures for other Latin American countries were:

	Percent
Dominican Republic	0.2
Costa Rica	0.2
Jamaica	0.2
Guatemala	0.4
Brazil	1.2
Venezuela	1.3
Mexico	1.4
Argentina	1.6

While there has been some growth in other countries since 1980 it would appear that Cuba's investment in agricultural research is at a level comparable with the top group of Latin

American countries. It must be stressed that this is based solely on the research expenditures of the Ministry of Agriculture. The comparable figure for industrialized countries is about 1.5 percent.

No published figures of the total number of Cuban scientist-years in agricultural research are available. The best estimates are given in Table 3.3. If the same ratio of technical and support staff to scientific staff used in Table 3.1 is applied, then the total research staff would be 13,795. Applying the annual average cost of 4,500 pesos per staff member provides an estimate of the national agricultural research budget of 62 million pesos or 1.6 percent of GSP in agriculture. This may overstate the true percentage, as some of the research is directed at the food processing sector (in particular in the sugar sector) and, as noted, the value added in these sectors is counted under industry, not agriculture.

In any event it appears that a range of between 1.5 and 2.0 percent represents the probable order of magnitude of the Cuban agricultural research effort. It is certainly indicative of a serious policy of investing in agricultural research. The level compares more than favorably with other countries at similar stages of development and with more advanced ones as well. In addition, the effective research capacity is likely to grow substantially in the future. Even if the total number of staff were not to expand (a fact quite contrary to the stated plans) the productivity of the existing researchers, who currently average five years of experience, will increase with time.

Another factor contributing to the long run productivity of the Cuban agricultural system is the low rate of turnover. While no data are available, casual observation suggests that turnover rates are vastly below those in most other Latin American countries.

Table 3.3 Estimated Number of Scientific Staff in Cuban Agricultural Research System

Agency	Institute	Number of Scientific Staff
Ministry of Agriculture	17 Institutes	1,053
Ministry of Higher Education	CENSA	158
	ICA	120
	INCA	80
	Estacion Indio Hatuey	35
Academy of Sciences	INIFAT	100
	Other Institutes	230[a]
Ministry of the Sugar Industry	ICINAZ	75
	ICIDIA	140
	CEDIC	200
Total		2,191

Note: a Estimated on the basis that one-third of the total scientific staff of 1,000 in the Academy are in institutes related to agricultural science.

Source: Data provided by Ministry of Agriculture and Casas, 1984.

4 Collaboration Between the Cuban Agricultural Research System and the International Centers

Cuba has ongoing collaborative programs with IRRI on rice; with CIAT on rice, beans, cassava and tropical pastures; with CIP on potatoes; and with CIMMYT on maize and sorghum. The latter is the ICRISAT outreach program for Latin America. Contacts have been made with IITA for work on yams and plantains. Work with IRRI started in 1967; with CIAT in 1977, with CIP in 1981; and with CIMMYT in 1982. Formal agreements have been signed with each center and include either annual plans of work, or in the case of IRRI, three-year plans. An agreement is presently being negotiated with IITA.

MINAG officials consider the collaboration with the CGIAR system highly valuable and one that has produced tangible results in increasing food production, training their staff, providing valuable germplasm, improved methodologies and documentation. The CGIAR system is viewed as the main source of tropical agricultural technology in contrast with the collaboration from socialist countries which focus on basic research, equipment procurement, and postgraduate degree training.

4.1 General Constraints

A critical factor affecting the positive impact of the CGIAR system is the seriousness with which MINAG views this collaboration. Also the centrally planned system makes the research-extension-producer pipeline very direct. When a CGIAR-related technology is officially approved, it is actually against the law not to comply with it, and its adoption can be virtually instantaneous and universal.

MINAG officials identified several constraints to cooperation with the CGIAR centers: their own financial limitations, travel restrictions and communication difficulties. During the

last five years, budget constraints have become a reality in Cuban research institutions. Prior to that, cost was seldom an issue and many research programs were carried out without a formal budget. Partly because of the drop in world sugar prices, austerity programs have been implemented, and actual budget cutbacks have taken place. This is particularly critical when deciding to send trainees to faraway centers such as IRRI and IITA. Continuing the practice of covering the local expenses of CIAT scientists while in Cuba is now in question.

Travel to CIAT was severely affected when diplomatic relations were suspended between Cuba and Colombia. CIAT has set up some mechanisms to overcome these restrictions and minimize delays in Panama. Collaboration with CIP and CIMMYT is unaffected because of diplomatic relations with Peru and Mexico, and direct flights to both countries. Communications by mail, telephone and telex are difficult and slow, posing major operational constraints to collaboration with any international center.

In addition, the centrally planned system based on five-year plans poses a constraint to major initiatives during a running plan. Adherence to five-year plan goals is very strict and only factors beyond control, such as adverse weather or international price fluctuations, are acceptable excuses for non-compliance with the goals. On the other hand, when CGIAR-related research and training are incorporated into the five-year plan, compliance is virtually guaranteed.

The following sections describe the CGIAR-MINAG collaboration by commodities. Much of the information was gathered during the authors' visits to the MINAG research institutes as well as written reports supplied during those visits. Of special value were the Institute reports in "Reunion de Balance de las Investigaciones Agropecuarias" (MINAG, 1984), and a background document prepared by MINAG officials specifically for this review.

4.2 Rice

The first contact between the CGIAR system and Cuba was with IRRI in 1967. At that time, Cuba planted considerably more rice than currently; 180,000 ha with an average yield of 2.2 t/ha. The cropping system was direct seeded and irrigated using tall-statured U.S. varieties with high grain quality, but susceptible to the hoja blanca disease. There are two rice plantings a year: the winter planting ("siembra de frio"), from December to February, with 25 percent of the area, and the spring planting, ("siembra de primavera"), from March to August. Virtually all irrigated rice is produced by eight large state farms. Small areas of upland rice are planted by individual farmers, but these are not included in production and area statistics. The area planted to rice at present is estimated to be 140,000 hectares. The decrease in area has been due to the need to incorporate additional land into sugarcane production.

4.2.1 Germplasm

Since 1967, a total of 15,207 rice varieties and lines from IRRI and CIAT have been introduced and tested in Cuba. Of these, 1,726 are in MINAG's germplasm bank and 9 have been released as commercial varieties. The released varieties presently in use cover 100 percent of Cuba's rice area.

The initial release was IR8, in spite of its poor grain quality and susceptibility to *Sogatodes oryzicola*. Subsequent releases were IR 490-9-33 and IR 800-C9. A few years later, CICA-4 was released, combining short stature, high yields with good grain quality and tolerance to *Sogatodes oryzicola*. This virtually eliminated sogata and hoja blanca as limiting factors.

Not all the CGIAR rice germplasm came directly from IRRI or CIAT. Collaboration with the National Rice Program of Peru produced the release of the Naylamp variety in 1972. Naylamp is a close relative of CICA-4 and it doubled rice yields in the

Coast of Peru. Another Peruvian-related release is J-112 (known in Peru as PNA-112) which is more tolerant to salinity than other short-statured commercial varieties. Another salt-tolerant line, Caribe, a selection from the Thai variety H5, was subsequently released as well as the IRRI line, IR 1529-430-3-2-1.

In 1980, a significant yield breakthrough was obtained with the release of J-104, selected from a Peruvian segregating line whose yield averages 1 t/ha more than other varieties. In 1982, a cross of IR 1529-430-3-2-1 and a USSR line (Binir 5223) produced "Amistad 82," named as an example of international collaboration. Its main attribute is early maturity (107 days for the spring planting and 120 days for the winter planting). Amistad 82 is at the extension (pre-release) stage with about 1,000 ha planted and yields of 6.5 t/ha. Its shorter duration permits considerable savings in both irrigation water and nitrogen fertilizer. Furthermore, it will permit double cropping of rice. Presently rice is rotated with beans or pastures or used as a catch crop between sugarcane replantings.

The Cuban Rice Institute continues to receive many of the IRRI and CIAT network trials. Collaboration with two centers is considered complementary rather than competitive. IRRI is viewed as the preferred source, especially in relation to salinity tolerance and grain quality, while CIAT materials are more relevant for disease and insect tolerance.

Continuity of this germplasm pipeline is considered vital. Cuban rice scientists would prefer receiving segregating population at the F3 level rather than only advanced lines both from IRRI and CIAT. Advanced breeding lines previously screened for attributes not necessarily important to Cuban conditions, limit the possibility of selecting for specific traits of local importance. Cuban rice researchers would also like the opportunity to select segregating materials during visits to both

centers. Presently 80 percent of their breeding lines are from local crosses and the rest from the CGIAR pipeline.

4.2.2 Technology and methodology

Through visits of CGIAR scientists, as well as through the training of Cuban rice scientists at IRRI and CIAT, the following technologies or methodologies have been incorporated into the rice research system:

- o Varietal screening for tolerance to *Pyricularia*, salinity, *Sogatodes* and hoja blanca.
- o Water leveling, after Dr. Jennings identified it as a major constraint. Presently about 18 percent of the rice area is considered correctly water-leveled and a larger proportion leveled to an acceptable degree.
- o Cut irrigation water at 50 percent flowering. This concept originated during a visit to an IRRI water management experiment. Although it is not a universal recommendation, it reportedly works well on many Cuban rice soils and has reduced water use. This has prompted research on cutting irrigation earlier and in some areas no yield losses have been reported when the last application is given at the initiation of flowering. This technology is presently at the extension (pre-release) phase.
- o Identification and correction of zinc deficiency. Collaboration with Dr. Yoshida resulted in the awareness of this problem, as many of Cuba's rice soils are calcareous. Critical levels have been established and zinc is routinely applied to about 50 percent of the rice growing area.
- o Fertilizer management studies have decreased phosphorus application levels. Phosphorus is now recommended to be applied to every other rice crop.

4.2.3 Research organization

Training at IRRI and CIAT made Cuban rice specialists more

aware of the needs for a multidisciplinary approach, instead of the traditional "breeding plus pathology" approach. Their initial research impact produced enough credibility to increase the staff of the rice institute from 3 scientists in 1969 to 38 at present. The program is now organized as the Rice Research Institute with four experiment stations. The present research organization is well geared for collaboration with the CGIAR system.

The rice institute has a long history of technical publications which appear mostly in the journal "Ciencia y Tecnica," published since 1978 and a more applied "Boletin de Reseñas Arroz" since 1980.

4.2.4 Training and information

Training has been a major contribution of IRRI and CIAT. A total of 15 Cuban rice researchers have received trainig at IRRI since 1972. In addition, nine others have received training at CIAT since 1978. The disciplines included breeding, agronomy, grain quality, soil chemistry, plant physiology, plant pathology, entomology, and biometrics at IRRI, plus breeding, agronomy and production at CIAT. The levels of training included rice production courses, specialized training and visiting scientists. All specialists trained at IRRI and CIAT are presently working in the rice program.

IRRI and CIAT rice documentation is received regularly, and although late, it is much appreciated. They are, however, unaware of recent IRRI books, and have expressed concern that Cubans are seldom invited to IRRI workshops; for example, the one on wetland soils in 1984. Their interest in rice clearly extends beyond the receipt of germplasm and they feel often left out of important conferences.

4.2.5 Relationships

The combination of IRRI and CIAT is highly complementary to

the Cuban national rice program. Although virtually all the rice is produced in high-input state farms, the products of small farm-oriented research from CGIAR centers have been successfully applied. It is relevant to note that CIAT's regional rice program does not provide the depth and breadth required by Cuba.

4.2.6 Main concerns

The present new concerns of Cuban rice researchers focus on 1) the management of saline rice soils; 2) improving fertilizer nitrogen recovery; 3) providing stimuli for higher rice yields in the empresas; and 4) improving irrigation water management. The CGIAR system and associated centers can collaborate with the first two issues by providing more germplasm with salinity tolerance from IRRI and CIAT; irrigation management techniques from IIMI; soil management in wetlands through IBSRAM; and nitrogenous fertilizer manufacturing technology from IFDC. Participation in IRRI's INSFFER network for fertilizer efficiency is desired. They are interested in sulfur-coated urea and urea supergranule manufacturing and in the INSFFER nitrogen placement technology.

4.3 Beans

Collaboration with CIAT's Bean Program started in 1977 and was formalized with a "convenio" in 1979. At that time, Cuba was importing about 90 percent of its total black bean requirements, and beans did not receive high priority in MINAG's plans. Germplasm and training have drastically changed the picture within a few years. Activities are centered at El Tomeguín Grain Experiment Station in Alquízar, which operates as the national headquarters for bean, corn, soybean and sorghum research.

4.3.1 Germplasm

A total of 2,135 CIAT bean accessions have been evaluated at El Tomeguín since 1977. The seven-year trend,

shown, in Figure 1, illustrates a sharp increase during the last three years. Initial work consisted mainly of yield trials, IBYAN's of different seed coat color, followed by advanced lines and screening for *Empoasca*, golden mosaic virus and bacterial resistance. A most important development took place in 1984 when F2 populations of 20 backcrosses for bacteriosis were selected at CIAT by Ing. Benito Faure, a Cuban bean breeder and Dr. Stephen Temple, CIAT bean breeder. During the authors' visit, two CIAT scientists and five Cuban counterparts were examining each line and making on-the-spot evaluations and decisions.

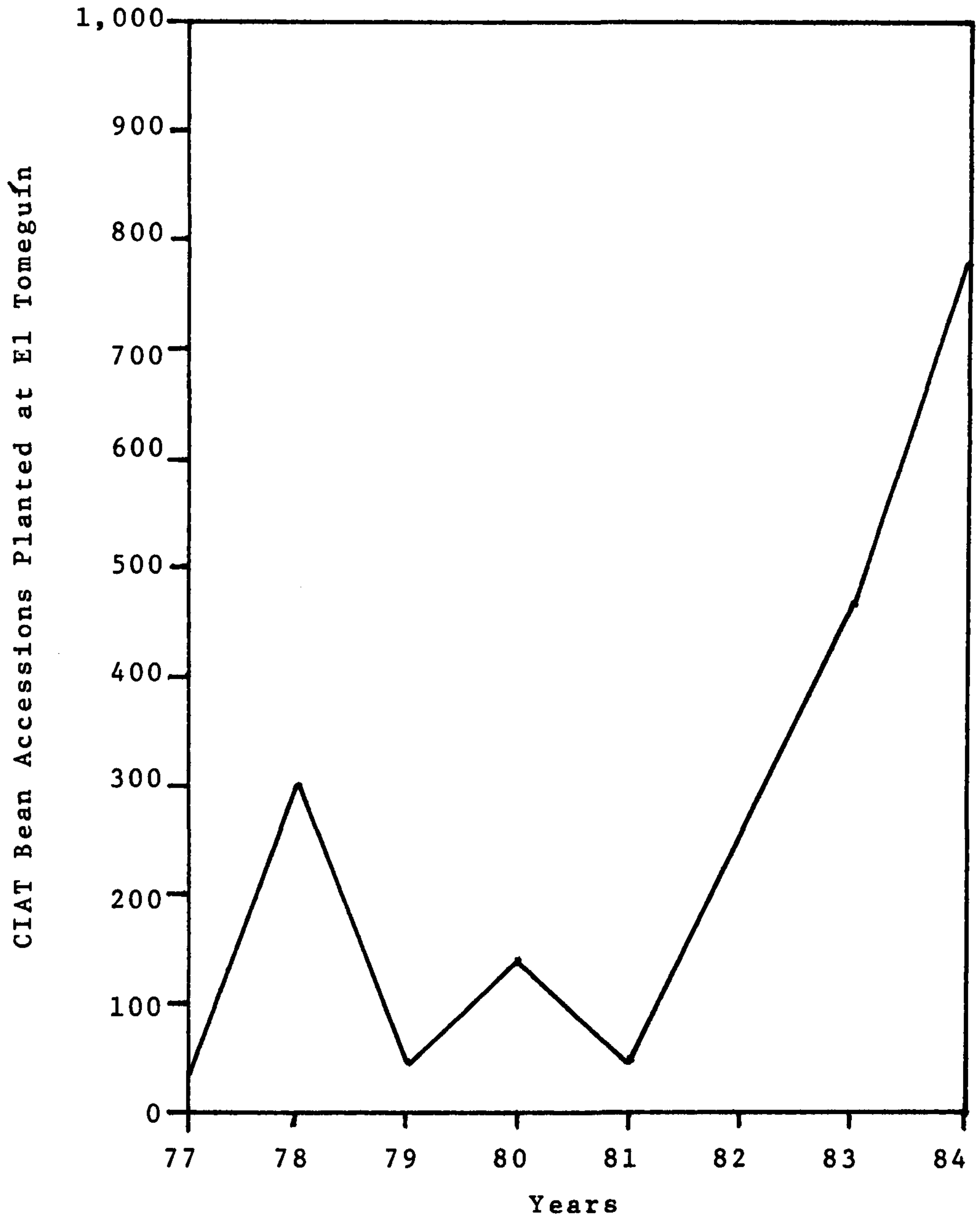
A total of seven black bean varieties have been released out of this cooperative program. The first one was ICA-Pijao in 1979 which had a similar impact to IR 8 in rice. After field testing during 1977 and 1978, CIAT assisted Cuba in acquiring one ton of ICA-Pijao seed produced on Colombian farms. About 90 percent of Cuba's bean area in new varieties is planted to CIAT-type germplasm. The main thrust is to replace ICA-Pijao with bacterial resistant varieties, overcoming this main defect of ICA-Pijao. ICA Pijao still covers 80 percent of the country's bean area. A total of six additional varieties have been released, among them ICA-Quetzal, BAT-304, Hatuey 23 (red coated), and Tomeguín 1. BAT-304 is early maturing and designed to fit in a rotation with rice.

Segregating materials in the present germplasm pipeline, selected specifically for Cuban conditions by joint CIAT-Cuban teams, are evaluated at two locations (El Tomeguín, Habana Province and at Velazco, in Holguín Province).

4.3.2 Technology and methodology

Bean breeding research in Cuba follows almost totally CIAT research technologies and methodologies. No major farm-level agronomic technologies have been introduced from CIAT. This is partly due to the high input system characteristic of Cuba.

Figure 1 CIAT Bean Germplasm Pipeline to Cuba



Source: El Tomeguin Experiment Station, unpublished data.

4.3.3 Research organization

The Cuban Bean Program is also organized as a multidisciplinary team and with research concentration in two major ecological regions. The team consists of 15 scientists: 2 breeders, 1 bacteriologist, 1 mycologist, 1 virologist, plus 10 part-time specialists on seed production and biometrics. Most of the work was traditionally concentrated at El Tomeguín, representative of the highly fertile, irrigated Matanzas soils with the least agronomic constraints. In 1983, a new project was established at Velazco, Holguin, in the eastern region of the country involving 3,000 ha of irrigated beans produced by individual farmers. CIAT germplasm introductions now go through the quarantine period at both locations, thus saving time.

4.3.4 Training and information

A total of 17 Cuban bean scientists have received training at CIAT since 1978 in agronomy, seed production, breeding, entomology, and virology. This includes both researchers as well as extension workers and producers from the Provinces of Matanzas, Guantánamo, and Ciego de Avila. All but one of these 17 trainees work in the Cuban Bean Program.

A noteworthy feature of training at CIAT is the development of a PhD equivalent thesis research at CIAT by Ing. Benito Faure conducted under the supervision of Dr. Steve Temple of CIAT and an advisor from the University of Havana. Field work was conducted at both CIAT and El Tomeguín. The "Candidato a Doctor en Ciencias" degree will be awarded by the University of Havana.

In addition, five bean courses have been conducted in Cuba on a yearly basis since 1980 in cooperation with CIAT scientists. A sixth course was conducted at Velazco without direct CIAT participation. A total of 151 persons have received training at such courses. Participation of CIAT scientists during the course is considered highly valuable. The following CIAT scientists have contributed: Drs. Guillermo Galvez (all), Carlos Flor

(all), Aart van Schoonhoven (II), Steven Temple (I), Silvio Hugo Orozco (IV), Oswaldo Voysest (III) and César Cordova (III).

The flow of information and documentation from CIAT is considered by all highly satisfactory; the national directors made special mention of this facet of the collaboration with the centers.

4.3.5 Relationships

The CIAT-MINAG relationships on beans are considered by both sides as highly complementary, with total coincidence of needs and priorities. No specific concerns were voiced. Praise for the excellent work of Dr. Galvez was widely mentioned. In addition to program continuity which is viewed as essential, the main thrusts for the future are tolerance to bacteriosis and mechanized harvesting.

4.4 Cassava and Tropical Starchy Crops

Collaboration with CIAT's Cassava Program is centered at the Instituto de Investigacion de Viandas Tropicales, most commonly known by its old name CEMSA (Centro Experimental de Mejoramiento de Semillas Agámicas). "Viandas" is a generic term used in Cuba to encompass starchy foods like cassava, plantains, malanga isleña (Colocasia esculenta - taro, coco yam), malanga morada (Xanthosoma mafaffa - tanier, yautia), sweet potatoes, yams (Dioscorea sp.) and the potato. All but the potato are considered tropical and thus fall in the domain of CEMSA. Located at Santo Domingo, in Villa Clara Province, it is the only national program related to CGIAR crops that is headquartered further away than commuting distance from the city of Havana.

CEMSA was established in 1967 as a producer of vegetatively propagated materials of these crops. Research started as a sideline, mainly collecting native clones. After having a significant impact on sweet potato production with the

propagation of the "Haiti" variety, CEMSA attained national attention and program status in 1970. Its professional staff increased from 3 in 1970 to 10 in 1975, and to 38 in 1985. In 1975, research priorities were established with groups on germplasm collection, breeding and cultural practices. Released clones of malanga isleña resulted in a national yield increase from 5 to 30 t/ha between 1976 and 1980. During this period, CEMSA became a genuine research institution.

Collaboration with CIAT started in 1977 with cassava germplasm introduction, technology and training. Attempts at collaboration with IITA started in 1982. A formal agreement was signed with CIAT in 1979, but none has been signed with IITA so far.

4.4.1 Germplasm

Approximately 426 cassava clones and 13,784 segregating seed materials have been provided by CIAT to Cuba since 1977. Twenty of the clones have been included in the Cuban germplasm bank which serve as parents for crosses done at CEMSA. The hybrid seed introductions from CIAT number between 1,500 and 2,000 annually.

One clone, CMC-40, known in CIAT as M Col 1468, was released in 1983. In addition to desirable yield and quality, CMC-40's early maturity decreased the growth period from the normal 11-12 months to 8 months, allowing rotation with other crops and permitting the planting of cassava at different times of the year in order to assure a steady supply to the markets. CMC-40 is presently grown on 2,000 ha (or 6 percent of the national area planted) following its release less than two years ago. A second cassava clone CEMSA 74-725 was released in 1985. Three additional ones are at the extension (pre-release) phase in 1985: "Jagüey Dulce" for the saline soils of Guantánamo; CEMSA 4-28 and CEMSA 80-99. The latter two are locally bred hybrids.

Some sweet potato germplasm was received from IITA and planted. No follow-up by IITA scientists has occurred, in spite of Cuban requests. Communication difficulties are very serious. CEMSA has also requested plantain and malanga germplasm from IITA without success.

4.4.2 Technology and methodology

The main impact of CIAT's Cassava Program on Cuban agriculture has been the widespread adoption of a group of rapid propagation and agronomic practices collectively known as the "Sistema Colombiano".

- Major fungal and bacterial diseases have been identified and methods for their control have been established.
- Rapid propagation and tissue culture techniques have been successful in eliminating bacteriosis from commercial germplasm.
- Planting in ridges, the use of lignified stakes only, their placement at 180°, better fertilization and weed control, together with high-yielding clones have increased national average yields of fresh cassava from 5 t/ha in 1978 to 16 t/ha in 1984 on 60 percent of the area. Coupled with an increase in area planted from 20,000 to 34,000 ha over the same period, national production almost quadrupled from 100 kt in 1978 to 394 kt in 1984. These estimates were provided by Ing. Adolfo Rodríguez, the national root crop research director.
- The rapid propagation process has increased the multiplication rate of stakes 50-fold, guaranteeing plants free of seed-transmitted pests and diseases and 100 percent clonal purity.
- The nutrient requirements of cassava, particularly in neutral and calcareous soils are being identified. The use of Cate-Nelson critical levels has decreased fertilizer rate recommendations which were often excessive.
- The rapid cassava propagation method has been adapted to plantains and malangas, with success. National *Colocasia*

malanga yields increased from 5 to 30 t/ha between 1976 and 1980, partly due to adopting some features of the "Sistema Colombiano" to this crop.

4.4.3 Research organization

The concept of an integrated national commodity program was developed from contacts with CIAT. A multidisciplinary team evolved from a breeding-seed production program. The present CEMSA professional staff consists of 6 breeders, 6 soil fertility-plant nutritionists, 10 plant protectionists, 8 agronomists, 4 seed production specialists, an economist, an irrigation specialist, and a librarian. Researcher time assigned to the various crops reflects the national priorities within tropical starchy foods. In full-time equivalents they are: plantain and bananas, 18; cassava, 9; sweet potato, 4.5; malanga and yams, 6.5.

Research substations are organized along agroecological zones. The headquarters at Santo Domingo is located on fertile Mollisols of the Santa Clara series where 30 percent of the cassava is grown. A nearby substation at Cascajal concentrates on plantains. Other substations in Ciego de Avila, Camagüey and Guantánamo focus on Oxisols, "brown" soils and saline soils, respectively. Applied research work is conducted in all provinces via 26 model cooperatives. A training program was also developed. In essence, CEMSA has applied the concept of multidisciplinary and multilocation crop research programs to a group of related crops.

Outside of MINAG, CEMSA collaborates with the Universidad Central de Villa Clara and the Instituto Jorge Dimitrov in Oriente. International collaboration outside the CGIAR system is limited to posting of CEMSA advisers in Angola and Mozambique.

4.4.4 Training and information

The cassava information service has substantially

strengthened CEMSA's library which now includes 11,000 entries in cassava alone. Training has taken place both at CIAT and in-country. Twelve staff members, 9 from CEMSA and 3 producers have received training at CIAT on cassava production, agronomy, soils, plant pathology, plant breeding, rapid multiplication, tissue culture, entomology, nutrition and genetic resources. Only the five most recently appointed CEMSA staff members have not received training at CIAT but plans are that all will. One person participated in the root crops production course at IITA.

Two postgraduate CEMSA courses were held in 1983 and 1984 in collaboration with CIAT. A total of 78 producers with an "ingeniero" degree working on state farms and cooperatives participated. They, in turn, replicated the course at the provincial level and subsequently reached about 400 persons. The CIAT-CEMSA technology is thus widely used. CEMSA staff is especially appreciative of the high quality of CIAT audiotutorial materials and its cassava production course book.

One CEMSA soil scientist, Ing. Juan Portieles, is conducting research for his PhD-equivalent degree at CIAT under the direction of Dr. Reinhardt Howeler, with part of the field work conducted at CEMSA. His studies are showing the micronutrient requirements of cassava in the calcareous Santa Clara clay soils, and that continuous cassava cultivation is possible in these rich soils without the need of rotation with other crops.

4.4.5 Relationships

CEMSA staff views its relationship with CIAT as excellent and with IITA as disappointing. Continuity of CIAT collaboration is deemed essential, not only in the interchange of germplasm, technologies and training but also in more specific issues. These include strengthening entomology, soil fertility and cassava utilization research. The development of new laboratories for soil and plant analysis is viewed by CEMSA as

requiring CIAT's help in installing the Hunter-type semi-automated technology.

Cassava utilization is becoming a major concern. Production surpluses are beginning to appear, and cassava flour is being introduced in the baking of cookies and in pasta for pizza, substituting in both cases up to 10 to 15 percent of wheat flour. Cassava is a potential import substitute for animal feed and is viewed as a major thrust for the following quinquennium. CIAT should be in a good position to provide the necessary collaboration.

CEMSA is very interested in establishing strong ties with IITA on malanga and plantains, but not on *Dioscorea* yams. An overture from IITA toward formalizing collaboration would be a very positive step.

CEMSA staff were delighted with the news that CIP now has the CGIAR mandate on sweet potatoes. The good relationship with CIP on potato research augurs well for similar collaboration on this very important Cuban crop. Of specific interest is resistance to the insect *Cylas formicarius*.

There is a certain amount of discrepancy between the CIAT "low input" approach and the "high input" philosophy evident in most Cuban crops. Although cassava is probably the least input-oriented of major Cuban crops, it is irrigated during the establishment phase (usually 2 to 3 times), receives heavy fertilization--an average of 1.3 t/ha of NPK fertilizer. With the use of the "cartograma" based on soil tests and the Cate-Nelson methods, recommended rates have been reduced by one-third. As CEMSA soil fertility specialists focus on critical soil test levels for major cassava-producing soils, the low input philosophy may gain momentum. Reducing fertilizer rates is one of the most disputed recommendations by the state farm and cooperative directors. This situation is very similar to that

found with U.S. farmers; the extension service recommends that no more phosphorous be applied to soils that have reached very high soil test levels.

4.5 Tropical Pastures

The area devoted to pasture production in Cuba (2.5 million ha of cultivated pastures plus 3.5 million ha of "natural" pastures) encompasses two-thirds of the country's land area, several times that devoted to sugarcane (1.4 million ha). Cattle production systems in Cuba are probably the most intensive found in the tropics at a large scale. Approximately 1.2 million ha of cultivated pastures consists of sprinkle-irrigated guinea grass (Panicum maximum) which receive 300 kg N/ha/yr, annual applications of phosphorus and potassium, and animal manure every two to three years. Dairy or dual purpose cattle are housed in impressive facilities where they receive urea, molasses, corn and soybeans, chicken manure and cut forage supplementation. Milk production enterprises are concentrated on the better soils, capable of producing 15 to 20 t/ha of pasture dry matter per year with fertilization and irrigation. At the other extreme, pure beef production farms are located in less favorable soils and use lower levels of inputs. The main pasture species in areas without irrigation are Panicum maximum and Hyperrhenia rufa.

Pasture deterioration is considered a major problem. About 200,000 ha are seeded every year of which 130,000 are degraded pastures, and 70,000 ha are new lands brought into pasture production mainly from secondary forest or brush (manigua). This significant amount of annual land clearing reflects the need for increasing milk and beef production. The rate of reseeding of cultivated pastures relative to the total area planted, however, is about 5 percent per year. This suggests either an extremely long persistence of cultivated pastures (20 years), or an inadequate rate of pasture reseeding.

Contacts with CIAT's Tropical Pasture Program began in 1977 at the time it was being reorganized into its present form. With only 20 percent of Cuba's soils being acid, the low input approach of CIAT's program did not seem to fit well with the Cuban system. The possibility of using legumes to decrease costs and the focus on marginal soils, however, sparked the interest of Cuban pasture specialists and the Minister of Agriculture as well.

MINAG's Instituto de Investigaciones de Pastos y Forrajes, founded in 1976, located outside Havana, coordinates pastures research in Cuba. It has 11 substations throughout the country. It also collaborates with three key research institutes of the Ministry of Higher Education: the Indio Hatuey Forage Experiment Station in Perico, Matanzas; the Pasture Fertilization Station in Barajagua, Cienfuegos; and the Instituto de Ciencia Animal (ICA) just outside Havana. Collaboration with CIAT has centered on germplasm, technology and training.

4.5.1 Germplasm

Five type B regional trials (ERB) have been planted in various regions of Cuba, totalling 132 grass and legume accessions, plus 46 additional entries in special-purpose collections of individual species. Plant introduction begins at the Indio Hatuey Station, where the quarantine facilities are located, as well as one of the best *Panicum maximum* collections in existence. CIAT procedures for testing are followed, usually taking additional data beyond that suggested by CIAT. The Indio Hatuey Station is also responsible for producing foundation seed. Certified seed is then produced by seed production enterprises. Germplasm from CIAT or of other origin is presently tested in 57 ERBs throughout the country.

Three grasses from CIAT are at the pre-release stage. *Andropogon gayanus* 621 was found not only to be adapted to acid soils but also to neutral and calcareous ones, providing a

positive alternative for lower input systems throughout the country. It is presently being multiplied at seed production farms. Commercial release is anticipated within the next two years. Brachiaria decumbens is more or less at the same stage of development with an anticipated release. The third grass species, Brachiaria brisantha, is also at the pre-release stage for poorly drained soils. A total of 2,100 ha for seed production has been planted to these three species. Their impact is not viewed as likely to replace Panicum maximum in irrigated high input areas, but to provide alternatives to Panicum maximum and Hyperrhenia rufa in rainfall-dependent areas on marginal soils.

Among the legume species the Stylosanthes guianensis cultivars 184 and 136 have performed well and are under seed multiplication in Guantánamo. Other promising legumes are Centrosema hybrid 438 and Pueraria phaseoloides 9900. All these accessions are at the preliminary phases of extension (especies promisorias). Non-CIAT accessions for other ecosystems such as Siratro (Macropitilium atropurpureum), Leucaena leucocephala and Glycine wightii (cv. Tinaroo) are also at the same stage. Although some grass-legume mixtures are being tested by producers, it appears likely that the use of pure legume stands as "protein banks" may be promoted faster as a partial alternative to feeding concentrates.

4.5.2 Technology and methodology

The introduction of CIAT's low input technology was quite a departure from the Cuban approach to pastures during the 1960s and 1970s. In the words of a pasture specialist, "it opened our eyes" to concepts kept on the back burner, such as the role of legumes and the need to become more cost efficient. The concept also spurred Cubans to classify their pasture areas according to which of the approaches would be most suitable. The introduction of this philosophy has made impact on areas beyond acid soils. A total of 15 technologies emanating from the collaboration with CIAT have been applied. Among them are:

- o An increased awareness of soil limitations. With a fairly uniform climate throughout most of the country, soil constraints are recognized as the key for "regionalizing" the technology. Pasture specialists have developed a table of physical soil constraints on pasture lands (Table 4.1). From this table, it is evident that germplasm selection for acid soils only addresses a minority, albeit important, of Cuban pasture areas.
- o Low density pasture establishment technology, developed by Dr. James Spain for the Colombian Llanos, has been successfully adapted to *Panicum maximum* cv. Likoni plantings in about 5,000 ha in Las Tunas Province.
- o Protein bank concept and its utilization.
- o Germplasm evaluation technology.
- o Seed production technology, including identifying appropriate areas.
- o More efficient ways of determining pasture fertilization recommendations.

Table 4.1 Physical Soil Constraints in Pasture Lands of Cuba

Constraints	Percent of Area
Rocky, strong	32
Shallow depth	30
Poor drainage	30
High erodibility	23
Acidity	21
No physical limitations	6-9
Salinity	12-15

Source: Dr. Juan Jose Paretas, MINAG.

4.5.3 Research organization

The National Pastures Institute has adopted most CIAT research methodologies. The increased awareness of soil limitations has permitted them to focus their efforts on a more realistic basis. Certainly the future thrust of the CIAT-related program will be focused on the eastern provinces, which contain the bulk of the acid soils devoted to pastures. A similar approach but with a different genetic base is needed for shallow, generally calcareous soils.

The research staff consists of 40 specialists, four of which have the PhD-equivalent degree, and an additional four are on their way towards the degree. Research staff is projected to increase to 100 by 1990, at which time the physical plant of the institute should be complete, including laboratories.

4.5.4 Training and information

Cuban pasture scientists are very pleased with the flow of information from CIAT's Tropical Pastures Program. It is their main window to tropical pastures technology. Approximately 20 members of the program have been trained at CIAT, including staff members of Indio Hatuey Station, the Animal Health Institute and the Soils Institute. They consider the continuity of such training essential and plan to send most of the new staff to CIAT for training.

An interesting aspect is the long-term assignment of Dr. Juan Jose Paretas to CIAT as a Visiting Scientist in pasture development. Not only did he contribute significantly to the CIAT program, but he was instrumental in adapting the low density seeding technology to Cuba.

Unlike the bean and cassava programs, no in-country courses have been held in coordination with CIAT. This would seem a potentially useful activity to pursue.

4.5.5 Relationships

In spite of major differences in target area and philosophy, the CIAT-MINAG collaboration in tropical pastures is considered highly beneficial, mainly due to its different outlook and methodology. What appears to be an obvious gap is a pipeline on drought-tolerant grass and legume germplasm to serve the non-acid marginal soils of Cuba devoted to pastures. An obvious source is CSIRO Australia, perhaps via CIAT.

Contacts with CIAT's Tropical Pasture Program have decreased somewhat in the last two years. No CIAT pasture scientist has visited Cuba since 1982. They are concerned and hope that activities can be continued and the momentum reestablished.

A pasture development program needs more time than crop production programs to make an impact. To have grasses at the pre-release stage together with a new outlook and methodology is commendable progress after only five years. Impact on beef and milk production can reasonably be expected in the next few years.

4.6 Potatoes

Potatoes are a major component of the Cuban diet with an average consumption of 25 kg per capita, eaten mostly as french fries. Total area planted is 14,000 ha with average yields of 19 t/ha. A total production of 239 kt provides 90 percent of Cuba's needs. The import figure includes a barter with the USSR, which ships potatoes to Cuba during the summer months, when Cuba has none, while Cuba ships potatoes to the USSR after their winter harvest. The most important areas are in the provinces of Havana, Matanzas and Ciego de Avila provinces, all on fertile, irrigated Matanzas clay. Potatoes are planted from November through December and harvested from February to April. They are grown in rotation with vegetables, sweet potatoes, and maize. It is a high priority crop (having Programa Principal Estatal

status); thus other crops are subject to potato planting decisions on potato land. About 90 percent of potatoes are produced in state farms. Over 50 percent of the production is obtained from Havana Province. Virtually all commercial varieties are of West European or North American origin: Desiree (30 percent of the area), Red Pontiac (great cooking quality but susceptible to late-rust), Claudia, Kennebec, Arca, Baraka, and Mariela. Sixty-five percent of the seed is imported annually from Holland and Canada. Fertilization is intensive, averaging 2.6 t/ha of actual NPK fertilizers. Irrigation and pest control are similarly intensive. Harvest is semi-mechanized.

Responsibility of potato research in Cuba is at the La Katuca Station, near the Rancho Boyeros airport south of the city of Havana. This new station is part of the Instituto de Investigaciones de Hortalizas, Granos, Papas y Fibras "Liliana Dimitrova." Ing. Olympia Gómez, Director of "Liliana Dimitrova", is also head of the National Potato Program.

Informal collaboration with CIP began in 1974 with the training of three potato specialists. No significant follow-up actions ensued until 1981 when a formal agreement was signed. Cuba joined PRECODEPA in 1983, thus forming part of this regional network.

4.6.1 Germplasm

There has been regular flow of germplasm from CIP since 1982 as well as from Canada, France, Holland, USSR, and East Germany. Most of this material is aimed at the traditional winter planting season, for which the main interest is in germplasm with disease resistance. Caribe-1, a Canadian hybrid, has been released, and four additional ones are at the extension (pre-release) phase.

The main focus of CIP collaboration, however, is totally different. Cuba wants to extend potato production into spring and summer plantings and is, therefore, vitally interested in CIP's

thrust towards adapting potatoes to the lowland tropics. Collaboration with Dr. David Midmore of CIP is considered highly positive. Over 30 clones tested under hot tropical conditions in the Selva of Peru are now being tested in Cuba.

Cuba is likely to play the lead role in PRECODEPA on potato adaptation for the tropics. It is the only country in this network where potatoes are grown at sea level. What is needed is working relationships with other areas with similar ecological conditions. An obvious case is the potato growing region in the states of Sao Paulo and Paraná in southern Brazil. The climate is similar because these states straddle the Tropic of Capricorn as Cuba does the Tropic of Cancer. Also the Terra Roxa soils of these states are strikingly similar to the Matanzas soils of Cuba.

4.6.2 Technology and methodology

Many of CIP technologies have been rapidly adapted. In fact, many parts of La Katuca's lab and screenhouses strikingly resemble some of CIP's facilities at La Molina. The main contributions are:

- *In-vitro* seed production and tissue culture.
- Rapid seed multiplication. Cuba uses both CIP methods and some developed in France.
- Antiserum diagnosis for detecting virus.
- *Phytophotora* research.
- Adaptation to the hot tropics.

4.6.3 Research organization

The potato team at La Katuca consists of 14 researchers in the following areas: 2 breeders, 2 agronomists, 4 plant pathologists, 1 physiologist, 1 entomologist and 3 seed production specialists. A substation at 600 m elevation in the Escambray mountains permits the planting of a second crop during the year.

Regional cooperation is a major component. Through PRECODEPA, they work with Mexico, the designated leader for Phytophotora research. On the other hand, there are aspects of regional cooperation that do not interest them: rustic storage systems and the use of botanical seed.

4.6.4 Training and information

The flow of documentation from CIP is considered highly satisfactory. All present research staff have received training at CIP or in other countries through PRECODEPA. They have also conducted in-country, postgraduate production courses for the past four years. The contributions of CIP staff in organizing and teaching the courses are most appreciated, particularly the contribution of Dr. Carmen Siri in organization and Dr. Humberto Mendoza in teaching. A total of 120 professionals from state farms and cooperatives has benefited from training.

4.6.5 Relationships

The collaboration with CIP is considered excellent. What was needed was a "point-man" similar to Dr. Galvez from CIAT. Dr. David Midmore is viewed as playing that role, with a sharply focused program for hot climate adaptation. Some of the clones brought by Midmore and planted last August are very promising. Their expectation is to have Cuban-bred potato varieties in the near future.

4.7 Maize

Collaboration with CIMMYT on maize started relatively late (1982), partly because of the low priority assigned to maize in previous five-year plans. The relatively low priority presently assigned to this basic food crop is somewhat paradoxical. Cuba's maize area (77,000 ha) ranks third among food crops, after rice and sweet potatoes, and well above that devoted to beans, cassava, malanga or potatoes. The average yield is very low (1.2 t/ha). The country is only 19 percent self-sufficient in this

cereal. On the other hand, Cuba has had a well-known maize research program for over 40 years, out of which excellent germplasm developed and is widely used elsewhere in the tropics (Cuban Yellow, Poey T-66, etc.).

The main problem seems to be related to the competition for irrigated, prime land during the winter season against crops considered of higher priority such as potatoes, beans, and vegetables. Most of the maize is harvested as sweet corn which can produce 10 to 12 t/ha of ears with recommended technology and irrigation. The 60 to 70 day growing period fits well between the potato harvest and planting of summer vegetable crops. Most of the corn grown for grain, however, is imported.

4.7.1 Germplasm

The present thrust is to develop germplasm for spring and presumably summer plantings. A major breeding program is in progress at El Tomeguín Station headed by Ing. Marcos Torres. It is an extremely complete and sophisticated program and a most vivid example of breeding for virus resistance. The results include two maize hybrids already released, HDT-77 and HDT-90 for production by state farms, plus three varieties (Pichilingue 78-28, Across 79-21, and Across 79-25). These varieties came from a free-pollinated variety trial sent from CIMMYT from 1982-84. In addition, 10 lines from IITA have also been received. No CIMMYT germplasm for 1984-85, nor seed for multiplying the promising varieties have been received thus far.

4.7.2 Technology and methodology

Production technology for mechanized maize production is considered available. Spacing and planting systems are adjusted to those used for vegetables as a uniform standard for rotation in Matanzas soils. Recommended fertilizer rates are in the order of 150 kg N/ha, 150 kg P_2O_5/ha and 80 kg K_2O/ha, which appear reasonable for phosphorus and nitrogen-deficient soils. The need for potassium is questionable. Given the excellent soils

structure, zero tillage is perfectly feasible for an efficient maize-soybean rotation. These technologies were apparently developed without CIMMYT inputs.

4.7.3 Research organization

The corn program is staffed by five researchers at El Tomeguín, who also have responsibility for sorghum research. There is no major outreach program outside the station.

4.7.4 Training and information

Three maize scientists have been trained at CIAT and the program leader has attended PCCMA meetings in Central America under CIMMYT sponsorship. Visits from five CIMMYT scientists have been made since 1981.

4.7.5 Relationships

CIMMYT-MINAG relationships are at the development stage and are considered satisfactory. It appears that both institutions are still in the process of getting acquainted. Potential for expansion appears considerable, particularly if Cuba decides to increase its maize area as an import substitution measure. The geographical proximity to CIMMYT and ease of transport, should facilitate the contact. The role of Dr. Willy Villena, CIMMYT's Regional Coordinator is viewed as very positive.

4.8 Sorghum

Collaboration with ICRISAT has only been indirect, via CIMMYT's relay program, without a formal agreement or work plan. Some germplasm has been received and interest is high. Sorghum production has a great potential in Cuba's climate and soil, particularly in rainfed areas. The question is one of national priorities; sorghum could presumably contribute to the growing demand for feed grains.

5 Research Impact on Agricultural Production

5.1 Important Innovations in CGIAR Crops

Table 5.1 summarizes the impact of MINAG-CGIAR collaboration during the past 15 years, arranged by crop commodities. Collaboration with IRRI and CIAT is considered to have reached a mature stage; with CIMMYT on maize and CIP on potatoes it is considered at the development stage. Collaboration with ICRISAT on sorghum, IITA on malanga and CIP on sweet potatoes is considered incipient. Another noteworthy factor is the priority status given in the current five-year plan by the Cuban government. Of the nine commodities in which the CGIAR centers collaborate, only rice, beans, pastures and potatoes have Programa Principal Estatal status.

The impact of the CGIAR collaboration, therefore, increases with the length of the historical collaboration, and importantly the priority assigned by Cuba to the commodity. Other factors are the degree of interest from the CGIAR centers, and the nature of the commodity itself. The longer term nature and complexity of say, pasture research in comparison with a grain crop improvement program must be kept in mind when comparing the relative impact of programs.

5.1.1 Germplasm

The CGIAR system is considered Cuba's main external source of germplasm for tropical crops. Its role is vital. Requests for additional germplasm of vegetables from AVRDC, sorghum, peanuts and chickpeas from ICRISAT, sweet potatoes from CIP and plantains and soybeans, underscore the value placed on this contribution.

The amount in the pipeline (shown in Table 5.1) indicates the individual accessions received to date since collaboration began. These total amounts are also related to the degree of

maturity of the MINAG-CGIAR collaboration. The inclusion of segregating populations (F1, F2, etc.) in beans, cassava and potatoes are considered major assets. A similar thrust on rice was requested. Comparable activity in pastures is in effect with the introduction of accessions collected from the wild.

The number of cultivars released represents a real output of the collaboration. This has been limited to rice, beans and cassava. It is relevant to note that three grass species are in the pre-release stage of the pastures program undergoing animal production trials and massive seed multiplication. Release is envisioned within the next two years. Likewise it is relevant to note that three CIMMYT maize varieties are at the pre-release stage, in spite of the short duration of this collaborative relationship.

5.1.2 Program development and philosophy

The CGIAR centers have had a major influence in improving the organization, philosophy and research methodologies of the rice, beans, cassava, pastures and potato national programs. The CIAT cassava program philosophy has been effectively applied to other crops for which CEMSA is responsible such as malanga, plantains and sweet potato. What is missing in the latter three crops is a solid germplasm pipeline and an effective relationship with IITA and CIP. The Cuban maize program has had little contribution from CIMMYT except for germplasm.

It is also relevant to note that the CGIAR centers have had a positive influence in broader aspects such as to strengthen the information services through CIDA; to link on-the-job training with research, particularly in-country courses; to emphasize the need for gathering production economics data to determine profitability, and to decrease excessive use of fertilizer through the Cate-Nelson approach. All these innovations have had a positive effect in MINAG's research outlook, compared to that

which prevailed ten years ago, when high crop yields, regardless of cost were the main objective.

5.1.3 Production technologies

In addition to germplasm, several major agronomic technologies have been implemented as a result of MINAG-CGIAR collaboration. The main ones are:

- o Water levelling in rice fields
- o Use of early maturity rice varieties to save water
- o More efficient use of fertilizer in rice
- o Diagnosis and correction of zinc deficiency in rice
- o Rapid propagation of disease-free cassava planting materials
- o Ridge planting of cassava with lignified stakes
- o Improved fertilizer efficiency for cassava
- o Drying for cassava utilization
- o Low density pasture establishment techniques
- o Protein bank concept and applications
- o Regionalization through soil constraint analysis
- o Pasture seed production technology and site selection
- o Determination of more efficient pasture fertilization techniques
- o In-vitro potato seed production and tissue culture propagation
- o Rapid potato seed multiplication
- o Antiserum diagnosis for detecting potato virus diseases
- o Adaptation of potatoes to the hot tropics
- o Adaptation of cassava rapid multiplication techniques to malanga

There are undoubtedly other production technologies that have been either directly or indirectly introduced as a result of MINAG-CGIAR collaboration. The ones listed, in addition to germplasm, are those mentioned to the authors by the staff of the specific national programs.

5.1.4 Training

The impact of training at CGIAR centers is also considered of vast importance, not only as a means to gather knowledge about a specific area but also to provide insight on tropical agricultural research at its best. The numbers of MINAG scientists trained at CGIAR can also reflect Cuban priorities, as Table 5.1 shows. Also the percentage of present staff trained at the CGIAR centers reflects that. The proportion are: 133 percent for cassava, 113 percent for beans, 100 percent for potatoes, 80 percent for maize, 58 percent for rice and 50 percent for pastures. Values in excess of 100 percent indicate the training of producers and other Cuban staff not part of the national research institutes. In some cases it reflects staff no longer associated with the program but this is rare. It is the aim of virtually all national programs to have all their research staff exposed to the CGIAR collaborating institute under some type of training or visit.

The development of in-country courses with CGIAR assistance is considered a major advance by the beans, cassava and potato programs. The rice program has conducted an annual training plus planning sessions with about 100 people for the last 15 years or so. Such meetings reach virtually all major rice producers of the country. The pasture program does not appear to have either of these two mechanisms.

The number of professionals and producers reached so far by the in-country training courses is major. On rice it is basically the same group on a yearly basis. On beans, cassava and potatoes, the numbers of people reached are quite impressive. The pipeline for CGIAR-related technology is indeed a very direct one.

The last item in Table 5.1 introduces one measure of the impact on production: the proportion of the area planted to a commodity where CGIAR-related technology is utilized, either as

Table 5.1 Summary of Innovations Arising from MINAG-CGIAR Collaboration

	Rice	Beans	Cassava	Pastures	Potatoes	Maize	Sorghum	Malanga	Sweet Potatoes
General Aspects									
Priority status (PPE)	YES	YES	NO	YES	YES	NO	NO	NO	NO
Number of Cuban research scientists	38	15	9	40	14	------5------		6	4
CGIAR Center	IRRI & CIAT	CIAT	CIAT	CIAT	CIP	CIMMYT	ICRISAT via CIMMYT	IITA	CIP
Collaboration began	1967	1977	1977	1977	1981	1982			
Status of collaboration	------------mature------------				---developing---		--------incipient--------		
CGIAR Germplasm									
Pipeline	15,207	2,135	14,210	178	30	106	same	same	same
Segregating populations	NO	YES	YES	N/A	YES	NO	NO	N/A	N/A
Releases	9	7	2	0	0	0	0	0	0
Pre-releases	N/A	N/A	3	3	0	3	0	0	0
Program Development									
Research program organization	YES	YES	YES	YES	YES	NO	NO	YES*	YES*
Research methodologies	YES	YES	YES	YES	YES	NO	NO	NO	NO
CGIAR Technologies									
Major production technologies	4	0	4	4	4	0	0	1*	0
Training									
Scientists at CGIAR centers	22	17	12	20	14	4	0	1	0
In-country courses with CG inputs	0	4	2	0	4	0	0	0	0
Participants in-country	100/yr	151	478	N/A	120	N/A	0	0	0
CGIAR Impact on Production									
% Area under new technology	100	29	60	0.3	0	0	0	0	0

Note: * CIAT-related influences.

germplasm, production techniques or both. These figures are based on the interviews with the national program leaders. Impact on the rice area is total, on cassava is 60 percent of the area and on beans is 29 percent. This latter figure was based on an impact of 80 percent of the irrigated area in state farms.

The minuscule proportion in pastures reflects 7,200 ha of sown pastures, 2,200 of which are for seed production of pre-released grasses and 5,000 ha where the low density seedings have been utilized. This is a good beginning for a long-term program such as this one.

No measurable impact on area planted of CGIAR-related technology has occurred for potatoes, maize, sorghum, malanga and sweet potatoes. The following discussion will therefore center on rice, beans and cassava.

5.2 Contributions to Output

A summary of the impact of MINAG-CGIAR technology on increases in rice, beans and cassava production is shown in Table 5.2. The period is from 1970-72, using FAO data, to 1984 using data provided by the national program leaders.

5.2.1 Rice

Increases in rice production have been dampened by a significant decrease in the area planted from 172,000 to 140,000 ha. This is due to pressure from the sugar sector. National average rice yields have increased by 90 percent, from 2.0 to 3.8 t/ha. With 100 percent of the rice area under new technology, production has increased from 340 to 532 kt of paddy rice. A full 73 percent of this production increase is attributable to the MINAG-CGIAR generated technology.

5.2.2 Beans

Our best estimates of bean production statistics indicate no

change in the area planted to beans in the last 15 years. Yields have increased by 17 percent, from 0.70 to 0.82 t/ha as a national average. The area affected by the new bean technology is estimated to be 29 percent of the total bean area. The impact of the MINAG-CGIAR technology has thus far concentrated on state farm production, where beans are irrigated. The new technology has produced average yields of 1.4 t/ha in 80 percent of this target area, where the technology has been applied. This impact is diluted by the larger proportion of beans produced in sugar enterprises and by private farmers. The MINAG-CIAT team is addressing the latter group at Velazco, Holguín. In spite of this limitation, overall the impact has been to raise bean production by 21 percent since collaboration started seven years ago.

5.2.3 Cassava

The impact of MINAG-CGIAR collaboration has been more spectacular with cassava than any other crop. Our best estimates indicate that total area planted has increased from 20,000 to 34,000 ha for 1978 to 1984. Approximately 60 percent of the area is fully under the new technology, where yields have increased from 5 to 10 t/ha. The overall impact of yield is diluted by the 40 percent of the area not affected by technology which we assume to maintain average yields of 5 t/ha. Nevertheless the overall effect is one of more than doubling national cassava yields (from 5 to 11.6 t/ha). With the increase in area planted, national cassava production has quadrupled in the last six years, from 100 to 390 kt. The increase due to the new technology is estimated to be 224 kt, or 224 percent.

5.3 Returns to Agricultural Research

Estimates to the return of MINAG investment in rice, bean and cassava research are included in Table 5.2. The annual value of increased production was based on world market prices of

Table 5.2 Impact of MINAG-CGIAR Technologies on Increased Production of Rice, Beans and Cassava in Cuba

Items		Units	Rice	Beans	Cassava[a]
Area:	1970-72	000 ha	172	35	20
	1984	000 ha	140	35	34
	Change	000 ha	-32	0	14
Area under new technology		percent	100	29[b]	60
Yields:	1970-72	t/ha	2.0	0.7	5
	1984	t/ha	3.8	0.82	11.6
	Change	t/ha	1.8	0.12	6.6
	Change	percent	90	17	132
With new technology		t/ha	3.8	1.4	16.0
Production:	1970-72	kt	346	24	100
	1984	kt	432	29	394
	Change	kt	86	5	294[c]
Increased production due to new technology		kt	252	5	224
		percent	73	21	224
Annual value of increased production[d]		US$ m	40.2	2.9	11.2
Annual MINAC research budget		US$ m	1.1	0.5	0.3
Annual internal rate of return[e]		percent	54	29	48

Notes: [a] The data used for cassava were supplied by the director of the national research program. The base year is 1978.

[b] Based on the assumption that all the area grown on state farms (10,000 ha) is sown to new varieties.

[c] Percentage change in production relative to base period.

[d] Using world market prices of US$300, $570 and $80 per ton for rice, beans and cassava respectively.

[e] Estimated by multiplying the total number of staff (scientific plus technical and support staff) by an average cost of 4,500 pesos per staff member, and converting to US$ at the official exchange rate. There is no allowance for research done on these crops by universities, research centers under the Ministry of Higher Education, or by the Academy of Sciences.

US$300/ton for milled rice, US$550/ton for beans and US$50/ton for fresh cassava at the farm gate. The estimates of the annual MINAG research budget were calculated according to the procedures described in section 3.

In 1984, the value of increased rice production was US$40.2 million with a research expenditure of US$1.1 million. For every dollar invested in rice research the country reaped US$436.5 of additional rice production. In the case of beans, despite the more limited impact, increased production in 1984 was worth US$2.9 million and research expenditures were US$0.5 million. For every dollar invested in bean research US$5.8 of additional beans were harvested. The annual increase in cassava production was at US$11.2 million in 1984. With an annual research investment of US$0.3 million, for every dollar invested in cassava research, US$36.3 of additional production was harvested. The returns to investment in rice and cassava research were almost identical. An alternative measure is the internal rate of return to investment in research. This was estimated as 54 percent for rice, 23 percent for beans and 48 percent for cassava. This is that rate of return that Cuba would need to receive on alternative investment for it to be as attractive as research in these commodities.

5.4 Future Outlook

With such favorable returns from research, the continuity and expansion of CGIAR support is highly desirable for Cuban agriculture. Continuity in the present mature programs for rice, beans, cassava and pastures; full development of the ongoing maize and potato programs and the incipient programs on sorghum, malanga and sweet potatoes should become part of the overall plan. New initiatives with these and other centers outlined in Table 5.3 appear to be a logical extension.

Considering the entire agricultural economy, it appears that emphasis should be given to:

1. Attaining sustained self-sufficiency in rice, beans and maize, both through yield increases and area expansion.
2. Decreasing import dependency for feedstuffs for livestock production through increased production of maize, sorghum and soybeans; major thrust in utilization of additional cassava production for animal feed; and increased area under improved pasture technology on marginal acid and non-acid soils.
3. Maintaining self-sufficiency in potatoes, cassava, plantains, and malanga.
4. Increasing the efficiency of input use, particularly fertilizers, irrigation and pesticides, through sharply focused factor-oriented research. Particular attention should be given to the depletion of the irrigation aquifer under some Matanzas soils and the subsequent intrusion of saline water. Attention should also be given to the use of these prime lands during summer periods.
5. Cuba would need a substantial increase in area sown to major crops if it were to approach self-sufficiency even after allowing for increases in yields (Table 5.4). This suggests that given the perceived pressure on land resources there will be a continued demand for yield-increasing technologies.

Table 5.3 Additional Collaboration Needs Reported by MINAG Officials

Crop or Factor	Additional Requests	Potential Collaborator CGIAR Center	Other
Rice	Segregating materials (F3 and F4)	IRRI,CIAT	-
	Management of saline rice soils	IRRI	IBSRAM
	Improving nitrogen fertilizer efficiency	IRRI	IFDC
	Improving irrigation management	IRRI	IIMI
	Participation in international conferences	IRRI	-
Beans	Strengthening bacteriosis research	CIAT	-
	Mechanized harvesting	CIAT	-
Cassava	Strengthening entomology	CIAT	-
	Developing soil-plant analysis laboratories	CIAT	-
	Cassava utilization as animal feed	CIAT	-
Malanga	Develop collaboration with IITA	IITA	-
Sweet Potato	Develop collaboration with CIP	CIP	-
Pastures	Germplasm for non-acid marginal soils	CIAT	CSIRO
	In-country training courses	CIAT	-
	Land clearing methods	CIAT	IBSRAM
Potatoes	None - continue as is	CIP	-
Sorghum	Intensity - develop a relationship	ICRISAT	-
Vegetables	Very strong interest in establishing collaboration with AVRDC	-	AVRDC
Peanuts	Interested in exploring collaboration	ICRISAT	-
Chickpea	Interested in exploring collaboration	ICRISAT	-
Soils	Interested in establishing collaboration on semi-arid tropics and vertisols	ICRISAT	IBSRAM
	Interested in joining acid soils network	-	IBSRAM
Agroforestry	Interested in establishing collaboration	-	ICRAF

Table 5.4 An Estimate of the Areas Needed for Three Basic Crops to Achieve Self-Sufficiency

Crop	Current Consumption[a] (kt)	Yield[b] (t/ha)	Total Area Needed (000 ha)	Current Area (000 ha)	Percent Change (000 ha)
Rice (paddy)	780	4.0	194	140	+54
Beans	134	1.5	89	35	+54
Maize	498	3.0	166	77	+89
Total	-	-	449	252	+78

Notes: [a] Based on production plus imports.
[b] Yields which could be achieved with superior practices and current varieties.

Appendix

Persons and Places Visited

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Estacion Experimental de Papas, "La Katuca"
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Ing. Benito Faure, Fitomejorador de frijol
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Ing. Juan Miguel Portieles, Especialista en Nutrición Vegetal
Ing. Jose Venutra, Director Estacion Experimental "Fructuoso Rodriguez"

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Bejucal, Prov. Habana

Ing. Rafael Salazar, Director
Ing. Agustin Hernandez, Ingeniero Principal

Cooperativa "Amistad Cuba-Paises Nordicos"
Guira de Melena, Prov. Habana

Francisco Suarez, Presidente
Pedro Martinez, Vice-Presidente
Ricardo Lacanche, Contador

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