CIAT in the Decade of the Eighties

Second approximation to the Long-Term Plan

for discussion with representatives from national agricultural research/development institutions in a special seminar to be held at CIAT

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PREAMBLE

The indicative plan contained in this document projects the activities of the Center over the decade of the eighties. The plan focuses specifically on the three biennial budgetary periods over the years 1982-1987, with more general projections thereafter.

The first approximation of the plan was prepared in an interactive process involving CIAT management, research staff and the Board of Trustees. Representative of collaborating national research institutions will be consulted at a special workshop to be held at CIAT where the second approximation of the plan will be presented and appropriate modifications which synthesize the opinions of the group will be incorporated in the final document.

In preparing the plan three basic sets of considerations were important in guiding the planning process:

a) The needs for new technology designed to increase food production, particularly in the developing countries of the Western Hemisphere, and the manner in which the Center's programs should evolve to meet these needs.

b) The degree of success of the Center's programs and how these expected results will modify future priorities and strategies.

c) The budgetary implications of the plan projections in the light of existing and expected constraints to growth in Center activities.

In the development of the plan there has been no indication that would call for a deviation from the current general structure of CIAT research over the period, at least until 1987. The plan places continued emphasis on common beans (Phaseolus vulgaris), cassava (Manihot esculenta), rice, and tropical pastures. An integral part of the plan is the proposal for an external review of the programs which would constitute the third TAC Quinquennial Review of the Center to be carried out in 1987. This in-depth review would thoroughly analyse the degree to which the Center has realized its objectives in the four commodities and make recommendations with respect to CIAT's future role in those commodities or in possible alternative activities.

A basic orientation of CIAT towards the agricultural sector in the Western Hemisphere is implicit in this document. The plan projects CIAT activities within the framework of the constraints to increased production and productivity of basic food commodities important in the hemisphere. The need for improved technology in these commodities in regions outside the Western Hemisphere has not been neglected and provision for an appropriate level of CIAT involvement has been projected in the plan.

A series of factors may alter the projections contained in this document. Since these factors are quite unpredictable the plan represents only the best estimate of the most appropriate future activities of the Center. In particular, the work of CIAT can only meaningfully be defined when seen against continuing developments in collaborating national agricultural research and development institutions. CIAT has strived, and will continue to strive, to assure maximum complementarity with national efforts and thus will need to adjust its activities in step with the evolution of national needs for international cooperation which complements and supports their own programs.

Additional elements of uncertainty are implicit in the inherent unpredictability of biological research and in the ever existing possibility of new and unexpected challenges, and in global socio-economic circumstances the may have important repercussions in the definition of the mandate. Naturally, the degree of certainty of the projections decreases with time.

The document opens with an analysis of the socio-economic context in which planning has been placed. A specific focus on the agricultural sector in the developing countries of the Western Hemisphere is a reflection of the basic orientation of the Center. This analysis is followed by a discussion of the role of CIAT within this context and a review of intitutional progress over the first ten years of the Center's existence, leading to a definition of the overall objectives and strategies of the Center. The plan continues with an analysis of the basic philosophy underlying the strategies in developing international collaborative and cooperative research and technology transfer activities with national institutions.

The strategies to achieve the objectives in four basic commodities are then outlined and projections made with respect to future activities in the light of expected developments at the national level. The plan concludes with a discussion of new initiatives designed to complement the work of existing programs and a Center-wide analysis of projected resource requirements and their budgetary implications.

Chapter 1: THE PLANNING CONTEXT: SOCIO-ECONOMIC ENVIRONMENT IN TROPICAL AMERICA

"Hunger is at least as much a political, economic and social challenge as it is a scientific, technical or logistic one[1]". This statement clearly highlights the complexity of the world food problem and the fact that there is no single, no easy and no cheap solution to it.

Improved agricultural technology adapted to the socio-economic and agro-climatic conditions characteristic of the developing world is a necessary, but by no means sufficient, component of a world food strategy. Recognizing the key role of agricultural technology in increasing food production in the tropics, the CGIAR system was formed in 1971, which in addition to CIAT now includes nine other international centers and three related activities. While the final product of centers such as CIAT is improved production technology, the CGIAR system has recognized that such technology can be a means to achieving more basic socio-economic goals, viz.,

a) Improving the production, quality and stability of supply of basic food commodities in developing countries;

b) Improving the nutritional status of those segments of the urban and rural population still below minimal nutritional requirements; and

c) Improvement of the income levels of the limited resources population of the rural sector, and, indirectly, of the low income urban population.

The manner in which the introduction of new technology works its way through systems of food production, distribution and consumption and impacts on nutrition and income distribution is complex and never fully corrective. Improved technology will never by itself be a solution of the problem of income distribution and nutrition but it could certainly contribute to it. Moreover, there are agricultural technologies that will have a greater impact than others on these two related problems. In order to understand what these technological alternatives are it is first necessary to review the socio-economic structure into which the agricultural technology will enter.

CIAT, within the CGIAR, network, began with no fixed crop mandate or

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[1] Overcoming World Hunger: The Challenge Ahead, Report of the Presidential Commission on World Hunger, U.S. Government Printing Office, Washington, D.C., 1980.

unique ecological orientation. CIAT's research within the CGIAR system is very much regionally focused on Latin American agriculture. In clear recognition of CIAT's role vis-a-vis other research and extension institutions, changes in research activities follow a horizontal approach, (i.e., addition or deletion of essentially crop programs), rather than a vertical approach in which activities expand into either more basic research or extension, or both. Thus, the relevant context for planning agricultural research at CIAT will be an analysis of agriculture within tropical Latin America.

1.1 Socio-economic Goals in the Production Context

1.1.1 The Production Gap

Food production in Latin America has grown at a sustained rate of 3.6% per annum since 1950, a rate consistent with growth in aggregate demand. The regional aggregate, howeve, is highly deceptive. In the last decade in only five of twenty-one countries has food production kept pace with demand growth (Appendix 1). Only in Argentina have consumer food prices increased at a slower rate than general consumer price levels.[1] All countries in Latin America except the temperate countries Argentina and Uruguay, remain net-imported of food staples.[2] If current rates of growth in production are projected to 1990, food deficits in all tropical countries are expected to increase by 50%, except for Brazil and Paraguay. Thus, to maintain food prices constant in real terms, and to maintain current levels of self-sufficiency in food will require an increase in the rate of growth of agricultural production in most Latin American countries.

1.1.2 Land, Labor and Growth

Growth in agricultural production depends on either bringing more land and labor resources into production or using the current stock of those resources more efficiently. The general patterns is some combination of the two curses, resulting in an increase in the productivity of the resource in most limited supply. This would define the nature of the type of technical change demanded. In the Latin American case land is a highly abundant resource. Studies comparing potential arable land to land

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[1] FAO, The State of Food and Agriculture 1978, Rome, 1978.

[2] IFPRI (International Food Policy Research Institute), Food Needs for Developing Countries: Projections of Production and Consumption to 1990, Research Report 3, 1977.

currently under the plow estimate that Latin American agriculture is utilizing only somewhere between 18 to 35 percent of its potential land resource. Moreover, the average size farm is 112 hectares, very high by developing country standards. In the aggregate there would appear to be a surplus of land relative to labor. This situation would imply that the most efficient growth strategy would focus on increasing the productivity of labor while at the same time expanding arable land. One logical outcome of this strategy would be increased farm mechanisation.

Such a conception of Latin American agriculture is a gross oversimplification of its complexity. Past growth in agriculture has not followed such a path. Except for Argentina, Uruguay and Venezuela, Latin American countries have been increasing productivity of both land and labor. During the 1960–78 period, tractor use increased at a 5.6% annual rate while fertilizer use grew at a 11.2% rate. This intensification of land use appears to be inconsistent with the conception of a land-surplus economy.

This apparent inconsistency arises from the very heterogeneous nature of Latin American agriculture. An agricultural frontier does exist in most tropical South American and Central American countries but expansion at this frontier is competitive with intensification of farms currently in production. The high costs of bringing new frontier land into production using existing technology make it less profitable than intensifying on land already in production. This competition between extensive and intensive development is further complicated by the very skewed distribution of land which is particularly characteristic of Latin American agriculture. The majority of the farm population have very limited land resources and to increase production they must concentrate on techniques to increase yields. Large-scale farmers, on the other hand, control the major portion of the land resources and find that relative labor costs are high. As farm size increases there are rising costs in obtaining and managing large numbers of seasonal laborers. Thus, large farmers invest in labor-substituting mechanization or specialize in extensive production activities, such as pasture beef systems.

An agricultural growth strategy for Latin America that efficiently utilizes both land and labor resources is complicated by the distribution of these two resources and the very marked differences in the quality of the land resource. Three very different growth strategies emerge: (a) intensification of production by large farmers on the more fertile areas, essentially through mechanization and higher input use; (b) expansion of agricultural production at the less fertile frontier; and (c) intensification of production by small farmers on existing land, essentially through higher and more stable yields.

Each type of growth strategy implies a very different research focus. In a planning context the issue is not only in what areas research will result in the largest production gain but also in which areas CIAT has a comparative advantage, especially in relation to the three socio-economic goals presented earlier. A dynamic large farm sector exists in Latin American agriculture, reliant on mechanization research easily transferable from more developed countries. Rapid growth in large farm agriculture within a very skewed land distribution can produce a very accelerated treadmill effect, i.e., the movement of "less efficient" farmers out of agriculture. While there are not sufficient employment possibilities in the urban sector, large social stresses develop. The rest of this section addresses the issue of whether or not there is potential complementarity between the three strategies, thereby helping to define research requirements.

1.1.3 Large Farm Intensification

Larger farmers in Latin America, while controlling the major portion of the land resource, tend to utilize it very extensively. In Brazil, for example, farms above fifty hectares make up 85% of the area in farms but have only 53% of the area in crops. In Colombia, large farmers own 76% of the land but have only 40% of the land in crops. Latin American policy makers, realizing the inefficiency in use of land by large farmers, have concentrated on inducing these farmers to shift from extensive beef production systems to crop systems. Policies to foster mechanization, such as credit subsidies, overvalued exchange rates, land taxes, and price supports for mechanizable crops have been implemented in many countries. These policies have been complemented by investments from multinational agricultural supply firms, who find large untapped markets with low distribution costs and minimal requirements for redesign of chemical, seed and mechanization technologies.

A very dynamic sector has been created, as is reflected in the very high growth rates in mechanizable crops. Since 1961 sorghum production in Latin America has increased at a rate of 13% per annum while in Brazil wheat production increased at 11%. Growth in soybean production was even more rapid. In all these cases over 75% of the growth was due to area expansion, reflecting the extensive nature of crop production on large farms. Thus, while such crop yields have remained stagnant, overall land productivity has increased due to shifts from pasture production to crops.

The concentration of agricultural policies on intensifying the land use of large farmers has had two important results. First, production growth of extensively produced commodities, especially beef, has lagged behind demand. Second, in seeking to increase the efficiency of land use on large farms, policies have not dealt with, and, in some cases, have exacerbated the inefficiencies in the use of labor. High rates of under-employment exist in the agricultural sectors of Latin American countries (see section 1.1.5.). Inefficient labor use cannot be ignored because of the obvious linkages to income and nutrition goals.

1.1.4 Expansion of the Agricultural Frontier

At the frontier, infrastructure development is usually limiting, making input and marketing costs high. Labor is in short supply but land is relatively cheap. Thus, expansion at the frontier is usually based on extensive production systems. In the Latin American context extensive beef production systems are predominant at the frontier. This is, in fact, complementary to intensification of large farms on more fertile land, in that it induces a more efficient utilization of land resources.

As large farmers on good land shift into crops, rising land values result also in the intensification of the remaining pasture land. Thus in the 1960-70 period improved pasture area increased at a 3.6% annual rate, a full percentage point greater than the expansion in crop land. In addition to this growth which represents 21 million hectares of pastures, 92 million hectares were added at the frontier, representing a growth of 2.2% per year in natural pastures. These two processes resulted in an annual growth in beef production of 3.4%, well short of the growth in demand for beef of 5.4%. Thus, expansion on the frontier is a necessary complement to large-farm intensification, if demand for food crops and beef is to be met.

Even with rising beef prices, the area sown to pasture was not expanding fast enough to meet demand. For much of the abundant land area of Latin America, such as the "llanos", the "cerrado", the "pantanal" and the Amazon jungle, the costs of production for infrastructure and soil correction appear to be presently too high to support a more rapid expansion of land use at the frontier. Selection of crop and pasture species for these areas with reduced fertility requirements should improve the potential profitability of land use. Investment in new technology that increases productivity of adapted crops, such as rice and cassava, and of beef pasture systems in the Oxisols and Ultisols typical of the Latin American frontier should, in fact, aid in the intensification, with crops demanding higher fertility levels grown on large farms on prime lands. Instead of spending public funds on research to reduce the costs of crop establishment for large farmers, a more socially efficient solution would be to bring down the cost of beef production on the frontier. The effect of rapid beef expansion on price would induce large farmers to shift to more profitable, and more intensive, alternatives. Pasture technology specifically designed for the frontier should thus induce a more socially acceptable utilization of land resources in Latin America.

1.1.5 Small Farm Intensification

An unfortunate paradox exists in Latin American agriculture. Small farmers are, from a social point of view, the most efficient producers in the combined utilization of land, labor and capital resources[1] but because they control such a minor portion of the land resource, their contribution to output is limited. So, though efficient, the potential of the small farm sector to contribute to increase total food production is somewhat limited. However, increasing the productive employment of labor should have as high, or higher, a priority as fostering the more productive utilization of land resources, since employment is the principal determinant of income and welfare.

Underutilized labor in the agricultural sector results in migration to urban areas. However, the conditions of Latin American cities offer ample evidence that rural poverty is not being solved by transfering it from rural to urban areas. High rates of rural-to-urban migration are characteristic of Latin American economies. In the 70's urban growth eased slightly but still averaged a 3.7% annual rate of increase and in Brazil and Mexico over 4.5%. This process has put extreme pressure on job creation in the urban sector. Since industrial growth has been capital intensive, most of the employment is occurring in the tertiary sector and most of this in the low-productivity service jobs. The service sector is as well the entry point for most rural-urban migrants--if they can find jobs at all--and in most countries average labor productivity is lower in these jobs than in the agriculturla sector.

The employment problem is further complicated by the fact that, because of the young age profile of the population, the rate of growth in the labor force will actually increase from 2.4% in the 1960-70 period to over 2.9% in the 1980-2000 period. Since in Latin American countries the rural population represents more than 30% of the total, and over 50% in the poorest countries, rural-to-urban migration flows will remain large putting more pressure on urban job creation. ILO studies[2] of representative Latin American countries have stressed the fact that a full-employment strategy over the next decade depends on increased employment in the agricultural sector and maintenance of the role of the agricultural sector as a residual employer.

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1 R.A. Berry and W. Cline, Agrarian Structure and Productivity in Developing Countries, John Hopkins University Press, 1979.

2 ILO, International Labor Office of the United Nations, Toward Full Employment: A Programme for Colombia, Geneva, 1970.

Full employment thus requires some check on rural-to-urban migration for at least the next few decades. However, the rate of this migration is highly responsive to changes in intersectoral income differentials. In Latin America a 10% increase in the relative income between the tertiary sector and the agricultural sector increases the migration rate by 9%.[1] Moderation of migration depends on improving agricultural incomes, especially among the more mobile portions of the agricultural population. About 35% of the economically active population is landless labor. Moreover, subfamily size farms make up approximately 50% of all farms. The existence of a highly mobile agricultural population that is very responsive to intersectoral income differentials, strengthens the argument for an agricultural development strategy that increases rural incomes of small farmers and landless laborers.

Small-farm intensification is a necessary component in ameliorating both rural and urban poverty in Latin America. Migration affects average nutrition of the low-income strata of the population. Studies have indicated that the nutritional situation of the urban poor is inferior to that of the rural poor, even with higher incomes.[2] Given the importance of reducing rural-to-urbam migration rates, another alternative is to allow for increased population access to land through frontier colonization. In comparison to migration to urban areas, colonization schemes tend to be costly and do not result in significant population flows. In the Santa Cruz area of Bolivia and the "selva" of Peru such labor flows have been significant but have not solved the rural employment situation in the "sierra". In the better soil areas of Parana, Goias, and Mato Grosso in Brazil frontier settlement, and associated infrastructure development, has been rapid and effective. In general, however, the potential for expansion of viable family-size, crop-producing farms at the frontier is limited by soil sonstraints, lack of appropriate technology, poor access to markets, relatively high capital requirements and inconsistent land settlement policies over time.

Improvement of small farm productivity remains the most viable avenue in affecting rural (and urban) employment. For the case of Brazil, for example, 40% of rural employment occurs on farms of less than 10

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[1] Lynam, J.K., Latin American Agriculture: a cross-sectional analysis in Trend Highlights of CIAT's Commodities, Econ. 1.6, CIAT, April, 1981.

[2] J.O. Ward and J. Sanders, Nutritional Determinants and Migration in the Brazilian Northeast: A Case Study of Rural and Urban Ceara, Economic Development and Cultural Change, 29 (1980): 141-164.

hectares and almost 75% on farms of less than 50 hectares. To what extent can both labor productivity and employment be expanded in this farm size category? It is an empirical question but whose resolution must focus on labor intensive crops, employment generating production systems, and yield raising technologies as necessary components. However, only under certain limited conditions are strategies to simultaneously intensify both large and small farms compatible. If large and small farmers compete in the same commodity and large farmers continue to have access to the subsidized capital of most mechanization policies, small farmers, in most intances, would not be able to compete. Any initial positive impact on small farm income would vanish and even become negative with the fall in price. The inherent nature of Latin American agriculture argues for crop specialization by large and small farms, with small farmers concentrating on labor-intensive crops and large farmers on mechanizable crops, a current characteristic of Latin American Agriculture. Research on facilitating mechanization of labor intensive crops could shift the comparative advantage away from small farmers in these crops, and thus, even though such research may be effective in increasing the output of such a crop, the social costs of these research investments could well be offset by the social costs.

1.1.6 A Combined Growth Strategy

If food is to be supplied at reasonable price levels and minimal incomes are to be assured through productive employment, then growth in Latin American agriculture will have to come from more productive employment of both land and labor resources. Enough public and private resources are being directed at large scale agriculture to assure its continued dynamism into the future. An efficient growth strategy would as well include expansion on the frontier with intensification of production by small farmers. However, the compatibility of the three strategies rests on each group producing the crops in which they have comparative advantage and, especially, the large farmers not competing with small farmers in the same product market. Technical change is a key element in a combined strategy requiring a certain diversity in research investment, since the consistency of the strategy implies very strict design requirements for each particular crop. Table 1.1 summarizes the comparative advantages of a range of commodities with respect to farm size and frontier expansion. However, to complete the picture it is necessary to consider the relative importance of the crops in food consumption.

Table 1.1 Relative Comparative Advantage of Major Commodities Under Different Production Conditions[1]

Commodity	Current Production Areas		
	Small farm	Large farm	Frontier Land[2]
Wheat	x	xxx	–
Maize	xxx	xx	–
Rice	x	xxx	xx
Sorghum	–	xxx	?
Cassava	xxx	–	xx
Potatoes	xxx	?	–
Plantain	xxx	–	–
Beans	xxx	x	–
Soybeans	–	xxx	?
Sugar	x	xxx	–
Beef	–	xx	xxx
Swine	x	xxx	–
Poultry	–	xxx	–
Milk			
Dual purpose	xxx	x	x
Specialized	xx	xxx	–

1/ Crosses represent relative comparative advantage based on evaluation for yield potential, labor versus capital intensity, and expansion potential.

2/ Predominantly acid, infertile soils.

1.2 The Goals in a Nutritional and Demand Context

In developing market economies price is a fundamental determinant of food production levels, rural incomes, and nutrition. However, improving price incentives to farmers is often in conflict with cheap food staples for urban areas. Agricultural technology provides a potential wedge in the market mechanism allowing price reductions to consumers through cost reductions at the farm level. Maximizing the impact of new technology on nutrition will depend on understanding food consumption patterns, particularly of the poor.

1.2.1 Nutritional Deficiencies

In Latin America the most pressing nutritional problem is inadequate caloric consumption among large sectors of the population (Appendix 2). Protein deficits are also encountered and are especially serious in vulnerable groups, such as low income children and pregnant women.

Nevertheless, calorie inadequacies must first be overcome or protein additions will principally--and therefore inefficiently--be utilized as energy source. In fact, where calories are limiting in the diet, a percentage change in calories will have a greater positive effect on nitrogen balance than a proportionate change in (more expensive) protein.

The true magnitude of the problem, however, is hidden when national averages of per capita availability of calories and protein are used. Figures have more meaning when expressed as a percentage of the population with diets below the minimum requirements. Using such an indicator, the extent of the caloric deficits in Latin America appears to be indeed staggering (Appendix 3). It ranges from one-third of the population in Chile and Uruguay to over two-thirds in Guatemala. Inadequate calorie-protein availability not only implies reduced energy levels but also can result in permanent damage in vulnerable groups such as growing children. Future investments in human capital, such as health, education and training, cannot substitute for or undo human capital deterioration resulting from inadequate diets in the early years of growth. Hence, improving nutrition of major segments of the population must be a principal concern of most Latin American governments to prevent human capital deterioration of their future work force.

Increasing income, i.e., an employment policy, is the most direct means of correcting nutritional inadequacies. The magnitude of the problem is too immediate to rely only on the longer term nature of such strategies. Necessary complements are to identify and increase production of cheaper nutrient sources, and to utilize appropriate policies to increase the caloric and protein intake of the population strata with deficits. Understanding the Latin American diet, and its diversity, is thus a necessary starting point in ascertaining the relevance of commodity choice for agricultural research and its ultimate impact on nutrition.

1.2.2 Subregional Importance of Major Staples

Latin American food consumption patterns vary substantially between regions. A consistently major source of calories in the Latin American diet is sugar, strictly a calorie source but important because of its low cost (Appendix 4). Maize is of considerable importance in Mexico, Central America and some Andean countries, but of lesser importance in the rest of Latin America and the Caribbean. Wheat is important in all regions but only in the Southern Cone dominates as the principal caloric source. Rice provided in 1972-74 over 12% of the calories in the Caribbean, Colombia and Brazil. Cassava provided over 9% of the calories in Brazil and Paraguay (Appendix 4). Beef was an important source of calories in the Southern Cone and Paraguay and of protein in most of Latin America (Appendix 5). Beans provided over 10% of the proteins in Mexico, Central America, Paraguay and Brazil.

In summary, from the aggregate food consumption pattern no one staple can be singled out as dominating across Latin American countries as the major source of calories and protein.

1.2.3 Diversity in the Diet

In the rural sector, major sources of calories vary according to local supplies, which in turn vary widely throughout the region due to the extreme variability in edaphic and climatic circumstances. In the urban sector, large variance is observed in the food expenditures of the lowest income strata across cities and subregions (Appendices 6 and 7). Consumer budget data from ten Andean cities (1967-1969) show that 15 to 30% of food expenditures of the lowest income categories were in beef and milk. Moreover, these percentage expenditure allocations were maintained over the income categories. Beef was not only a preferred food in the Andean cities but the urban poor allocated a major portion of their food budget to a predominately protein source. However, the principal nutrient deficiency is calories. Sugar and rice were also consistently important expenditure items in most of the Andean cities, but could not be said to dominate in total expenditures on caloric staples. Other sub-regionally important commodities in the food budget of the urban poor were wheat products, corn, beans, cassava and potatoes, but again there existed no single dominant staple. Diversity of the diet and subregional importance of the principal staples, are thus also major characteristics in the case of the urban poor.

1.2.4 Technology and Nutrition

Agricultural technologies can have indirect effects on the diet of the low income urban population through their effect on food prices. Declining food prices are desirable in this context, but product prices must also give proper production incentives to farmers. New technology can mediate these two conflicting roles of price in the market, but rately will benefits be equally shared between both consumers and producers. If improving welfare of consumer has the higher policy weight, then choice of commodity should focus on non-exported food staples, in which quantity demanded is relatively unresponsive to changes in price or income. Quite naturally these commodities tend to be the principal food staples of the poor.

The case of the northeast of Brazil, containing the largest population concentration with nutritional problems in Latin America, could illustrate the case. Cassava flour, beans/cowpeas[1], and rice are the principal sources of energy contributing more than 50% of the calories in the yet insufficient diet (Appendix 8). Bean/cowpeas were as important as meats and fish together as a source of protein (Appendix 9). Cassava flour, beans/cowpeas and rice were among the cheapest sources of calories and protein. The fact that in this region expenditure in these commodities increases with income (Appendix 7), is indirect evidence that larger amounts of these specific commodities will be demanded by the low income consumers if prices are brought down further. Here is where agricultural technology has an important role in reducing nutritional deficits in a region with acute nutritional problems. Moreover, in this particular case the balance of beans or cowpeas with cassava helps offset the lower protein composition of cassava as compared with the cereals. Policies to stimulate production and consumption of these lowest cost nutrient sources would be expected to have a much more rapid effect in eliminating nutritional deficits than the gradual shift to higher consumption levels of other high quality, high nutrient cost foods.

1.2.5 Demand Growth

As a direct consequence of the high rate of growth of population and the increase in income, aggregate demand for food in Latin America is growing at 3.6% per annum, a rate consistent with the growth in total food production (Table 1.2). This balance is only apparent since: (a) in 16 out of 21 countries food production growth lagged behind demand (Appendix 10); (b) in most countries nutritional problems have continued, if

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[1] Close substitutes in northeast Brazil, statistically reported together.

Table 1.2 Various indicators of growth and importance of selected commodities in the Latin American food economy, 1960-1978.

	Growth in demand	Growth in production	Growth in area	Growth in yields	Total Production[a]		Contribution to total calorie Consumption	Contribution to total protein Consumption	Percent of food budget spent by lowest income strata	
	P	E	R	C	E	N	T		Andean cities[b]	NE Brazil[c]
Wheat	3.4	1.9	1.4	0.6	-	8	18	15	4-17	4
Maize	-	2.8	1.1	1.7	-	40	16	15	0-6	3
Sorghum	-	12.5	9.2	3.3	-	9	-	-	-	-
Rice	3.5	3.3	2.8	0.5	-	18	9	7	2-14	7
Potatoes	3.3	2.3	0.0	2.4	-	3	2	2	{2-11}	-
Cassava	2.4	1.9	2.4	-0.5	-	17	4	-		12
Total pulses	3.0	1.4	1.7	-0.3	-	6	5	13	1-7	16
Beans	3.0	0.3	1.1	-0.8	-	5	3	11	n.a.	n.a.
Beef	5.4	3.4	-	-	58	-	5	14	9-24	9
Pork	4.5	4.1	-	-	22	-	1	4	0-2	5
Chicken	6.1	9.5[d]	-	-	20	-	1	3	0-3	3
Milk	5.5	3.9	-	-	-	-	6	12	6-18	4
Agricultural Sector	3.6	3.5	2.0	1.5	100	100	-	-	-	-

[a] Tropical countries only; 1978 data. First column includes cereals, grains, root and tubers all expressed in cereal equivalents. Second column includes only meats expressed in carcass weight.

[b] Ranges for 12 Andean cities for period 1968-72 (Source: Appendix 6)

[c] 1975 (Source: Apendix 7)

[d] 1970-78

Source: Unless otherwise indicated estimates are from FAO Production Tapes, and FAO Food Balance Sheets for 1972-74.

not worsened, since growth in production of major staples lagged behind demand; and (c) those commodities in which production increased most rapidly (export crops, feed grains and poultry), had more impact on the diet of the middle and high income strata than on the diet of the poor, where the bulk of the nutritional problems lie (Appendices 6 and 7).

Given the skewed income distribution in Latin America[1], income growth has resulted in the highest demand growth for those food commodities most preferred by the middle and high income strata. As a response to high demand growth, production of those commodities has increased rapidly, sometimes at the expense of more basic food crops. Such is the case of poultry and, indirectly, of feed grains. The annual growth rate of poultry production was 9.5% from 1970-78 in Latin America as compared with 3% in the U.S. Production growth of sorghum and soybeans for feed, exports, and soybean oil was even more rapid[2]. The dramatic expansion of soybeans in the Brazilian south helped push bean production into more marginal areas. In Brazil and Mexico 44 and 32% of food crop utilization in 1972-74 was for animal feed[3]. Over the period 1961-65 to 1974-76 maize accounted for more than one half of the production growth of food staples in Brazil whereas sorghum was responsible for nearly one-half of the increase in Mexico[3].

From 1961-65 to 1974-76 the Brazilian growth rate in the use of cereals for feed was 6.3% and the Mexican growth rate was 16.4%. In developing countries with rapid increases in incomes the total use of cereals for livestock feed has increased considerably faster than the use of cereals for human consumption.

In summary, in response to a higher growth rate of demand due to higher purchasing power of the middle and high income groups and to high export demand, production is growing faster in the case of poultry, feed grains and export crops than in the case of calorie and protein staples. Production is substantially lagging behind demand growth in the case of maize for direct consumption, wheat, rice, cassava, beans and beef.

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1 Jain, Shail, Size Distribution of Income: A compilation of data, the World Bank, Washington, D.C., 1975.

2 CIAT, Latin America: Trend Highlights for CIAT Commodities, Internal Document Econ. 1.5, April 1980, pp. 77-134.

3 K.L. Bachman and L.A. Paulino, Rapid Food Production Growth in Selected Developing Countries: A Comparative Analysis of Underlying Trends, 1971-76, Research Report 11, International Food Policy Research (IFPRI), October 1979, p. 30.

1.2.6 Priority on Major Staples

In Table 1.3 a ranking of the principal Latin American commodities from both the nutritional and demand growth perspective is summarized. Both wheat and maize are important as caloric sources and their demand is increasing for food and feed, respectively. Rice, beef and milk are already important in providing calories and proteins in most of Latin America. Moreover, a rapid demand increase is expected for these commodities, especially beef. Cassava and cassava flour are extremely low cost calorie sources and important sources of calories in Brazil and Paraguay, countries which account for 40 percent of the population in tropical Latin America. Countries implementing nutritional programs for their lowest income sectors could take advantage of the low cost of calories from this crop and cassava's potential to be produced on less fertile soils. With technological change in marketing and/or processing fresh cassava may have a future potential growth as a food and/or feed. Beans are important sub-regionally for protein and are the lowest cost protein source. Beans could be an important complement to a nutritional program aimed at increasing cassava consumption since protein deficits become an important concern once calorie deficits have been overcome. Rising bean prices in many countries indicate that demand growth is exceeding that of supply in recent years. Finally, the fastest growing demand is for poultry, substantially affecting the derived demand for sorghum and soybeans. However, the combined impact of growth in poultry and feed grains on relieving nutritional problems is not as high as in the case of the more basic staples, viz., maize, wheat, rice, cassava, beans, beef and milk.

1.3 Commodity Choice and Research Strategy

As discussed in Section 1.1. within the Latin American agricultural sector there is a substantial heterogeneity in farm units in terms of land/labor ratios. This results in substantial heterogeneity in production technologies, a certain crop specialization by farm size, and differential retunrs to production resources across farm size units. Within this highly skewed land distribution a dynamic large farm sector has either emerged (aided by subsidized mechanization schemes), or lies latent. This dynamism can produce conditions in which competition drives less efficient farmers or less productive labor out of the agricultural sector. Very rapid rural-to-urban migration has characterized Latin American economies, requiring substantial investments in social infrastructure and in many cases swamping urban employment generating capacity. Moreover, a substantial portion of the rural-to-urban migrations enter into the low-productivity service sector, often with a decline in nutritional status. Thus a labor-intensive, small farm development strategy is a necessary complement to the dynamic large farm sector. The two strategies will

Table 1.3 Summary evaluation of the principal commodities based on nutritional importance and expected demand growth[a]

	Important Calorie Source in Latin America	Sub Regionally Important Calorie Source	Important Protein Component in Latin America	Sub Regionally Important Protein Source	Low cost Calorie Source	Low cost Protein Source	Rapid demand Expansion for Food	Rapid demand Expansion for Feed
Sugar	X				X			
Rice		X		X			X	
Maize		X		X				X
Wheat	X		X				X	
Sorghum								X
Potatoes		X					X	
Cassava								
Dried		X			X			P*
Fresh		(X)**					P	
Field Beans				X		X	X	
Soybeans								X
Beef		X	X				X	
Milk		X	X				X	

[a] Based on Appendices 1-10. * P: Potential Importance ** ( ): Few countries only

be more consistent with each other if competition is minimized, i.e., if the two sectors of small and large farms do not effectively compete in the same commodity market.

Targeting technology impact to small-scale farmers requires the existence of crops in which these farmers have a comparative advantage and the design of technologies which maintains this comparative advantage. However, the impact of food production and price will obviously be much more limited than if larger farmers were as well drawn into production. Thus, some concern must be given for the importance of these commodities in the diets of the urban poor, since there exist trade-offs between benefits for the rural vs. the urban poor. The Latin American diet is marked by substantial variability between regions. Maize, whear, rice, cassava, sugar, beans, and beef are all important sources of calories and protein, but the degree of importance varies by region. Depending on the region, the choice of any one of these food staples will have an impact on the nutrition of the poor through technology introduction.

If new agricultural technology is to contribute simultaneously to growth and equity goals, research cannot concentrate on only once crop, one ecosystem, or one particular group. As the above discussion has highlighted a consistent crop selection and research strategy is required if CIAT is to contribute to impact or growth, income, and nutrition goals.

It is recognized that due to the heterogeneity of Latin American agriculture there is no one crop that could contribute significantly to total agricultural production and, simultaneously, significantly affect the rural and urban poor (Table 1.3), as it is the case of rice in Asia. In chosing to do research on a portfolio of crops CIAT attempted to chose crops in which, by complementing national and other international research institutions, the total contribution to the socio-economic goals is highest. A first requirement was that these should be predominately food staples. Secondly, the choice of crops should be such that some provide for an increase in the productivity of small farmers and their income, while others should contribute to the expansion of agricultural production on both good lands and on the frontier. These research thrusts are reflected in the division of CIAT into crop research and land systems research. The consistency of the strategy is in fact built around the Center's choice of crops: beans, cassava, rice, and tropical pastures for the acid, infertile soils.

Each has regional importance as a calorie and/or protein source. In terms of contributing to the major nutrition problem (i.e., calories), maize, wheat, or sugar would have been other possible choices. The first two are under the mandate of CIMMYT. Sugar, on the other hand, is already the lowest cost calorie source in the diet partially reflecting the large investment in research that has already gone into this crop. Other possible crops important from the production point of view, but of lesser significance in achieving the overall socio-economic goals, are sorghum and soybeans. These crops, however, are not food staples (except soybean oil) and would tend to benefit more the middle and high income consumers and large farm producers. These crops are, however, displacing other feed and food crops grown in good lands. Given CIAT's size and budgetary limitations, and the early state of technology development in the four current programs, it is too early to consider adding any of these commodities as core funded programs at this time. However, special projects with the specific goals of developing varieties of sorghum and soybeans adapted to the acid soils could be hosted inasmuch they are also consistent with socio-economic goals and complementary alternatives to upland rice, cassava and tropical pastures for the frontier areas. A possible CIAT involvement with these crops is discussed in Chapter 6.

A brief description follows as to why CIAT's portfolio of crops provides the best balance in meeting both production and nutrition goals in Latin America and how the research strategies in each case is consistent with the overall socio-economic goals.

1.3.1 Tropical Pastures

Beef is a principal part of the Latin American diet and forms a major portion of the food budget, even among the poor. Demand for beef in Latin America is increasing at a rate that is far outrunning growth in production. Moreover, beef is an extensively produced commodity and the production systems do not require well-developed infrastructure for inputs or marketing outputs. In terms of fostering expansion at the frontier, beef production is a logical choice.

The research strategy of the Tropical Pastures Program has focuses on relieving the principal constraints to extensive beef production systems in the acid, infertile soils of Latin America, with emphasis on the savanna regions. The constraints lay primarily in the low nutrient production of the pasture system, especially in the dry season. The search for adapted and more productive grass and legume species was considered to be the key to developing a low-cost, minimal input technology for these areas.

1.3.2 Cassava

Cassava is a traditional calorie source of the rural population in Latin America but has limited importance in urban areas, except where consumed as a flour, especially in Brazil. The plant is extremely efficient in the production of carbohydrates and is particularly well adapted to more marginal agricultural conditions. Its low purchased input requirements, relatively high labor requirement, adaptability to intercropping systems, and flexible harvest period result in production originating from small farm systems. Given that demand is sufficiently elastic, the crop is ideally suited to intensifying small-farm production systems. The potential for developing alternative end uses for cassava, such as starch as a carbohydrate source in animal feed, and as raw material for ethanol production, appear to guarantee this market elasticity. Competitiveness in these markets, however, appears to be dependent on lower production costs, that is, improved production technology.

The research strategy in the Cassava Program has three principal thrusts: (a) development of low-cost, minimum input technology, particularly directed at small farmers; (b) research on developing cassava as a crop for expansion onto the frontier; and (c) research on more efficient processing and utilization technologies. The Program combines research on both production and utilization technologies, since a primary constraint in cassava production systems is its rapid perishability after harvest, as well as to insure that processing technologies are of a sufficiently small scale to allow resource poor farmers access to end markets. As such, cassava is one of the few crops through which improved technology can result in increased productivity of small farm systems in more marginal production zones.

1.3.3 Beans

Beans are an important protein source particularly in Brazil, Mexico and Central America where they constitute between 10-20% of the proteins (Appendix Table 5). Bean production is stagnant in Latin America, with area expansion utilized to compensate for yield declines in most countries, especially Brazil. Most bean production comes from the small farm sector, where beans are typically produced in association with other crops, principally maize, and on the poorer lands. The maize bean association is labor intensive but gives high returns per unit land area.

Bean productivity is low as a broad spectrum of insects and diseases attack this crop. Due to the devastating nature of many bean diseases farmers often prefer to plant beans in marginal rainfall conditions. Moreover, governments seldom provide adequate price supports or other financial incentives to bean producers. As a consequence of thes physical and economic factors discouraging bean production, few farmers are prepared to use expensive inputs such as fertilizers or chemicals for disease control; hence, yields are low. Yields and returns have been so low that beans have been displaced from former production areas (such as parts of southern Brazil and the Cauca Valley in Colombia) by more profitable crops. In the last decade bean yields in most Latin American countries have been declining due to these crop shifts and the inability to maintain even low yields at the extremely low levels of input use.

The research strategy of the Bean Program is to increase bean productivity through the incorporation of multiple disease resistance into commercial cultivars. Tolerance to drought and moderately low fertility levels is also sought. The search for cultivars able to fix atmospheric nitrogen is also emphasized. The Bean Program strategy focuses on stabilizing and increasing bean yields without major increases in purchased inputs. Nevertheless, once new varieties are available moderately increased input levels will be economically feasible due to higher potential yields and reduced yield variance. The emphasis of the strategy is on obtaining production increases without major increases in input costs so that the principal producer of beans will remain the small farmer.

As a large part of bean production comes from climbing beans, which are almost entirely produced in association or in relay with maize, the Program is dedicating a considerable effort to the improvement of beans in association, while maintaining maize yields. Such technology is again most appropriate for the small farmers due to its very high labor requirements.

1.3.4 Rice

Rice is a major calorie staple in the Caribbean, Brazil and many countries of the Andean Zone. In most of tropical Latin America, rice consumption has been increasing as a rapidly urbanizing population has shifted from other staples to rice as a principal calorie source. This process has been hastened by the stable (or even declining) relative price of rice, as production has kept up with demand growth in most Latin American countries. In many cases this rapid production growth has been as a result of the introduction of improved varieties, combined with rapid adoption by mechanized farmers in favored rice areas.

Rice is predominantly a large farmer crop but there is nevertheless large a diversity in the types of production systems utilized, varying between intensive irrigated systems to extensive upland systems on the frontier. Average yields in the different systems vary markedly. The principal factor determining the type of system is the rainfall pattern and possibilities of improved water management. The relevant issue for most rice producing countries is the choice of system in which to invest research resources. The new technology has primarily benefited the irrigated sector and farm yields are rapidly reaching the feasible yield potential of the current technology. Future yield increments in this sector will not be as dramatic. For maintaining growth in rice production the investment issue centers around the benefit cost ratio of investing in, and expanding irrigated land vis-a-vis raising productivity of upland production. The potential for meeting increased rice demand from irrigated areas from upland areas varies among countries.

CIAT's Rice Program recognizes the need to focus on research for both irrigated and upland conditions. For irrigated rice, the largest yield gains have already been made in most countries and the focus will principally be on maintenance research, and in basic research to develop rice blast and Sogatodes leaf hopper resistance. The upland research, on the other hand, will concentrate on selecting for adaptation to stresses characteristic of upland conditions. This research will focus on those upland areas with a more stable rainfall regime, where the chances of achieving a significant yield increment are the highest. The upland research strategy focuses on the utilization of land at the crop frontier which will be grown under relatively extensive, mechanized conditions.

Chapter 2: THE PLANNING CONTEXT: THE ROLE OF CIAT

Effective agricultural research is a continuum, encompassing that range of activities from basic research, such as genetic engineering, to monitoring of farmer adoption of improved varieties and cultural pactices. This research continuum encompasses a complex of interacting institutions, running the gamut from basic to applied research, and from research to extension activities. The International Centers occupy a particular niche in this institutionsl complex. They in effect provide the institutional link between basic research and the applied research and extension urgently needed for tropical conditions.

This translation of science into practical technology requires a relatively long-term commitment of resources, relatively large start-up costs, an effective "critical mass" of research scientists, and decision-making free from the compromise and vested interests of the political process. The international research center combines these attributes with the potential economies of scale inherent in plant breeding, i.e., the assembly of large germplasm banks, large scale screening, crossing, and selection, and multi-disciplinary evaluation. These economies of scale, however, do not extend to most agronomic research, extension, or fine tuning of the plant breeding process. International Centers are thus only effective if working in tandem with well-organized national programs.

Resources for agricultural research are limited. National research programs cannot systematically work on all crops for the totality of ecosystems that exist. Priorities are often set by the more powerful forces in the economy. International centers help to overcome what is a persistent public resource constraint in developing countries. Moreover, their international focus allows them to compensate for biases in technology development and institutional organization. The comparative advantage of an international center such as CIAT lies in compensating for the underinvestment in several critical technological and institutional areas, which have become second priority to more dominate concerns.

2.1 CIAT's Role in Technology Development

Given the above mentioned underinvestment, CIAT's comparative advantage in the Latin American context lies in technology development in three basic areas.

2.1.1 Focus on Basic Food Commodities

Agricultural research in Latin America has focused on the more dynamic growth sectors in the agricultural economy, essentially the medium to large farm sector. Before the development of a large domestic urban market, growth came in tropical export crops, such as sugar cane, cotton, coffee, cacao, and rubber. It was these crops which received the bulk of the research resources. With the rapid urbanization of the last three decades and the orientation to import-substitution development schemes, the principal growth sectors have shifted to highly income elastic food and feed crops, again principally associated with large-scale mechanized production patterns (see 1.1.3.). Thus, past efforts have given relatively little attention to the crops which are the most important sources of calories and protein for the largest number of peoples and serve as a source of income to the largest number of farmers. The international centers, as they are able to concentrate on these commodities, can make a unique contribution towards overcoming the large knowledge gap which still exists on the basic food crops, particularly when they are grown by low resource farmers.

2.1.2 Technology Development for Low Resource Farmers

Compounding the paucity of research on basic food crops is the fact that, in many cases, the relatively little research done on these crops has been conducted under experiment stations conditions approaching more closely conditions of large, mechanized, irrigated farms. CIAT's emphasis on technology appropriate for use under the constraints faced by small farmers, and its cooperation with national programs in strengthening and developing methodology for on-farm evaluation of technology, allow the Center to pay a special role in developing technology for farmers with limited resources and for the less favored environments.

2.1.3 Technology Development for Expansion of the Frontier

There is also a lack of technology which will make possible the rational expansion into the frontier areas of tropical America. The low natural fertility of the soils together with a series of more localized problems are the chief reasons why these vast areas (approximately 50% of tropical America) still remain significantly underutilized. As an international center, CIAT can and must look towards the longer term future as well as the immediate needs and therefore has a comparative advantage in developing appropriate technology which will make possible logically sound and more intensive utilization of those areas apt for livestock production, eventually combined with crop production, in the frontier regions.

2.2 CIAT's Role in Overcoming Institutional Constraints

Solution of the technical constraints for improving agricultural productivity is often inhibited by institutional barriers. An international center, both by its additionality to the resource mix, as well as by the flexibility and agility resulting from its apolitical, non-governmental nature, can contribute in various ways to overcoming some of these institutional constraints. These include:

2.2.1 Investment Level and Priority Definition in Agricultural Research

There is ample, documented evidence that agricultural research plays an important role in agricultural development and that this is a highly profitable venture. This recognition has been reflected in the fact that agricultural research expenditures in Latin America have increased from US$61 million in 1965 to US$129 million in 1974. Nevertheless, in 1975, Latin America ranked last among the regions of the world in terms of research expenditures as a percentage of the value of agricultural products produced (Appendix 11). International funding for CIAT can contribute to the increase in total investment in agricultural research for the region, since most contributions to the Center come from sources which are not competitive with those funding other agricultural research institutions in the region.

The positive results coming out of collaborative efforts between CIAT and national programs can also stimulate national planning and treasury officials to recognize the value of agricultural research and increase the relative levels of funding for national research institutions. Additionally, there is an evident tendency by international organization to increase the level of their loan and technical assistance support for national agricultural research systems as they recognize the importance of having strong national institutions to most profitably cooperate with the international centers. Thus, the role of CIAT is additive as well as stimulative and catalytic in increasing investment in this important and profitable area to a more reasonable level. Moreover, there exist large economies of scales in research at a certain level of the research continuum. This level depends on the degree of development and self-sufficiency of each and all national programs in each crop or commodity. Avoiding unnecessary duplications in many small scale programs will certainly allow for a more cost effective utilization of the total limited resources available.

While there are understandable pressures for national institutions to spread their research efforts over a broad range of export, plantation and food commodities, the international centers are concentrating only on basic foods and through division of labors between individual centers have the luxury of focusing their efforts on only a few commodities.

Thus, CIAT, by maintaining a sharp focus on only a few crops, can make more rapid progress in developing technology for these commodities. By demonstrating the usefulness of concentration it can also have a catalytic effect in helping national programs establish clearer priorities, and thus avoid the dangers of over-diversification.

2.2.2 Building Human Capital

The insufficiency of qualified manpower is one of the most serious limiting factors in development of new technology. Data in Appendix 12 supports the belief that Latin America as a region has a low level of human resource available for research and extension in terms of man-years of scientists and extension workers, relative to the value of agricultural products produced. The major responsibility for increasing numbers of trained agricultural scientists must continue to lie with the universities in the region. Provision of scholarships for higher degree training should remain the responsibility of national programs with the support of donor institutions. CIAT has a comparative advantage in providing postgraduate training in specialized commodity areas and thus increasing the human capital available in these particular areas. By stimulating better support and prestige for agricultural research it can also be catalytic in improving working conditions and remuneration to help overcome the brain drain which often aggravates the manpower supply problems.

2.2.3 Stimulating Better Orientation of Research and Training

Some research institutions emphasize academic, publication-oriented disciplinary research. This is particularly true in universities, and thus affects a large portion of the valuable human capital available for agricultural research as well as orientation and quality of professionals trained in these institutions. As a center of excellence emphasizing problem solving, production-oriented, inter-disciplinary research, CIAT can make a special contribution towards demonstrating that practical research can also be highly stimulating and intellectually rewarding. By collaborating closely with Latin American universities, especially in the area of thesis research for higher degrees given by these universities, CIAT can help strengthen the applied orientation of the research in university institutions as well as of the manpower they produce.

2.2.4 Strengthening the Links Between Research and Extension

In some Latin American institutions agricultural research and agricultural extension are well integrated; however, in many countries these activities have developed and continue to operate independently. While CIAT is not actively engaged in agricultural extension its emphasis on collaborative activities with national institutions for on-farm evaluation, its training extension specialists in selected commodities, and its collaboration with national programs in developing in-country training, can help build the bridge between these two important functions.

Chapter 3: CIAT HISTORY AND ACHIEVEMENTS

The agreement between the Colombian government and the Rockefeller Foundation to found CIAT was dated 12 May, 1967. The first Board of Trustees was held on 17 October, 1967. The official Colombian government decree establishing CIAT as an institution was dated 4 November, 1967. Facilities of CIAT's headquarters were dedicated on 12 October, 1973. At that time its core senior staff numbered 39 (about one hald of 1981 figures). Thus, a large portion of CIAT's current program activities are ten years old or less.

Fundamental to the various research and training achievements summarized at the end of this Chapter (3.4) and of special importance in establishing the basis for a long-range plan for the '80s, are the achievements of an institutional nature which have been accomplished since CIAT's inception. These relate to sharpening of program focus, development of policies and development of facilities and institutional relationships.

3.1 Evolution of CIAT mandate

3.1.1 The Original Broad Base

Thanks to a very active and interested Boars of Trustees, which has continually insisted on rigor of analysis and increasing clarity of objectives, much progress has been made in the development of a clear Center philosophy and a sharpening of focus from the very broad base with which CIAT began.

The successes in the mid-1960s of the International Rice Research Institute, IRRI, in the Philippines and of the Centro Internacional de Mejoramiento de Maiz y Trigo, CIMMYT, together with the pending establishment of an International Institute for Tropical Agriculture, IITA, in Nigeria, prompted the Ford and Rockefeller Foundations to consider the problems of the hot tropics of Latin America. Dr. Lowell S. Hardin (Ford Foundation) and Dr. Lewis M. Roberts (Rockefeller Foundation) were commissioned by their foundations jointly to study the problems of agricultural productivity in that area and to recommend a course of action. The result of this study was the document "A Proposal for Creating an International Institute for Agriculture Research and Training to Serve the Lowland Tropical Regions of the Americas", written by Roberts and Hardin and dated October 1966. The document commented on the variety of ecological zones of the Latin American Tropics. It divided the area into three classes, viz.,

a) favorable-these have unexploited potential and include the northern coastal plains of Colombia, the Caribbean and Pacific littorals of

Mexico and Central America, the Pacific Coast of Ecuador and Eastern Andean slopes between 500 and 1000 meters from Venezuela to Bolivia.

b) unfavorable- the hot humid jungles of the Amazon and Orinoco basin and Colombian Pacific coast.

c) unclassified- the central plateau of Brazil and the Llanos of Venezuela and Colombia.

In addition the Roberts and Hardin paper identified high priority problems for the institute's attention. This extensive list of commodity and production system responsibilities is shown in relation to the discussion of subsequent modifications in section 3.1.2.

The report also stated that "the proposed Institute would follow in many respects the successful International Rice Research Institute model," but then says, "the Latin American Institute would not be concerned with a single crop or enterprise. It would concentrate on the identification and solution of tropical crop and livestock production and distribution problems and on the training of people in a problem-solving research and educational environment".

Thus, the concept of the institute seemed to embrace both an ecological base multi-commodity base. However, it is also apparent that the authors recognized the complexity of an ecological mandate for an institute and opted for a set of commodities as the means of moving agricultural productivity within the ecological zone.

Following the establishment of CIAT and appointment of its first Board of Trustees, the programmatic scope and operational philosophy of the Center were defined in greater detail by the management and the Board. Initially, this resulted in somewhat of an expansion of the scope envisaged by Roberts and Hardin. Thus, a broad foundation of development goals, geographic and ecosystem scope and commodity responsibilities was laid down in the first years of CIAT's existence. This provided the base on which the Center could, with experience and further studies, build a solid, smaller edifice.

3.1.2 Refinement of the Mandate

Since the earliest years a progressive refinement of CIAT's objectives and scope of activities has characterized the Center's development. This has resulted in a marked reduction in the number of commodities covered; a clarification and sharpening of the program strategies and priorities; and a narrowing of the geographic and ecological focus. The current objectives and strategies are spelled out in Chapter 4. The modifications to the program responsibilities from those originally envisaged by Roberts and Hardin are summarized in Table 3.1.

Such major refinements and re-definitions of programs have not come about easily nor capriciously. As important as the actual changes made has been the evolution of the way in which the cooperating institutions, the Center staff and management, and the CIAT Board interact in the making important policy decisions. These are discussed in the following section.

3.1.3 Mechanisms for Program Review and Modification

3.1.3.1 LDC participation. The views of the scientists and policy makers of the chief collaborators and clients for CIAT's products, i.e., the cooperating institutions in the countries CIAT serves, play a vital role in the development of policies and operationsl procedures of CIAT. Over the years various mechanisms have been developed to facilitate this essential input. These include:

a) Board membership. A high proportion of the members of the CIAT Board of Trustees are from tropical, developing countries, especially Latin America.

b) Senior staff selection. Nearly one half of CIAT's senior staff are citizens of tropical, developing countries, and thus, bring with them an intimate knowledge of LDC production problems and requirements.

c) Consultation travel. CIAT staff travel extensively in the course of their work and thus consult frequently with colleagues on research priorities and government policies.

d) Policy level consultation. CIAT regularly organizes seminars to which cooperating institution leaders are invited and at which their views are sought regarding ways in which CIAT can improve the effectiveness in its technology generation and international cooperation activities. These are basically of the two types:

   1) Seminars on advances in research- at which the CIAT programs present their results and plans and seek suggestions for changes.

   2) Special topic workshops- such as one held in November, 1977, on rice, at which rice research leaders from throughout tropical America were invited to advise the Center on the future nature of its Rice Program activities, and from which came the recom-

Table 3.1 Development of Program Mandate of CIAT.

Roberts and Hardin Recommendations	Subsequent Developments
(1) Top priority to be given to one or more grain legume crops such as soybeans, beans, cowpeas and pigeon peas.	(1) It was decided to concentrate all efforts on the common bean, Phaseolus vulgaris.
(2) "Corn and rice are of primary importance and should be investigated cooperatively with CIMMYT and IRRI, respectively, with the institute serving as a headquarters for collaborative work".	(2) The original maize program was dissolved in favor of a collaborative program with CIMMYT by which CIMMYT staff stationed at CIAT would work with national programs in the development and transfer of maize technology for the Andean zone. IRRI stationed a "Liaison Scientist" with CIAT with responsibilities within the CIAT Rice Program, for coordination of International Rice Testing Program activities in Latin America. IRRI and CIAT agreed that all their rice activities in Latin America would be conducted in close collaboration.
(3) "Livestock work would concentrate on ruminants with emphasis on study and prevention of diseases; nutrition; forage production, and the economics of various systems of husbandry under tropical conditions."	(3) Non ruminants were added to this set of activities by the start of a Swine Program in 1969. In 1975 the Board considered that the research component of this program had achieved its objectives and decided to reduce the staff and concentrate on technology transfer activities. These were successfully executed and the program phased out entirely at the end of 1979. After several external reviews and several position papers, the Board decided to restrict the geographic/ecosystem scope of the Beef Program to the acid, infertile soil regions of Latin America, with major emphasis on developing improved, legume-based pastures for this area. The program subsequently was re-named the Tropical Pastures Program.
(4) "The institute should look further to the development of proper cropping patterns or systems of rotation."	(4) This led in 1973 to the establishment of the Agricultural Systems Program (Later re-named as the Small Farm Systems Program) which was constituted to analyze farming systems so as to assist in the rapid adoption of improved technology. Following a special workshop in 1975 and its report on this set of activities, it was agreed that the responsibility for the incorporation of commodity technology into farming systems should rest with each commodity program. Accordingly, the following recommendations were accepted: (a) that the Small Farms System Program be phased out; (b) that an economist and an outreach agronomist be added to each of the three major commodity programs (i.e., cassava, beans, and beef); and (c) creation of an Agricultural Production System Coordination Group to oversee those inter-related studies that are not the responsibility of a particular commodity. The TAC Stripe Review of Farming Systems Research in 1978 endorsed this decision, indicating that farming systems research was indeed being carried out within the existing commodity programs of CIAT, as these were essentially developing components for whole farm systems.
(5) "Additional crops or categories of crops that are important and which may receive additional attention are: root crops - cassava, yams and sweet potatoes vegetables tropical fruits - plantains and citrus fruits"	(5) It was decided that of this wide range of possible commodities CIAT would concentrate its efforts on a single root crop, cassava.

mendation that CIAT begin work on Upland Rice.

e) Program level consultation. Each commodity program organizes periodic workshops with cooperators in testing networks or with cooperators on specific research topics, and in which the cooperators have an important voice in the design and future plans of cooperative testing, and on CIAT program strategies.

3.1.3.2 CIAT staff and management involvement. While priority setting and program planning is a day-to-day activity of Center staff, and is periodically formalized in the Biennial Program and Budget proposals, there are two sets of activities which merit special mention in relation to the interaction of Center staff with the Board in the development of Center policies. These are:

a) Annual program review. This is basically an internal, peer review at which all senior staff contribute to discussions of results and plans of all programs. The methodology for such reviews has evolved at CIAT so that a very frank, constructive and critical discussion takes place. The Program Committee of the Board attends and participates in these reviews.

b) Position papers. The CIAT Board has frequently used the mechanism of requesting the management to present a "position paper" when faced with questions of a policy nature regarding any of CIAT's program activities. These are normally prepared in draft by the program concerned, then submitted to peer review at an internal workshop. Sometimes an external review or a special workshop with outside consultants have been used to help define positions. Finally, the management presents the position paper to the Board, normally through the Program Committee, an important arm of the Board discussed below.

3.1.3.3 Program Committee of Board of Trustees. In 1974 the Board of Trustees established a Program Committee as a standing committee of the Board to report and advise the Board on matters concerned with the program of the Center. Specifically, the Program Committee was charged with the responsibility of advising the Board on the broad problems of research strategy of the Center and on research requirements, particularly staffing as it affects the budget.

3.2 Institutional Developments

3.2.1 Program Organization

Initially the Center's research activities were made up of commodity programs staffed by personnel organized in disciplinary groups, with an individual scientist's time often budgeted in fractions of man-years in each of several programs. Through several management and budgetary steps the staff has now been organized so as to place program scientists entirely in one commodity or another, with management of each multidisciplinary commodity team clearly the responsibility of the respective Program Coordinator. Important changes integrating the Center's training activities more fully into its respective commodity programs have also taken place. These are described more fully in Chapter 7.

3.2.2 Administrative Organization

Several changes in the organizational structure have taken place to accommodate the various program changes described above, and the growth of the Center. Research, training and support activities are currently organized within three directorates: Crops Research, Land Resources Research, and International Cooperation. Administrative and financial functions are managed by the Executive Officer and Controller respectively. These five principal officers are directly responsible to the Director General. More details of the current organization structures are illustrated in the organigram shown on Appendix 13.

3.2.3 Institutional Linkages

An important part of CIAT's achievements in its formative years, and an essential base for the activities programmed for the '80s, is the development of strong collaborative institutional relationships; since it is clearly recognized that CIAT acting alone is impotent. Therefore, cordial and productive relationships both of a formal (through various signed agreements) and of an informal nature have been developed with national programs through the continent; with regional organizations (such as IICA, CATIE and SEARCA): with international organizations (e.g., FAO and IADS): and with sister centers (e.g., rice with IRRI, and cassava with IITA). The relationships and understandings developed through these agreements, together with mutual respect, will form an essential foundation for the success of CIAT activities in the years ahead.

3.2.4 Infrastructure Development

3.2.4.1 Headquarters facilities. CIAT's headquarters and its main research farm are located on a 522 hectare parcel of land owned by the

Instituto Colombiano Agropecuario and provided without cost to CIAT. This was initially leased for a period of ten years from July 1970 to July 1980. In May, 1980, ICA and CIAT management signed a new agreement extending the use of the facilities to the year 2000. CIAT began its activities on this station using the original dairy farm building as temporary facilities. On October 12, 1973 the new physical plant was dedicated. This consisted of the Administration building; Library/Documentation/Information building; Training and Conferences complex (consisting of conference, classroom and seminar rooms, amphitheater, conference and reception area, offices, conference housing, trainee housing, kitchen/cafeteria, and dining room facilities); two research laboratory wings; field lab; motor pool; Genetic Resources Unit building; and experiment station facilities (including fencing, drainage and irrigation ditches). It was recognized that these facilities were inadequate for the program levels projected even at that time. Since then, additional facilities originally ommitted due to budgetary constraints, as well as additional facilities required by program expansion have been added. These are: additional field lab; additional office buildings (2); warehouse and purchasing offices; four additional greenhouses and associated headhouse facilities; farm equipment storage and maintenance facilities; seed processing and teaching facilities; and Communications building.

3.2.4.2 Substations. From the outset it was recognized that CIAT-Palmira was an excellent site for Center headquarters and some limited field research activities but that the soils, altitude and climated did not make the location highly representative of most of the tropical agricultural area of Latin America. Initially, it was anticipated that the ICA station of Turipana in Monteria would serve as a major ancillary site for work in other more tropical conditions. However, subsequent experiences and program changes have made it necessary to instead develop modest sub-station facilities in two specific ecosystems and perform a major portion of the research activities on a number of ICA stations representing various ecosystems. Two sub-stations have been developed to meet various specific needs. These are:

CIAT Quilichao. A 189 hectare farm located 40 kilometers south of Cali, with highly infertile, acid soils where much of the preliminary screening of germplasm for acid, infertile soil conditions and various nutritional studies, which cannot be performed under a more fertile land at CIAT headquarters, can be accomplished.

CIAT Popayan. A higher altitude station (1700 meters) with high rainfall. This provides the excellent conditions to screen beans, and to a lesser extent cassava, for diseases which cannot be adequately tested at the lower altitude of CIAT headquarters location.

These two substations are fully operated by CIAT and are on land which had been specifically purchased for this purpose and leased to CIAT at nominal rates by the Fundación para la Educación Superior (FES).

3.2.5 Cooperative Activities on ICA Stations

CIAT is fortunate for its Colombian headquarters location in that Colombia has a broad range of altitude and rainfall conditions which make it possible to do work under many ecological conditions representative of Latin America without crossing national boundaries. It is also fortunate that the Instituto Colombiano Agropecuario, ICA, is strong and cooperative. It has experiment stations in various locations representative of these areas. Through two specific cooperative agreements CIAT currently conducts a large amount of its work on various ICA stations, particularly the following:

a) Caribia, North Coast of Colombia-cassava.

b) La Selva, at 2200 meters near Medellin- climbing beans.

c) Obonuco, 2710 meters - research for high altitude conditions.

d) La Libertad, Colombian Llanos - rice blast research.

e) CNIA, Carimagua, a 20,000 hectare station in Colombian Llanos. This station is of vital importance to CIAT's Tropical Pastures Program and is also of great importance to CIAT's Cassava Program, since both place strong emphasis on the development of technology for the frontier, highly acid, infertile savanna regions which, of course, cannot be done in the area where CIAT's headquarters station is located. In Carimagua, a unique arrangement between ICA and CIAT has been arrived at under which most experiments are considered to be collaborative experiments between the two institutions. The station is administered jointly by ICA and CIAT; the station director is an ICA appointee, and the station superintendent a CIAT employee. The administrative policies for the station are made by a special joint committee consisting of three members of each institution.

3.2.6 Cooperative Research Activities in Brasilia

The Tropical Pastures Program's mandate for the acid, infertile frontier regions includes as its largest component the ecosystem represented by the Campo Cerrado of Brazil. Through a cooperative arrangement with the Cerrado agricultural research center, CPAC/EMBRAPA, CIAT has stationed three of its core senior staff of the Tropical Pastures Program at CPAC in Brasilia. All the work of these scientists is considered an integral part of the EMBRAPA research program but also has application beyond Brazil's borders.

3.3 Technical Achievements

It is neither possible nor appropriate in a long-range planning document to detail the many technical achievements accomplished in the Center since its inception. Nevertheless, it is considered desirable to give a general overview as to where the various CIAT programs have progressed on the technology generation/transfer continuum in order to set the stage for a better understanding of what these programs are expected to be doing in the years ahead, and make an estimate as to where they will have arrived on this continuum by the end of the decade.

The process for agricultural production technology generation and transfer can be symbolized by a pipeline in which the results of basic research are fed into one end of the conduit, and increased agricultural production eventually emerges from the other. While technology other than new varieties also forms an important component of the output of the international agricultural research centers, the development of new crop varieties is the best understood, and forms a good illustration of the sequence of activities related to generation and delivery of various types of technology. In this sequence the gathering together of germplasm accessions is the first phase in which the international center is involved. Selections from the germplasms collection, many of which are the results from national crop improvement programs, are often distributed through the international testing network while the time-consuming process of hybridization is going on. Thus the initial impact of the centers' crop improvement programs may well be through distribution of materials others have developed or selected. However, with time, the impact of the centers' breeding program should become evident, since the intensity of the selection and testing activities engaged in by the international centers for any particular species is usually greater than has ever been applied to that species. Thus it is only to be expected that eventually the best varieties appearing in international testing should come from the centers' breeding program. However, as national programs develop their own capacity and as strong cooperative efforts with the international centers become established, national programs are in an increasingly better position to develop varieties which will be superior in their own location situations and which compete strongly on a global basis in international testing networks. Thus, the interface between the center and national crop improvement programs is the international testing network, which utilizes materials coming from other sources as well as those from the center's breeding programs.

The entire process from germplasm collection to releasing finished varieties by national programs is a long one, requiring at least six years in beans, and nine years in cassava and pastures. In this context it is important to place in perspective the age of CIAT's various programs. The Rice and Tropical Pastures (previously referred to as Beef) Programs began when CIAT was founded with one and seven senior scientists, respectively. The Cassava Program began in 1972 with one senior scientist, and the Bean Program in 1973 with three senior scientists. It is, therefore, somewhat early to expect that the results will have already progressed sufficiently far in the pipeline to affect national production statistics. The latter has been dramatically achieved in the case of rice, where CIAT was able to build on the earlier program of IRRI and the rice research of the Colombian national institution, ICA. While the other commodities have not yet significantly increased national production levels there have nevertheless been substantial developments in problem assessment, germplasm accumulation, parental selection, progeny testing and methodology development. These developments are described in greater detail for the specific programs in Chapter 5 and 6. In this Chapter we will attempt to summarize what has been accomplished in the germplasm accumulation and technology transfer/adoption components in order to illustrate at what stage each program has arrived in the pipeline to give perspective to the plans and expectations which follow.

3.3.1 Germplasm Collection and Preservation

The assembly of the large germplasm base is not only an essential first stage in any plant improvement program but also an important responsibility as it relates to preservation of valuable genetic resources. Within the CGIAR system CIAT has been given global responsibilities for the collection, evaluation, preservation and distribution of germplasm in cassava, beans and tropical forages. At the time of this writing the number of accessions of these commodities in CIAT's genetic resources unit are as follows. Cassava: 2,600; Beans: 30,000; Tropical Forages: 7,250.

3.3.2 Technology Transfer and Adoption

3.3.2.1 Rice.

- Average yields in 20 Latin American countries have increased from 2.0 tons per hectare in 1967 to 3.2 tons per hectare in 1978 due chiefly to new varieities developed at CIAT and IRRI, in collaboration with national programs.

- In Colombia the national average yield or irrigated rice has risen from 3.0 t/ha in 1968 to 5.2 t/ha in 1980.

- Eight countries have named 29 new varieties using eight different finished lines received from CIAT and six countries have named 12 varieties from selections of advanced CIAT breeding lines.

3.3.2.2 Cassava

- A set of improved agronomic practices developed at CIAT has been shown to double yields in farmers' fields in more than 50 regional trials conducted over a space of six years in Colombia. These practices have now been adopted on state farms and farmer associations throughout Cuba, resulting in such a dramatic increase in production that cassava has been removed from the list of rationed food items in that country.

- Twelve countries are using CIAT materials in their own breeding programs.

- Eleven countries are increasing planting materials of varieties received from CIAT for distribution to farmers.

- Ten countries are using the rapid propagation techniques developed at CIAT.

- Seven countries have established facilities to receive CIAT's hybrids as meristem tissue culture to minimize hazards of international movement of vegetative material.

3.3.2.3 Beans

- Since the international testing program began in 1976, some 30 countries have received a total of 150 individual bean nurseries for testing. These nurseries initially consisted entirely of varieties developed by others and selected for the CIAT germplasm collection. Now, over 90 percent of the materials in nurseries are CIAT-bred lines (the materials to be included in the nurseries are selected on the basis of their being superior to all other materials in extensive series of tests prior to entry into the international testing nurseries).

- Seven countries have named a total of 11 varieties based on finished varieties, or selections from advanced breeding lines received from CIAT. Six of these varieties are already being grown by farmers in four countries.

3.3.2.4 Tropical Pastures

- Andropogon gayanus, a grass of African origin, highly tolerant to acid soils, low soil fertility, drought, insects and diseases, and selected for use in Latin America by CIAT, has now been named as a new cultivar in Colombia and Brazil. CIAT has made available 8 tons of basic seed for multiplication in those countries, and has also supplied

Venezuela and Panama with seed where the grass is under advanced testing.

- Several forage legume accessions collected and selected by CIAT have reached advanced stages of testing in Colombia and Brazil. Because of the growth habit of A. gayanus and the nitrogen fixation ability and higher protein content of the legumes, a much better impact is expected to be achieved when A. gayanus is used together with legumes. Several years of grazing trials have demonstrated a 10 to 15-fold increase in live-weight animal gains per hectare, and a 2 to 3-fold increase in per animal productivity, of selected grass/legume associations over the best-managed native savanna.

Chapter 4: CIAT: OBJECTIVES AND STRATEGIES IN THE EIGHTIES

4.1 Statement of Objectives

> To generate and deliver, in collaboration with national and regional institutions, improved technology which will contribute to increased production, productivity and quality of specific basic food commodities in the tropics--principally countries of Latin America and the Caribbean--thereby enabling producers and consumers, especially those with limited resources, to increase their purchasing power and improve their nutrition.

The components of this objective statement are amplified as follows:

4.1.1 Technology Development Orientation

Among the various components of economic and agricultural development, and among the various activities important for the improvement of human welfare, CIAT will continue to concentrate on the generation and transfer of technology. This does not negate the importance of institutional, social and political changes, but it does imply a confidence that application of modern science and technology to the problems of food production can make a significant contribution.

4.1.2 Collaborative Nature of CIAT's Activities

The objectives statement emphasizes that CIAT works in collaboration with national and regional institutions. This underlines the Center's strong conviction that successful accomplishment of the desired results involves the cooperation of various national, regional and international agencies, of which an international agricultural research center is but one. The place of CIAT on the technology development and transfer continuum, and its involvement in various states on this continuum, is schematically illustrates in Fig.4.1. Given CIAT's unique place between a range of more basic research institutions and collaborating national programs, the Center must articulate its activities in two directions. First, it must relate its technology generation efforts to developments in research institutions working at the more basic end of the research spectrum. Second, it must assure that all of its interlocking activities, whether in research or in international cooperation, are designed to be supporting of, and supplementary to, collaborating regional and national research/development institutions.

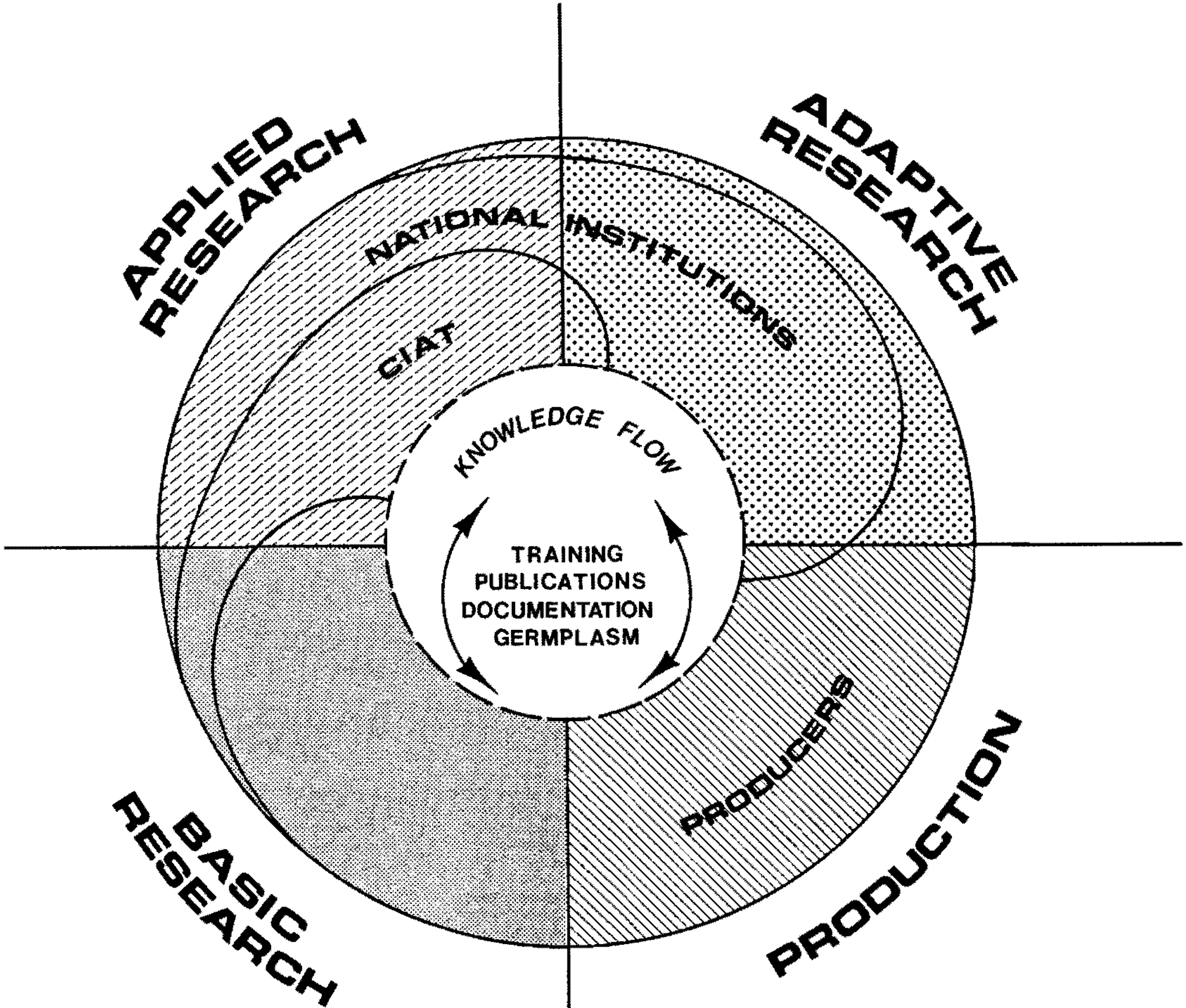

Figure 4.1 Placement of CIAT in the agricultural technology development process

CIAT recognizes that of the various institutions participating in the technology transfer continuum none are more important than the national agencies involved in agricultural research and dvelopment. It is only through strong national programs that the new technology can be evaluated under varied local conditions, modified as necessary and eventually be transfered to the farmers along with the essential support services required to make the technology useful and viable for the producer. Every effort is made by CIAT to maintain cordial and productive collaboration with its prime partners, the national institutions. In the area of CIAT's competence and within the limits of its resources, every effort will be made to strengthen the capacity of these institutions to carry out their functions as full and effective partners in the research continuum.

4.1.3 Geographical Orientation

The Center was founded to serve the tropics of the Americas and, during its first ten years, has orientes its programs towards that region. Each of the four CIAT commodities is firmly established as a basic staple food of the region. The Tropical Pastures Program has a strong ecological focus on the underutilized, acid, infertile soils of the Americas, while the Rice Program, in close collaboration with IRRI, is exclusively directed towards Latin America and the Caribbean.

With respect to cassava and beans, CIAT has been given world responsibility for these crops within the CGIAR system (with the exception of cassava in Africa, where IITA has a continental responsibility). It is recognized that with respect to both of these latter commodities CIAT technology with appropriate modification can have considerable impact outside of the Western Hemisphere. In the case of cassava an active technology transfer effort towards Asia has already begun and has demonstrated that, in this continent where cassava is of considerable importance and is largely unresearched, CIAT technology can play a very important role in increasing the crop's productivity. CIAT intends to further develop mechanisms for the development and dissemination of cassava technology in Asia. With respect to Africa, both IITA and CIAT consider it important to liaise their respective cassava programs. A mechanism for such a liaison is outlined in this plan.

In the case of beans, the most important production region outside of the American is in Eastern Africa. In many countries of the latter region beans are the second most important human food after maize. The need for new technology in the region is very pressing, and it has already been demonstrated that CIAT technology could have a very important impact.

The Center recognizes that in the case of beans and cassava, the technology as developed for the Western Hemisphere is such that with a relatively minor additional investment it can provide the base for productivity increases in the other continents. Thus, while CIAT's basic orientation of research will continue to focus on the Western Hemisphere, the Center will continue to expand its efforts to find mechanisms that will assure that the new technology has a maximum impact in other areas of the tropics, without unduly diverting attention from the immediate task.

4.1.4 Orientation to the Poor

CIAT identified limited resource producers and consumers, i.e., the rural and urban poor, as the principal beneficiaries of CIAT work, thus clearly incorporating human welfare objectives within the production goals. As will be described below this translates into technology design considerations.

The objectives statement, while recognizing the importance of making a contribution towards overall production and productivity, also emphasizes CIAT's commitment to the lower income strata of both the producer and consumer communities. In the developing countries of the Western Hemisphere these two communities overlap to a much lesser degree than in developing countries in Africa and Asia. Approximately 60% of the population in Latin America is urban and the trend towards an ever increasing percentage of urban dwellers is expected to continue through the eighties. Consequently total production, regardless of the resource base of the producer, cannot be ignored since this will affect the price of food for urban consumers.

Some countries, particularly those with large cooperatives and state farms, require technology for large scale, mechanized production. Nevertheless, CIAT concentrates its attention on production technology that is specifically adapted to the needs of small holders, both because a large proportion of two of the food crops dealt with by CIAT (beans and cassava) are produced by small holders, and also because the development of such technology requires a sustained and concerted effort which can best be made by a public funded, international institution.

4.2 General Strategy

In carrying out its particular role in the research and development continuum, the Center pursues the following basic strategies.

4.2.1 The Establishment of Research Networks for the Interinstitutional Transfer of Technology

The linking of individual researchers as well as research groups through the establishment of research networks is considered a prime mechanism for creating and maintaining a research and development momentum in benefit of any given commodity. Research networks not only facilitate the exchange of information and materials between the national and international level, but also serve the horizontal transfer of technology between national programs. CIAT is, and will continue to be, active in maintaining and fortifying commodity-based research networks through information and documentation services, germplasm exchange activities, seminars and workshops, and consultative visits.

4.2.2 The Development of Germplasm Based Technology

An analysis of production constraints of the commodities in CIAT's mandate has indicated that increased availability of improved germplasm adapted to the environmental conditions and prevailing production systems, will have the largest impact on production among the various possible alternative strategies for research. CIAT has been and will continue to be involved in technology generation which has as its central theme the collection, production and supply of new germplasm. In addition, agronomic components of technology of a non-site specific nature have been and will be developed parallel to and coordinated with the germplasm development activities.

4.2.3 The Selective Stregthening of National Programs through Training

Since the inception of CIAT, the strengthening of commodity research groups within national agricultural research institutions has been a central strategy of the Center. As mentioned above, the Center is well aware of the preeminent importance of strong national programs working in full partnership with CIAT. Through the provision of training opportunities the Center is in a position to make an important contribution to the strengthening of national counterpart institutions at the same time that training provides the principal conduit for the transfer of improved research and production technologies.

4.3 Operational Principles

Certain basic principles of operation have evolved at CIAT. These will guide the Center in the '80s in implementing the strategy described above. These include:

4.3.1 Relevance

CIAT's research is mission oriented directed towards the solution of the most important production problems in the Center's area of responsibility.

This includes sophisticated research whose relative magnitude will progressively increase over the eighties as national programs are able to assume a greater share of the adaptive research responsibilities. The success of the Center's research will always be measured by its contribution to increased food production and productivity, rather than an increase in the knowledge base or in academic publications.

4.3.2 Complementarity

The complementary role of CIAT, both in relation to specialized activities of collaborating, more basic research institutions as well as the adaptive research and technology transfer activities of national programs has already been describen in section 4.1.2. This translates into a basic operational principal of complementarity which will continue to dominate CIAT's work and relationships in the decade ahead. CIAT will concentrate resources on those activities in which it has the comparative advantage, and collaborate with others in doing what they can do best. The manner in which this relates to national programs is key and permeates the strategies of the programs and the International Cooperation activities described in later chapters.

In terms of more basic research institutions, both in developed as well as in developing countries, there is much useful work that can be carried out which complements and supports the more problem-solving research approach of CIAT. The Center has encouraged, and will continue to encourage other research institutions to engage in well-defined, basic research endeavours which have a high potential for pay-off in terms of CIAT's own work but which requires specialized facilities and skills not available at CIAT. Such work can either be accomplished wholly at the respective research institution, or in direct collaboration whereby a portion of the research project is carried out at the Center. Considering the fact that the Center is itself a recipient of funds designed to finance operations per se, and also considering that research collaboration from other research organizations is strictly additional to the Center's core operations, CIAT does not in principle finance such research out of core resources. Whenever possible, CIAT collaborates with interested scientists in helping to secure appropriate special project funds to make the collaborative research possible.

4.3.3 Principles of Technology Design

The role of CIAT, especially as related to its orientation towards the low resource farmers, greatly influences the nature of technology generated by the Center. Some basic principles of technology design emanating from these considerations include:

4.3.3.1 Minimal input orientation. Access to the benefits of new technology by the resource poor farmer is often limited if its successful utilization requires high levels of expensive inputs. In order that improved technology can meet the needs of small holders who produce the majority of CIAT's crop commodities, CIAT strives to design technology components which will minimize dependence on purchased inputs, and irrigation. At the same time there is a need to ensure that the technology maintains high production levels at higher levels of input use. The latter is a recognition of the need to increase overall food production to service the increasingly urbanized nature of society in developing countries, particularly in the Americas.

CIAT's concern for minimal input technology is closely allied to a strong concern for energy conservation. As ever rising oil and gas prices have driven up the cost of irrigation, farm mechanization, fertilizers, and chemical protective agents, it becomes imperative that new technology minimize dependence on high energy inputs. CIAT attacks the problem by developing (a) germplasm resistant to such constraints as insects, diseases, adverse soil conditions, and drought; (b) germplasm that has greater intrinsic efficiency in the uptake and/or utilization of soil nutrients and greater efficiency in the use of applied fertilizers; and (c) in the case of beans and pasture legumes, germplasm with improved capabilities in nitrogen fixation. At the same time, CIAT develops components of production systems that require low levels of energy inputs.

4.3.3.2 Technology component orientation. As an international research organization working through national agencies, CIAT does not aim to produce finished technology that fits specific ecological niches and meets the specific socio-economic conditions and quality preferences within a given setting. Rather, CIAT emphasizes the development of basic technology components such as improved germplasm base, research methodologies for the identification of optimal management practices; methodologies for the development of single and multiple crop systems where the commodities are important components in the system. These components serve national programs as building blocks for relevant production systems for single commodities as well as for multi-commodity systems that are viable and socially acceptable for given local conditions. To this end program scientists become as familiar as possible with the whole-farm systems into which such technology components are expected to contribute.

Due to environmental and socio-economic constraints the characteristics of the production systems in each of CIAT's commodities vary throughout the regions of interest. Whenever possible, CIAT attempts to develop technology components that have applicability across the various agroclimatic and socio-economic conditions. When this is not possible, technology components are developed that are specific to a given ecosystem and/or a given set of broadly defined socio-economic conditions. Whereas research for unique but broadly defined conditions within CIAT's zone of interest forms an integral part of the Center's technology development efforts, research on production factors which are of a more site specific nature is not considered a legitimate concern of CIAT when seen against the responsibilities and capabilities of national programs. Thus, such research as that pertaining to soil fertility and associated fertilizer recommendation are not of principal concern except in the development of research methodologies where these are lacking.

4.3.3.3 Evaluation and feedback mechanisms. Technology designed and tested only on experiment stations is not finished technology. There is no assurance that any given technology package is useful until it has been validated under the conditions and constraints at the farm level. Thus, on-farm testing is an integral component of the technology generation process. The results of such work are usually very location specific and CIAT does not have the resources nor the mandate to work in the wide range of ecological, socio-economic and agronomic conditions in the collaborating countries. Thus, the Center depends on and encourages national counterpart agencies to evaluate new varieties and practices on a regional basis, to modify these where necessary to meet local requirements, and to test the resulting technology systems under the real farming conditions representing the largest number of producers and conditions possible. However, CIAT considers it of utmost importance to actively collaborate with selected national and/or local agencies in the regional testing and on-farm validation of improved technology packages that include CIAT-developed components. In these collaborative projects CIAT's role normally is restricted to providing materials, information, and assistance in the design and analysis of the farm level research. Such regional testing and on-farm validation serve as vital sources of feedback into the Center's commodity programs to influence technology design.

4.3.4 Principles of International Cooperation

As is graphically illustrated in Figure 4.1, the work of an international agricultural research center is but one part in the complexity of activities which range from basic research to the eventual application of improved production technology by the farmer. The successful accomplishment of the desired end result--improved productivity and welfare--involves the cooperation of a multitude of local, national, regional, and international agencies. An international center can only make a contribution to the overall goal to the extent that it cooperates as a partner with these various institutions and plays a role that is complementary to the activities of other institutions.

From the unique vantage point of view of CIAT as an international research institution, its most important collaborators are the national institutions involved in agricultural research and development. It is only through strong national programs that new technology components can be assimilated into improved farming systems practices.

4.3.4.1 National institutions as full partners in the technology development process. The relationship between the national research institutions and CIAT clearly is one of mutual reliance and respect. On the one hand, national institutions look to CIAT for basic materials, information and back-up research on selected commodities and for coordination of research and development activities in the respective commodities on a supranational level. On the other hand, CIAT's work is meaningful only to the extent that it is complemented on the national level and is integrated in national research and development efforts. In the effort of agricultural research and development, professionals on the national and international level work as fully equal partners. It is in this spirit of full equality of national and international efforts that CIAT continues to expect to find the basis for effective collaboration and mutual complementarity.

4.3.4.2 Working with national institutions in relation to expressed needs
In de decade of the '80s, CIAT will continue to assist national programs in developing their national research capacities as they relate to the commodities in CIAT's mandate. CIAT realizes that with respect to anyone of these commodities, each collaborating country faces its own unique circumstances out of which grow equally unique country program needs. CIAT shall continue to address these unique country needs and to serve the respective country programs in relation to their expressed needs.

As many collaborating countries will increasingly be able to assume commodity research responsibilities that hitherto had to be assumed by CIAT, it is envisaged that, with respect to many countries, part of the present work by CIAT will progressively shift towards the national programs, thereby enabling CIAT to increasingly engage in back-up research and related activities that are most effectively carried out on the international level.

4.3.4.3 Mutual consultation. Given the necessity for an effective interfacing between collaborating national institutions and CIAT, frequent and meaningful mutual consultation becomes the basis for true complementarity. In the decade ahead, CIAT shall continue to put heavy emphasis on all activities that further the purpose of mutual consultation. The means by which this consultation is brought about are discussed in Chapter 3.

4.3.4 Limits to CIAT Involvement

The technology development process of which CIAT forms a part involves a multitude of participants, viz., the national research, extension and development programs, credit institutions, training organizations, public supply and marketing institutions, private enterprise, and--last but not least, the farm producer and his cooperatives. Given the fact that CIAT neither has the comparative advantage to evaluate and adapt new production technology in varied local socio-economic and agro-ecological conditions, nor the resources to effectively move beyond the national level, CIAT will continue to regard the research programs in each country as its prime counterparts, thereby limiting its direct interinstitutional technology transfer to these latter institutions. This implies that CIAT has no intention to become directly involved in technology transfer activities to the farm producer at farm level.

CIAT is most cognizant of the fact that improved agricultural productivity is both a function of the availability of viable production technology as well as the availability of inputs and conducive marketing conditions. Both of these preconditions impinge in no small measure on national policy making. In consideration of the fact that both national agricultural research policy as well as national policies regarding incentives for technology development and adoption are strictly within the decision-making domain of the respective countries involved, CIAT will continue to limit its role in these areas to the provision of appropriate forums which allow national policy makers to fully explore the consequences of alternative policies. However, aside from advocating the need for strong national research organizations, CIAT will continue to abstain from advocating any national policy options.

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Chapter 5: CROPS RESEARCH

In Chapter 1 the various commodities in the CIAT's mandate have been discussed in the light of the socio-economic conditions in the developing countries of the Western Hemisphere. It is clear from that analysis that rice, beans and cassava are important in the region for CIAT involvement. Their selection on the basis of this importance has been confirmed.

A basic feature of this plan is the concept of increasing productivity of the commodities through research in their traditional areas of production while also contributing to the development of stable and productive systems for the agricultural frontier. In this context cassava and upland rice research at CIAT is directed towards the dual objective of improving productivity in traditional areas as well as at the frontier. Irrigated rice and bean research at CIAT is more directed at traditional areas and their margins, although limited irrigated production areas for rice are being developed in some countries in frontier situations.

Other crop commodities which were identified in Chapter 1 as having great economic importance in the region particularly for frontier areas, are discussed in Chapter 6. In this Chapter program strategies and projections for the three crop commodities in the CIAT mandate are outlined.

5.1 Program Strategies and Projections: Cassava

Cassava is the fourth most important global food energy crop in tropical developing countries providing a significant source of calories in the daily diets of over 500 million people in 26 tropical countries. In many countries dried cassava is by far the cheapest source of calories (see 1.2) and for this reason is especially important for the poor. The per capita consumption of fresh and dried cassava products tends to be high among the poor, climbing as incomes rise among the poorer strata and then declining in the highest income groups. Since the crucial nutritional deficiency in most low income countries is calorie deficiency, cassava is particularly important because lower cassava prices would principally benefit the lower income strata by helping to improve their nutrition.

Although cassava is relatively low in protein, it can also contribute to augmenting protein availability when it is used as animal feed. Recent development of intensive livestock production systems dependent on feed concentrates has led to increased consumption of poultry products. In some developing countries the real prices of poultry have actually fallen in recent years. The resultant strong demand for feed grains has, in some cases, led to competition between the concentrate industry and the human food sector for calorie and protein sources. Production of sorghum has increased at very high rates (12.5% per annum in Latin America) on prime land which could otherwise have been used for food crops. Thus, the increase in demand for meat may have tended to bid away resources that might have gone to the production of other basic food staples. Use of cassava as an animal feed could vastly reduce this competition because of the availability of unused marginal land, which can not support many other crops but could produce cassava.

Despite the rapid growth in sorghum production, domestic production of feed grains often has been unable to meet demand, leading both to increasing imports of feed grains by many countries that can ill afford it, and also to upward pressure on the price of animal feeds. The resulting increase in the cost of meat tends to put it out of reach of the very poor. Production of cassava with underutilized domestic resources could promote employment, alleviate the burden of costly imports, and contribute to maintaining a supply of cheap animal protein.

5.1.1 Production and Demand Situation in Latin America

Cassava has always been a traditional calorie source in tropical Latin America. As a root crop cassava has several key characteristics that make it well suited for traditional agricultural systems: (a) high efficiency in the production of carbohydrates; (b) adaptation to soil and water stress; (c) an indeterminate harvest period; (d) high yields per unit of land and labor; and (e) compatibility with a variety of crops in association. Cassava fits well into small farm systems and as such, has been a major staple in rural areas in the lowland tropics of Latin America and in some countries in the Caribbean.

As Latin America urbanizes, the importance of cassava for direct human consumption will depend on its marketability and competitiveness with other calorie staples in urban markets. High perishability after harvest, bulkiness, and low commercial value by weight result in high marketing margins. This is compounded by high post-harvest losses. Whether low production costs are converted into competitive urban prices depends on the efficiency of the marketing process. In most cases in urban Latin America fresh cassava is more expensive than the principal grain staples, primarily because marketing margins are as much as 300% of farm-level prices. Where cassava goes through a processing stage before marketing, as in Brazil, the dried product is, in general, the cheapest urban calorie source available. Thus, only in Brazil, where most of the cassava is eaten in processed form, and Paraguay, where most of the population is still rural, is cassava a major calorie source in the national diet as a whole. Nevertheless, cassava will continue to remain a staple in rural areas in the lowland tropics.

A strategy to increase the incomes of the small-scale farmer through the development of new cassava technology is, outside of Brazil, constrained by demand for cassava as an urban food. As a carbohydrate source with a low unit production cost, cassava has potential to enter alternative markets, namely: as a wheat flour substitute (suitably enriched); as the carbohydrate source in feed concentrates; as feedstock in ethanol production; and as an industrila starch. Major expansion in demand in either the fresh urban market or the industrial markets depends on the relative price of cassava with other alternatives. In the industrial markets the price of cassava in almost all Latin American countries needs to be reduced in order for cassava to be competitive. Lower unit production costs, and thus cheaper prices for cassava can be best achieved by the application of new technology. Historically, there has been little research on the crop and the potential to increase yields from their present average yield level of 10 t/ha is very large. On the other hand, the introduction of improved cassava production technology without the complementary processing technology runs the risk of saturating traditional markets, resulting in a negative impact on farmer incomes. Thus, research on production technology in cassava cannot be independent of research on processing technology.

5.1.2 Production Systems and Constraints

Because of the many mechanisms for stress tolerance in the plant, cassava can be grown under a wide range of edaphic and climatic conditions. This very broad ecological range, however, severely complicates germplasm improvement, especially since in cassava a very marked genotype x environment interaction exists. The ecological conditions under which cassava is grown can be broadly subdivided into six major ecosystems (Table 5.1). The lowland tropical ecosystem with a pronounced dry season (ecosystem 1) is the most important in terms of production with an estimated 50% or more of total world production. The acid soil savanna (ecosystem 2), and the hot humid lowland tropics (ecosystem 3) are at present not major production areas. These ecosystems are potentially very important. Expansion of cassava production in these areas is already occuring in Mexico, Brazil, Malaysia, and Indonesia. The highland tropical areas (ecosystem 5), and the intermediate altitude tropical areas (ecosystem 4) of Latin America are of least importance at present. In Africa, potential for expansion in these ecosystems is great. High yielding clones well adapted to this ecosystem are not presently available in Africa but exist in the Americas. The subtropics (ecosystem 6) are important in the Americas with approximately 30% of total production being in this region; on a world basis, from 15 to 20% of total cassava production is produced in this ecosystem.

While each ecosystem is defined by climatic and edaphic parameters, there is also a series of unique insect and disease complexes associated

Table 5.1 Cassava production ecosystems and their main characteristics.

Eco-system	General description and representative areas	Mean temperature	Dry season duration	Annual rainfall
1	Lowland tropics with long dry season; low to moderate annual rainfall; high year-round temperature. (Media Luna, Caribia, Nataima and The Guajira, Colombia; Southern India; Northeastern Brazil; Northern Venezuela; and Thailand)	above 25°C	3-4 mo	700-200 mm (Unimodal distribution)
2	Lowland tropics with moderate to high rainfall; savanna vegetation on infertile, acid soils; moderate to long dry season; low relative humidity during dry season. (Llanos of Colombia (Carimagua); Llanos of Venezuela; Cerrado of Brazil)	above 25°C	3-6 mo	above 1200 mm (Unimodal distribution)
3	Lowland tropics with no pronounced dry seasons; high rainfall; constant high relative humidity. (Florencia, Quibdo and Leticia, Colombia; Amazon Basins of Brazil, Ecuador and Peru; rainforests of Africa and Asia)	above 25°C	absent or very short	above 2000 mm
4	Medium-altitude tropics; moderate dry season and temperature. (CIAT-Palmira and CIAT-Quilichao, Colombia; Costa Rica; Bolivia; Brazil; the Philippines; Africa; India; Indonesia; Viet Nam)	21°-24°C	4 mo	1000-2000 mm (Bimodal distribution)
5	Cool highland areas; moderate to high rainfall (Popayan, Colombia; Andean region; East Africa)	17°-20°C	—	above 2000 mm
6	Sub-tropical areas; cool winters; fluctuating daylengths. (Mexico (Culiacan); Southern Brazil; Cuba; Paraguay; Northern Argentina; Taiwan; Southern China)	Min. 0°C	—	above 1000 mm

with each ecosystem thus reflecting an interaction between cassava pathogens and environmental factors (Table 5.2).

Overlaid on this ecological pattern is a market variation in production systems. These range from the slash-and-burn system of the Amazon jungle, to planting cassava as an introductory crop in pasture establishment, and to the small-farm, multi-crop systems typical of most cassava production. The crop is labor intensive, requiring from 80-120 man-days per hectare. Cassava is often grown in association with a legume or maize. Frequently, it is also used as the last crop in a rotation, in which the farmer maximizes cassava's adaptation to infertile soil conditions. Purchased inputs are rarely used in cassava production systems, as usually it is not economical to control pathogens in such a long-season crop, and soil fertility is usually managed through fallowing systems.

Evaluation and selection of cassava clones has been carried out for centuries by farmers across a wide range of agro-climatic conditions. In general, most traditional cassava clones are relatively well adapted to the stress factors characteristic of the area in which they are grown. Nevertheless, the germplasm base in such a localized varietal development process is limited, thereby putting a ceiling on potential yield.

Systematic breeding and selection programs for cassava are rare. From those which are in existence very few improved varieties have reached farmers. Nevertheless, yields under experimental conditions of 80 tons/ha in comparison with average farm yields of around 10 tons suggest tremendous potential for raising farm productivity. The principal production constraints, therefore, is felt to be the lack of higher yielding varieties that give stable yields under stress conditions. The availability of such varieties becomes even more necessary as cassava moves from traditional production systems to more continuous production systems.

The application of scientific breeding and selection methodologies in cassava is complicated by the variation that exists in production conditions, the stress conditions under which cassava is usually grown, and the limitations put on the use of purchased inputs due to the limited resources of traditional cassava farmers. Cassava's adaptation to relatively more marginal agricultural areas, its long crop cycle, its limited yield response to purchased inputs in most ecosystems, and its low value all suggest that cassava will not be competitive with higher value crops on prime lands. The comparative advantage of cassava is, therefore, in areas where there are major constraints on the growth of other crops. Moreover, given its labor intensity, small farm systems should continue to have the comparative advantage in production. These factors imply that germplasm improvement will have to be accomplished under stress

Table 5.2 **Production constraints in different cassava growing ecosystems.**

	MAJOR CONSTRAINTS					
Ecosystem	Rainfall	Temperature	Diseases	Insect & Mites	Fertility/Soils	Others
1. Lowland Tropics (Dry Season) Coast	3-5 mo. dry season Limited rainfall		Anthracnose Pathogens of planting material	Mites (*Mononychellus*) Thrips Hornworm Whiteflies	Usually low soil fertility	Sandy soils with limited water retention. Low starch content
2. Lowland Tropics (Dry Season, and Soils) Carimagua	3-5 mo. dry season RH near saturation during rainfall season	Fluctuations enhance disease severity	CBB Anthracnose Superelongation Cercospora Brown spots	Mites (*Mononychellus*) Thrips Lacebugs Stemborers	Acid infertile soils Aluminium toxicity	Drought stress
3. Lowland Tropics (Humid) Florencia	Soil water saturation	–	Cercospora brown spots root rots* —	Mealybugs	Acid infertile soils with nutritional problems and Al toxicity	
4. Medium Altitudes Tropics (altitude < 1.000 m) CIAT	3-4 mo. dry season	–	Root rots Cercospora blight brown spots	Thrips Hornworm	–	–
5. Highland Tropics (altitude > 1.000 m) Popayán	Variable	Cool 17-20°C year round	Phoma leaf spots Anthracnose Cercospora white spots	Mites (*Oligonychus*)	–	–
6. Sub-tropics (Cool winter)	Variable	Cold winter 3 mo. less than 10°C	Anthracnose	Hornworm	–	Limited harvest period. Drought

conditions without recourse to major increments in purchased inputs.

The cassava crop is biologically one of the most efficient sources of digestible carbohydrate, particularly when grown on marginal lands. It is, however, a difficult crop to handle after harvest due to its high perishability. Recent estimates of post harvest losses are of the order of 25% or more. Increased production is very frequently limited by lack of nearby markets or processing plants which can readily transform fresh cassava to a more stable product. Farmers are often reluctant to increase production as no ready outlet exists and entrepreneurs are not willing to mount processing plants due to uncertainty of supplies. When this vicious cycle is broken production can increase markedly, as has recently occurred in Thailand with the establishment of a large number of small drying plants and an effective marketing system.

5.1.3 Objectives of the Cassava Program

The goal of the Cassava Program is to satisfy a need for food and feed carbohydrates by converting cassava from a traditional rural staple to a major, multi-use carbohydrate source in tropical food economies by exploiting the plant's carbohydrate production efficiency under sub-optimal environmental conditions. The Cassava Program thus focuses on both production and utilization technologies, particularly for Latin America. The Program also recognizes the potential of cassava as a major food and feed source in Asia and Africa and will place emphasis on adapting technologies developed at CIAT to Asian conditions.

This overall goal is to be reached through the following objectives:

a) To develop germplasm and associated cultural practices that require low input levels and are responsive to improved management, to increase cassava production per hectare in areas where cassava is presently grown.

b) To develop germplasm and associated management practices, which, under medium input conditions will lead to increased cassava production in the acid, infertile, underutilized soils of the lowland tropics.

c) To develop systems that can be used to improve the utilization of cassava and allow more efficient use of cassava for either direct or indirect human consumption.

d) To strengthen national cassava research and development programs so that they can more effectively carry out their role.

5.1.4 Research Strategy

New production technology for cassava must exploit the crop's comparative advantage under marginal conditions with low inputs. This precludes the use of such expensive inputs as continued chemical applications to control diseases and pests, irrigation to prevent drought, costly soil amendments to increase pH and reduce aluminum levels in the soil, heavy use of expensive fertilizers, and other high cost/high energy use practices. This leads directly to the development of technology based on improved germplasm that per se overcomes many of the constraints on production. Not all problems can, nor should they be, resolved by improved germplasm. These other constraints are to be minimized by management practices that include agronomic practices, biological control of insect pests, phytosanitary control of diseases, and efficient techniques for fertilizer use where these are necessary.

Major constraints on production occur due to lack of high yielding varieties tolerant to drought, disease and pests. These constraints can be partially overcome by the development of improved germplasm. This has indeed been one of the major areas of emphasis of the Program in the past, and will continue to be emphasized in the future. The methodology used in the past will be somewhat modified. The CIAT program has worked under low stress (CIAT), medium stress (Caribia) and severe stress (Carimagua) conditions; however, it has been difficult to obtain single varieties well adapted to all these conditions. It is quite probable that the same will apply to other cassava ecosystems. Accordingly, the Program will evaluate germplasm in each ecosystem (this has already been done in ecosystem 1, 2, 4 and 5) and use superior materials in crosses to produce clones specifically adapted to each area, rather than to try to develop broadly adapted clones. The material produced will be evaluated in advanced yield trials for yield stability and quality.

Improved germplasm is, however, only a partial solution. The rate of progress in any breeding program is roughly inversely proportional to the number of breeding objectives. Hence, breeding must be used only for solving problems of major importance. Such problems as control of the many minor pathogens that attack planting material cannot be resolved through varietal resistance, but rather through inexpensive chemical protectants. In addition, many problems are not even capable of resolution by breeding. For example, no varietal resistance has been found to the cassava hornworm. In this latter case, biological control methods have been developed. In cases such as phosphorus fertilization, the cheapest methods are searched for; such techniques as use of rock phosphorous and mycorrhiza are under study. Improved management practices of general applicability will be tested, along with the new improved lines for adaptability and stability over time within each ecosystem, through a series of regional trials. From these trials technology packages are recommended for use in a limited number of on-farm validation trials in Colombia in selected ecosystems.

Research on cassava utilization and marketing is a necessary complement to the research on production technology. To ensure the benefits of the increased production potential there must be some insurance that a sufficiently expansive market exists. CIAT will concentrate on utilization research that will contribute to expansion in demand for fresh cassava products, either as a direct or indirect human food. CIAT has neither the comparative advantage, nor the mandate, for performing research on improving processing efficiencies in the starch or ethanol markets. The fresh urban market will continue to remain the preferred (highest price) market; however, quality maintenance and high marketing margins limit consumption. The perishability of cassava is positively correlated to starch content. High starch content is an important factor in determining quality and high starch lines are being bred which could be more perishable. Research on the aspect will be emphasized. Cassava storage methods based on curing and the use of chemical protectants will be further developed. The animal feed market is increasing rapidly and one of the major limitations on cassava entering this market is the development of highly efficient natural drying techniques, particularly in the more humid tropical areas. Such techniques will be developed by CIAT. A further factor influencing and limiting the entrance of cassava to the animal feed market is lack of good economic data on the market potential of cassava particularly where government policies often subsidize other, often imported, competing products. The feed markets will be analysed in certain areas and the feasability of using cassava as an animal feed demonstrated. These studies will be made available to both the private and public sector and where interest is shown the CIAT program will cooperate in helping to set up demonstrative pilot projects.

5.1.5 International Cooperation Strategy in Cassava

The state of development of the cassava industry and the level of support by national programs and government agencies varies tremendously. Consequently, the assistance required by different countries, or even different regions of the same country, will vary over time. In this document an attempt has been made to classify countries according to development of cassava programs and then to identify the type of assistance required for each group. A generalized strategy for international cooperation with countries in different stages of development is given in Chapter 7. With reference to cassava the grouping of countries and the respective cooperation strategy is shown below.

The type of assistance and collaboration in different countries obviously depends on their present and future status. The overall objective of the

Program is that countries that have both the potential and need for increased cassava production progress to the advanced category.

5.1.5.1 Advanced cassava countries These countries have a clearly demonstrated potential for increased production, and declare increased cassava production as a definite goal in the national plan, and/or local agencies or industries have shown a real interest in increased cassava production. National programs or local agencies are strong and are able to support the cassava industry. In these countries the national programs are all relatively new and many need help and assistance in planning, particularly in defining priority areas of action. In addition, many of the young professionals need further training and experience in research and management.

The Cassava Program will assist the national agencies in project planning and through the provision of advanced training opportunities. The base for improved production technology will be new agronomic practices and germplasm. The national programs in this group are sufficiently strong to be able to develop both aspects. However, in the case of improved germplasm, they will benefit heavily from CIAT materials for several years. CIAT estimates that from the inception of a new breeding program to the release of a new variety approximately nine to ten years are required. By importing germplasm in the form of sexual seed or selected clones, national programs can capitalize on CIAT's efforts and shorten the period to six years or, in the case of clonal material, less than three years. The interchange of germplasm should not, however, be haphazard. Selected crosses from CIAT, tailor-made for specific ecosystems, would be evaluated by national programs. CIAT and national program personnel will determine which varietal characters are required in each country. Feedback on their field performance will be essential so that second generation materials can be better adapted. Much useful information is already being developed in the national programs and a large part can be applied in other countries or areas. CIAT will act as relay agency to see that each national agency is aware of what is happening in other countries.

Much of the basis of improved yields will depend on the technical capability of the national programs to provide certain types of back-up support to the farmers. These services will include the propagation of large stocks of "clean seed" of the new clones, insect hatcheries for biological control, and field diagnostic expertise. CIAT will assist in organizing in-country courses for training technicians in these techniques.

5.1.5.2 Developing cassava countries with strong national programs. These countries have strong national cassava programs and potential for increased production but have no national policy for increased cassava production on only poorly developed channels for marketing or utilizing increased production. These countries are thus in a somewhat paradoxical position of having strong national cassava programs but no overall strategy for production and utilization of increased cassava production.

Emphasis will be placed on determining the potential production and the economic advantages to the country when it reaches this potential. CIAT will collaborate in establishing regional trials using local varieties and imported germplasm so as to assess potential productivity. In cooperation with the CIAT Cassava Economics Section, the economic gain the country could expect if cassava production were to be increased, will be assessed. This information will be made available to policy makers so that they can decide if they wish to implement a full-scale national cassava project at the A-group level, in which case the operational strategy will be changed.

5.1.5.3 Developing cassava countries with weak national programs but with an expressed need to increase cassava production. In these countries either government or private industry has an interest in increasing cassava production and there is a known latent potential for increased production, but imporved marketing and utilization possibilities have not been explored.

The main emphasis will be on training personnel to test the CIAT-produced technology and germplasm and to assist in economic planning. CIAT will assist in establishing trials to validate the new technology under local conditions and will collect data for economic planning. If the decision is made to strengthen the national program, assistance will be given in the form of training and help in project planning.

5.1.5.4 Calorie-deficit countries not presently interested in cassava. These countries have no national cassava programs, and decision-makers are often not aware of the new cassava technology and what it has to offer in terms of solving their calorie deficit problem. The main emphasis in these countries will be to evaluate production potential through regional trials on a small scale and to determine the status quo of cassava production and the economic viability of increasing production. CIAT will help establish regional trials and collect the necessary information on present cassava production methods.

5.1.6 Program Accomplishments

In 1969 collection of germplasm was initiated throughout Latin America, and by mid-1971, 2200 clones had been assembled. The germplasm bank has formed the fundamental base for the varietal improvement program.

By 1973 the material was increased and evaluated with special reference to agronomic characters. Selected clones from the bank yielded as high as 61 t/ha/yr of fresh roots and 22 t/ha/yr of root dry matter. The importance of harvest index as a selection criteria was established. Sources of resistance to some of the major diseases and insects were identified and an agro-economic survey was undertaken to assess the production technology used by farmers and to determine the major constraints on yield and increased production.

One of the major bottlenecks for research and for distribution of new varieties was found to be the slow rate of propagation of cassava. A rapid propagation technique was developed that increased multiplication rate fourty-fold. Meristem tissue culture techniques have been developed and the methodologies have been shared with national programs to facilitate international germplasm transfer at substantially reduced risk of pest and disease transfer. At the same time, work was started on one of the major constraints to utilization: perishability. The basic physical data on drying of cassava roots was obtained and it was demonstrated that curing of cassava roots prevented rapid physiological deterioration after harvest.

During the years 1974 and 1975 the Program began to move its research outside of CIAT so as to test the newly obtained results over a range of environmental conditions and to evaluate disease and pest resistance in the field. Two major sites were established on ICA stations. At Caribia, representative of lowland tropical areas with a pronounced dry season (ecosystem 1), and of Carimagua, a high stress site representative of the acid infertile savanna (ecosystem 2). In addition, within Colombia, a series of regional trials were established to test newly developed clones. Colombia, due to its size and topography, has a remarkable ecological variability and, as a result, testing of lines under a broad range of conditions can be accomplished at very low cost. This testing network gave the basic data for the later establishment of international trials, the norms of which were established at an IDRC sponsored conference in which national agencies expressed their needs.

As the international trials were started the first links were made with national programs. National programs, except for the Indian program, were universally weak or non-existent. Contact was made with high-level officials in government agencies and a massive cooperative training program was started to provide the nascent national programs with trained personnel. As of 1980, some 209 trainees from 19 countries in the Americas, and 68 from 7 countries in Asia, have received post graduate training in various disciplines.

Through the period 1976-1980 thousands of hybrids were produced and tested, and high yielding, disease and pest resistant lines were obtained for further testing. Improved agronomic practices were also developed and these were evaluated with the new clones in both the regional trials and the on-farm evaluation trials. The net result of this work is best illustrated by the regional trials. With low input improved technology, average yields of local clones in Colombia was 20 t/ha (national average 8.0 t/ha). These data illustrate the potential for the CIAT technology to double yield at selected locations without even changing varieties. The on-farm validation trials have shown that small farmers can readily increase their yields by 70% using this technology. In addition, the impact of the new selected clones and hybrids boosted yields as 30 t/ha in the regional trials. These clones will have problems, such as a slow multiplication rate and inferior eating quality; however, they do demonstrate the tremendous yield potential that can be realized at the farm level by further research and development in the decade of the eighties. New clones being produced by the Program are rapidly overcoming some of the demonstrated deficiencies of earlier evaluated materials.

5.1.7. Projected Program Developments

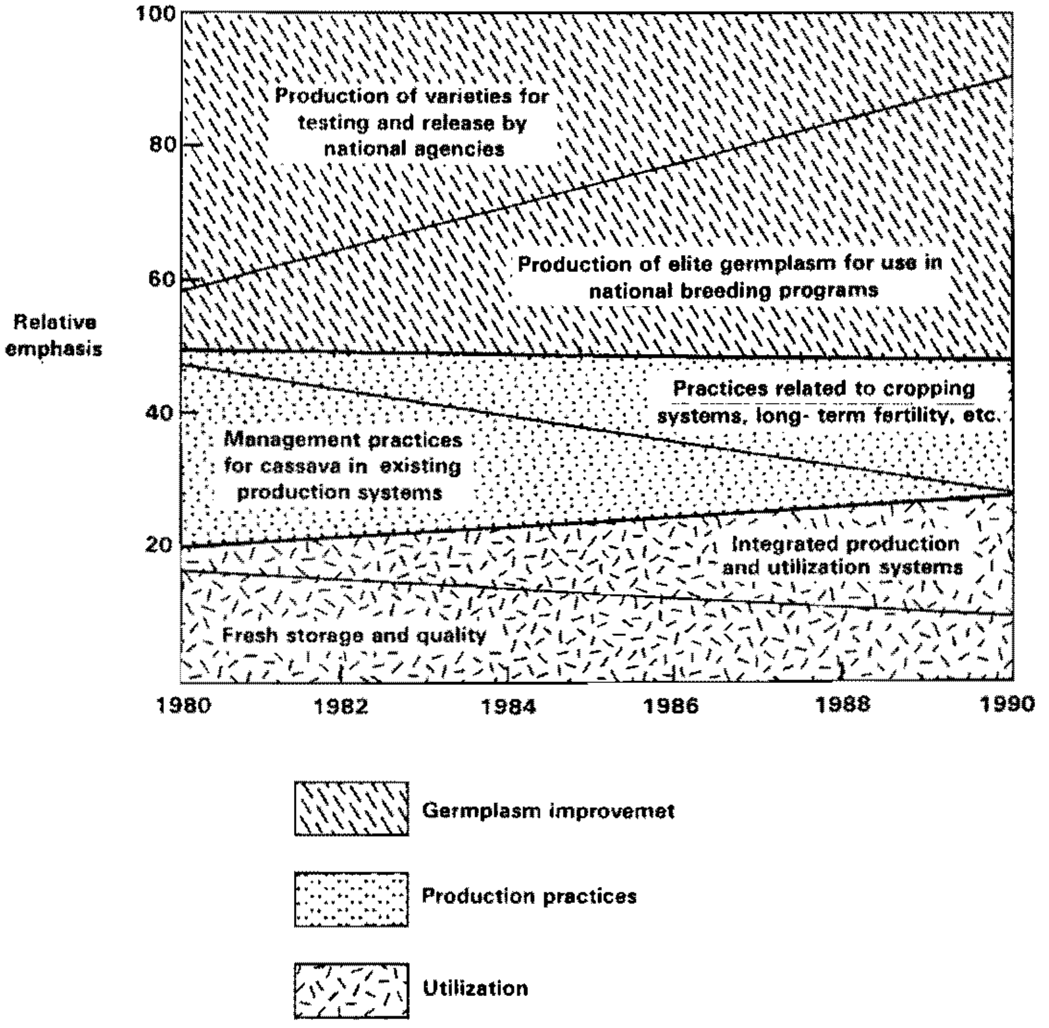
Although there are only minor changes and additions to the core research staff there will be considerable changes in emphasis within the overall program. The major change in emphasis in the germplasm improvement section will be towards developing specific germplasm for each ecosystem. Less emphasis will be placed on ecosystems 4 and 5, and more on ecosystem 1, 2 and 3. Outposted research work is projected for ecosystem 6. In addition, as national programs develop, more stress will be placed on providing sexual seed for selection in national agencies than on the production of finished varieties. A schematic diagram of the changing importance of various activities in the Cassava Program over the decade of the eighties is presented in Figure 5.1.

In the area of crop protection continued emphasis will be placed on host plant resistance as the basis for integrated pest management. As resistance sources are found more effort will turn to other methods of control, such as biological control and phytosanitary practices in those cases where host plant resistance is not the most appropriate form of control.

Up to the present much work has been done on realizing the maximum yield potential under moderate input levels through the development of technology that is broadly adapted to a wide variety of conditions. This emphasis will be modified so as to develop a technology that allows high and stable yields to be obtained in each ecosystem.

Work on utilization and marketing has not received much attention in the Program. Now that viable high yielding technology allows yields and

Figure 5.1 Relative emphasis in the Cassava Program on various aspects of technology development activities in the decade of the eighties



area planted to be substantially increased, more attention will be focused on improving the utilization of cassava.

Since the research requirements in cassava utilization are quite diverse and often of a short-term nature CIAT has projected research in this area on a more opportunistic basis than in other activities. Particular emphasis will be placed on fresh cassava storage and the future role of cassava as an animal feed, as well as other components including appropriate technologies for the sun-drying of cassava and in the processing of dried materials. The Program will continue to be alert to future world developments in the industrial uses for cassava in order that farm level processing can be developed to meet these new demands. In this research, emphasis will be particularly placed on techniques which are low users of energy in relation to output and which are appropriate for small farmer conditions.

5.1.7.1 Germplasm improvement. The germplasm development section (consisting of two senior scientists) is already evaluating the germplasm bank in four of the major ecosystems. The germplasm bank will be evaluated in a fifth ecosystem, the hot, humid lowland tropics. As the initial germplasm evaluation is completed attention will turn to the production of elite lines containing combinations of desirable characters for each ecosystem. Large quantities of sexual seed from these elite lines will also be produced for use by level A national programs. Breeding will be dynamic in order to incorporate new techniques (section 5.1.7.2 below).

The elite lines will form the basis for crosses in varietal improvement. The varietal improvement section will develop clones specifically adapted to each of the major ecosystems. In the coming years more attention will be given to selection for yield stability and root quality, both for the fresh and processed markets. Neither the varietal improvement section nor the germplasm development section can work in ecosystem 6 as this ecosystem is not represented in Colombia. The strategy in this important area will be discussed in a later section.

5.1.7.2 Tissue culture. Major problems in a vegetatively propagated crop such as cassava are associated with storage of germplasm, and production of disease-free stocks. The tissue culture section of the Germplasm Resources Unit is developing methodology for cheap storage of germplasm as plantlets, and production of planting stocks from meristems. It is expected that within three to five years these procedures will become routine. When this occurs attention will turn to use of tissue culture techniques for production of haploids, protoplast fusion and even, eventually, genetic engineering in support of varietal improvement.

5.1.7.3 Plant nutrition and physiology. Research in these areas is conducted by a physiologist and a plant nutritionist. The basic nutrient requirements of cassava and the physiological characters associated with high yield under non-stress conditions have been defined. The plant nutrition section will identify material that grows well under extreme conditions of low pH and high aluminum levels and define characters associated with high yield potential under low soil fertility conditions in conjunction with the physiology section. In addition, particular attention will be paid to the most efficient use of limited quantities of fertilizer. In this respect the possibilities of using cheap rock phosphates with mycorrhizal/cassava associations will be assessed. The physiology section will concentrate on stress factors that cause instability of yield and quality with a view to developing varieties with high yield stability under climatic variation in each ecosystem.

5.1.7.4 Plant protection. The plant protection section (2 senior scientists) identified diseases and pests that attack cassava, and evaluates their importance in decreasing yields. Important diseases and pests are studied in detail so that control measures can be developed when necessary. In the past, major emphasis has been placed on superelongation disease, bacterial blight, thrips and spidermites where resistance sources have been found. As these problems are resolved through breeding they progressively become more a part of the germplasm development sections. Many of the diseases and pests can best be controlled by other means. Biological control and cultural pracice measures have been developed and new emphasis is placed on biological control of mealy bugs and other insects. Treatments to control pathogens of planting materials have been developed by the pathology section. Attention will now turn to pathogens of stored planting materials. The major diseases and pests and development of control methods are shown in Table 5.3.

5.1.7.5 Agronomic practices and regional trials. The agronomic practices section (2 senior scientists) will concentrate on the development of suitable cultural practices for the different ecosystems (i.e., ecosystems 1-5) and will pay particular attention to modification of these practices to ensure compatibility with the new germplasm. The regional trials section combines the best new clones with the improved management practices and tests these under a broad range of conditions. Special emphasis is placed on development of multiple cropping systems for use by small farmers.

5.1.7.6 Economics. The work of the economics section (one senior scientist) revolves around the analysis of the potential economic impact of improved cassava technology in Latin America. The analysis provides a framework for integrating demand potential and competitive prices in various end markets with necessary production costs at the farm level. On-farm research trials provide a systems methodology for defining potential productivity and technology design requirements for the research

Table 5.3 **Major disease pests and control measures. (Control methods in parentheses are still being developed or are the most likely form of control to be developed)**

Disease or Pest	Losses	Distribution	Control Methods
Cassava Bacterial Blight	Up to 100%	Widespread	Clean seed, agronomic practices, (resistant varieties)
African mosaic disease	Up to 90%	Widespread in Africa and India	Clean seed, rogueing, resistant varieties
Superelongation	Up to 100%	Limited, only in Americas	Stake treatment (varietal resistance)
Frogskin disease	Up to 100%	Very limited, only in Americas	(Disinfection of tools, clean planting material)
Phoma	Up to 100%	Limited to cool humid areas	(Varietal resistance)
Cercospora leaf spots	Up to 30%	Very widespread	(Varietal resistance)
Pathogens of planting piece	Up to 100%	Very widespread	Stake treatment
Anthracnose	Not known but maybe high	Limited areas of Americas and Africa	(Varietal resistance)
Preharvest root rots	Up to 100%	Mainly in poorly drained areas	Crop rotation, ridging
Spidermites	Up to 50%	Widespread, in dry season	(Biological control, varietal resistance)
Hornworm	20% per attack	Widespread in Americas only	Biological control
Thrips	Up to 28%	Widespread	Varietal resistance
Scales	Reduces germination, up to 20% from later attacks	Widespread	(Biological control, varietal resistance)
Mealy bugs	Probably high	Limited	(Biological control, varietal resistance)
Shootflies	Up to 34%, generally very low	Widespread in Americas	Only necessary in early growth stages (Varietal resistance)

Major Source: A. Bellotti and A van Schoonhoven (1978). Cassava Pests and Their Control. CIAT Series 09EC-2. pp. 71.

Lozano, J.C. and R. Booth (1974). Disease of Cassava (Manihot esculenta Crantz) PANS 20(1)30-54.

program. With methodologies established on the basis on research in Colombia these production and demand studies in the next decade will be extended to collaborating countries in Latin America.

5.1.7.7 Utilization. The organization of the utilization section is somewhat different from the other subsections in that, although utilization is a vast topic to be researched, there is only one senior position. This position will be used to give continuity in a program that is expected to be dependent on a large number of special projects, mainly of a shorterm nature, to resolve specific problems.

5.1.8 Future Headquarters-based Research Staffing Requirements

The viral diseases of cassava in the Americas were not previously considered as major constraints on yield. However, in the last few years two new diseases, probably caused by virus infestation, have been identified and both have proved capable of causing complete crop failure. Intensive investigation of these diseases is under way. A program virology position is projected for 1983 in order to advance this research.

Recent work at CIAT and other institutions has amply demonstrated the importance of mycorrhizal associations in improving the phosphorous nutrition of cassava. A special project with GTZ funding has recently been mounted to determine the potential for economic exploitation of this association. If results suggest that the effect can be greatly enhanced through research then a new position may be requested for a microbiologist within the Cassava Program.

Production of good quality planting material, and its storage, is vital if high yields are to be obtained. More and more data is being collected that shows that "seed" production may require different crop management practices to that used for root production. A senior staff position is not required for this research at present but if new varieties with high yield potential do produce less "seed" of good quality than traditional varieties it maybe become necessary to develop research in this field. The new avenues of research which have been described above may not necessitate an increase in staffing. The plant nutrition section may well move into the mycorrhizal field, and the plant physiology or agronomy sections into seed production research, without increased staff needs. In the case of the virologist an increase of one senior staff is definitely required.

The general CIAT-wide strategy for postings in locations other than at headquarters is addressed in Chapter 7. The following projections as to outposted staff requirements by the Cassava Program are considered vital over the decade of the eighties if the program is to achieve its objectives.

5.1.9 Outposted Research Staff

5.1.9.1 Subtropics. Ecosystem 6 (the cool winter areas) is an important cassava producing ecosystem in the Americas and in other regions of the world. Due to its location, CIAT at present cannot work in this area to provide basic germplasm to regions such as parts of Mexico, southern Brazil, Paraguay, Bolivia and the more northern islands of the Caribbean. It is proposed that, beginning in 1983, one senior research scientist with research support be placed at a research institute, (probably in Santa Catrina in southern Brazil), to first evaluate CIAT and local germplasm under these conditions for further breeding. This material will then be made available to other countries where ecosystem 6 predominates.

5.1.10 Regional Cooperation

5.1.10.1 Asia. Approximately 40% of the total world cassava production is in Asia. Until quite recently the only country with a major national cassava program was India. Over the last five years national programs have developed in Thailand, Malaysia, Philippines, Indonesia, and Sri Lanka. CIAT has been involved in supporting these programs through training, consultation and the provision of imporved germplasm. CIAT has had a regional services position under special project funding in Asia which facilitated this work, particularly in the introduction of germplasm and organization of training. The funds for this position have now ended and Asian national agencies have requested that CIAT once again station personnel in Asia to assist with coordination of activities in Asia and in germplasm development. From CIAT's point of view it is becoming progressively more difficult and expensive to provide the Asian national agencies with technical assistance from the Colombia headquarters. The two areas where these constraints are greatest are in coordination of training activities and in maintaining an awareness of changing national needs, and in supplying countries with germplasm specifically adapted for Asian conditions. This latter situation is of great concern because, at present, the range of genetic variability in Asia is extremely limited. It is proposed that CIAT, starting in 1982, outpost one regional cooperation position in Asia that would provide continuity and liaison for possible teams which would be non-core funded.

5.1.10.2 Andean Zone. The countries of the Andean Zone are traditional cassava producers. They have recently become major importers of grains for animal feed and several have expressed the desire to increase cassava production to replace imported grains. Cassava programs in this region are universally weak or non-existant. Regional services for the Andean Zone will be accomplished through interaction by headquarters-based staff with the neighbouring countries in the zone. No outposted regional position for the zone is projected in the plan.

5.1.10.3 The Caribbean, Central America and Mexico. While the region is at present of less importance as a cassava producing area, many countries in the region are classified as calorie-deficient. Cassava programs are only now being developed and require considerable assistance in planning and training during their formative years. In addition, for many years these areas will be directly dependent on CIAT-developed germplasm. In most cases they will require finished varieties rather than sexual seed or large number of populations for selection. An outposted regional cooperation scientist is projected for 1985, to provide support to the national agencies in the region.

5.1.10.4 Africa. In the CGIAR system CIAT has global responsibility for cassava, and IITA has regional responsibility for Africa. At present about 40% of the world's cassava is produced in Africa. Much of the germplasm management practices developed in CIAT may be applicable in Africa (e.g., biological control agents for mealy bugs, a major pest in Africa, were recently sent from CIAT for testing and multiplication by IITA). Two major differences exist between African and the Americas in cassava production. Firstly, the major disease, African Mosaic, does not occur in the Americas; and secondly, slash-and-burn culture is much more widespread. These two major differences make it necessary to have a major cassava research effort in Africa. The IITA program does not, however, have the same resources as CIAT, particularly in the case of genetic variability, and its efforts could be greatly enhanced if there was more liaison with CIAT. In addition, it is vitally important to evaluate American and Asian clones under conditions of African Mosaic in case the disease arrives in these continents. Resistant clones would then be available. For these reasons it is tentatively proposed to place, starting in 1986, one CIAT scientist in IITA with major responsibilities for germplasm exchange and more rapid interchange of research developments between the two institutes.

5.2 Beans: Program Strategies and Projections

The common dry or field bean (*Phaseolus vulgaris* L.) is the most important grain legume species for direct human consumption in the world. Production spans regions as diverse as Latin America (3.6 million tons per annum, 1977-79), Africa (1.4 million tons), the Middle East, China, and the United States. Beans are a traditional food in Latin America, particularly in Brazil, Central America, the Andean Zone, and in some of the countries in the Caribbean. The analysis presented in Chapter 1 indicates that beans are the cheapest source of protein and a relatively unexpensive calorie source.

The common bean is generally a crop of the small farmer and is grown in a wide range of cropping systems which often include maize in the annual cycle. The majority of bean production occurs in systems utilizing few purchased inputs, and yields are generally low. While production in Latin America has increased approximately 1% per annum over the last decade, yields have generally declined and currently average on the order of 600 kg/ha. Area expansion has enabled a slight production growth to continue, but this growth has not kept pace with population, much less demand growth. Due to rapidly increasing exportation from Argentina, mainly to Europe, Latin America has become a net exporter of beans, although some countries such as Cuba, Brazil and Venezuela have substantially increased their imports in recent years. Bean prices have increased more rapidly than general inflation in many countries. In Brazil, real prices tripled from 1972 to 1976. Over the same period, per capita consumption decreased from 26 kg to 22 kg, thus further aggravating the nutritional problems of the poor.

Even though market prices have generally increased, beans production is characterized by low profitability and high risk which are related to low and very unstable yields, associated with seasonal climatic variability, and, hence, seasonal price fluctuations. These factors have increasingly led to the displacement of beans in traditional areas by higher value crops. Thus, in Brazil, soybeans have displaced beans on the more fertile soils, and productivity has declined due to the marginal lower fertility soils into which production is moving. A similar effect has occured in Mexico, but in this case increased sorghum production may have been the competitive influence.

Selected commercial bean varieties, grown under experimental conditions with appropriate plant protection and irrigation, are capable of far higher yields than is evident in national production statistics. Experimental bush bean yields in monoculture of 3-4 t/ha in a crop season (90-120 days) are not uncommon. Experimental yields of climbing beans grown on artificial support (monoculture) have exceeded 5 t/ha in 100 days at CIAT. A large yield gap exists between farm and experimental situations, a gap which could be reduced substantially through the use of improved varieties and production technology. Economic analyses have indicated that were production in Latin America to rise by 5% per annum over the next five years, the increased production would be absorbed by increased consumption, with an average price decline of only 3%.

5.2.1 Production Systems and Constraints

In the developing countries of the Western Hemisphere, beans are grown over a wide range of latitudes and altitudes and in recurring series of cropping systems which have evolved on small farms to adjust to various environmental and socio-economic constraints. The four major cropping systems of production can be classified as follows:

a) Bush beans in monoculture, typified by low to middle altitude areas in Mexico, the Dominican Republic, Brazil, Peru, and Chile.

b) Bush and semi-climbing beans in relay systems with maize, typified by low to middle altitude areas in Mexico, Central America, Colombia, and Brazil.

c) Bush beans in direct association with maize (sown at same time), typified by middle altitude areas in Colombia, Venezuela and by many areas in Brazil.

d) Climbing beans in direct association with maize, typified by the higher altitude areas of Guatemala, Colombia, Ecuador, and Peru.

In these systems the predominant role of maize as a companion crop is clear. A major constraints to increased production of beans per se is the competitive influence of maize within the various cropping systems. Most studies reveal yield reductions of the order of 50% in associated systems with maize. In farmers' terms it is obvious that the total return from the system is more important than the individual components. Data on the micro-regions of production of beans in the Americas is being collected by the Agroecosystems Analysis Unit which will provide an accurate accessment of the relative production importance of the various systems. Preliminary data suggests that the rank order in terms of total production is roughly in the order presented above.

In terms of biological constraints, of major world crops, beans are undoubtedly one of the most susceptible to diseases and insect attack. More than 200 pathogens are identified which can influence the productivity of the species. Diseases and insects across all zones of production constitute the most important common constraints to increased production and productivity. The most common and widespread of the diseases in the Western Hemisphere are: bean common mosaic virus (BCMV), bean rust (Uromyces phaseoli), anthracnose, (Colletotrichum lindemuthianum), and angular leaf spot (Isariopsis grisela). Common bacterial blight (Xanthomonas phaseoli) and bean golden mosaic virus (BGMV) are equally severe in particular locations and years. Most commonly utilized cultivars are not resistant to the major diseases of importance and, at best, show a low level of tolerance. Each of these diseases can cause yield losses as high as 80%-100%. The transmission of BCMV, anthracnose and bacterial blight through infected seed has caused the widespread dissemination of these diseases, not only in the Western Hemisphere but also in regions outside the center of origin of the species. The disease problems in Africa are similar to those that occur in Latin America except that halo blight (Pseudomonas phaseolicola) is relatively more important.

Among the insect pests, leaf hoppers (Empoasca spp.) and pod weevils are considered of greatest significance as constraints to production. Yield reductions in highly susceptible varieties due to Empoasca have been measured as high as 90%, with reductions of 20-50% commonly occuring in many farm situations, even when insecticides are utilized. Insects of stored grain, such as Zabrotes and Acanthoscelides, inflict heavy losses, forcing farmers to sell their harvest rapidly, which is contributing factor to post harvest price declines. The bean fly (Ophiomya phaseoli) in the most common insect in Africa causing severe losses in yield in many countries.

The data available on the bean micro-regions has allowed a growing-season climatic zonification to be carried out (Table 5.4). The seven zones are classified according to average growing season temperature and water balance conditions, with each zone representing a group of diverse microregions with similar mean climatic conditions prevailing during the actual growing season of bean production common in each microregion. The data suggests that a large proportion (76%) of bean production in Latin America occurs at temperatures considered close to optimum for the species (20-23°C). On the other hand, 73% of total production occurs in micro-regions with moderate to severe mean water deficits at some time during the cropping season. Only a small proportion of this production occur under irrigation. In climatic terms, beans are thus exposed to quite serious water deficits, and this constitutes one of the major constraints on production. The quite surprising tendency for production to take place over a narrow temperature range is an indication of a relatively high sensitivity in adaptation to temperature conditions in these species.

Physiological defects of currently utilized cultivars (mostly land races) contribute to low and unstable bean yields. Most cultivars are of poor plant type, with the pods in contact with the soil at maturity, which can contribute to a poor quality product due to pod attack by soil-borne pathogens. Many cultivars are of determinate bush habit with early and intense flowering characteristics which contribute to yield instability. These cultivars show little ability to compensate for low sowing-densities common on most small farms, and have no mechanism for renewed flowering when stress is relieved.

Soil related constraints are assuming a greater importance as bean production moves to more marginal soils. Soil acidity and high phosphorus fixation characterize many of the soils now utilized. Associated aluminum toxicity leads to reduced root development and increased sensitivity to water deficits. Nitrogen deficiency is also a limiting factor in many bean soils, and this is complicated by a low nitrogen fixation capacity in most currently used cultivars.

All of the major environmental and biological constraints to increased

Table 5.4. Zonification of bean production in Latin America

Type	General Description	Mean growing[1] season temperature °C	Range in mean[1] daily growing season water balance ± mm/day	Latin American Production ('000 ton)	% total
A	Average temperatures mean seasonal water tolerance adequate	22	-1.5 to +0.4 [2]	661	17
B	Average temperatures, slight excess in water balance	23	+0.4 to +4.0	118	3
C	Average temperatures, large deficit in water balance (irrigated areas)	23	-5.6 to -5.1	528	14
D	Average to moderately low temperatures with possible deficit in water balance towards end of growing season	20	-2.7 to -1.6	1672	42
E	High temperatures with possible deficit in water balance towards end of growing season	26	-4.1 to -0.3	262	6
F	Moderately low temperatures and moderate water balance deficits	16	-2.3 to -1.9	451	11
G	Low temperatures and adequate mean seasonal water balance	13	-0.9 to -0.52	45	1

1 Mean of conditions in microregions constituting each production zone type.

2 Values refer to range in mean water balances conditions occurring within the growing season.

bean production are researchable. While national programs of research in beans have existed for many years, progress towards the resolution of the problems through new technology has been limited. Some countries with historically strong national research programs, such as Mexico and Colombia, have made considerable progress in production indicating that a potential exists for improvement through research.

5.2.2 Objectives of the Bean Program

The goal of the Bean Program, in collaboration with national research efforts, is to increase the yield of beans and to improve the stability of production by focusing research on the principle constraints. The program has focused its research strategy in the light of the constraints in the Western Hemisphere. In general, the constraints on production in Africa parallel those in Latin America. The problems at all levels are probably more serious in Africa, and a concerted effort will be required to provide solutions through research. Much of the research carried out in Latin America is applicable in Africa but regional adaptive work is still required.

In recognizing the magnitude of the task, the Program has always sought to delineate its range of activities and to concentrate in those areas where it has a comparative advantage. Thus, it has avoided the humid lowland tropics where disease pressure is excessive, and the high acid, infertile soils of the agricultural frontier where bean production would only be possible with massive soil amendments. The Program has also confined its activities to Phaseolus vulgaris; avoiding the temptation to work with other grain legumes, such as lima beans (P. lunatus), cow-peas (V. ungiculata) or soybeans. Investigations in other closely related Phaseolus species (i.e., P. coccineus and P. acutifolius), has been confined to those characteristics of those species likely to lead to genetic improvement in P. vulgaris. The Program has thus narrowed its specific objectives to the following.

a) In collaboration with national research institutions, to develop improved technology for beans (Phaseolus vulgaris), particularly higher and more stable yielding germplasm, which will lead to increased national production and productivity in those Western Hemisphere countries where beans are an important source of food.

b) To assist in achieving the same objectives in other regions, particularly Eastern Africa, through institutional arrangements in which CIAT can provide an input which will allow advantage to be taken of the work in this Hemisphere.

c) To selectively strengthen the already existing national research programs in beans through training and the extablishment of a bean research network of collaborating professional scientists.

5.2.3 Research Strategy

In recognition of the overwhelming importance of biological constraints, the primary focus of the Program in terms of germplasm improvement has been on breeding for disease and insect resistance/tolerance in a range of selected commercial grain types. Initial emphasis was placed on overcoming losses due to BCMV, rust, anthracnose and Empoasca. By overcoming the yield reductions from these principle disease and insect pests, the Program aims not only to increase yields but also to reduce yield variance over time. Increasing emphasis on BGMV and common bacterial blight has been necessary in more recent years as the need for materials with these resistances became more evident in particular regions. Continuing emphasis on breeding for host plant resistance to the economically important diseases and pests will be necessary throughout the next decade. The emphasis on present massive screening programs will diminish as national programs increase their own research in that area. Increased attention by CIAT on the provision of more stable resistance sources and in studies on the epidemiology of the diseases will then be possible.

Parallel to the primary focus, i.e., diseases and pests, the Program has placed increasing attention on improvement in a range of other characteristics in the germplasm, including nitrogen fixation capacity, drought tolerance, and soil related constraints, particularly low phosphorus availability. Improvement in basic plant types within the various growth habit types has been approached gradually, and steady progress has been achieved. The chances of large and precipitating breakthroughs in yield potential through manipulation of the physiological constraints does not appear to be high in this species. The situation is similar in other grain legumes (e.g., soybeans and cowpeas), where progress has been characterized by steady progress towards particular objectives. The Program strategy of a heavy initial concentration on diseases and insects was a recognition of this situation.

The Program has made considerable progress in defining the plant types suitable for particular cropping systems both in bush and climbing beans. It is clear that no one type of plant can satisfy the rather diverse cropping pattern that exist. In designing plan type objectives the program has been particularly cognizant of the needs of the small farmer and the traditional cropping systems. In this technology design process, information provided by the Agroecosystems Analysis Unit has proved invaluable in orienting the research. Further progress along these lines is expected in the early years of this decade to allow the Program to continue to focus on principal constraints in each group of micro-region/cropping system situation.

5.2.4 Program History and Research Accomplishments

While initial studies on beans and other grain legumes had been undertaken at CIAT prior to 1973, formation of a coordinated program focused only on Phaseolus vulgaris dates from that year. Initially, five man-years of senior staff activity were involved. As additional breeding and pathology initiatives were undertaken, the team gradually increased to its presently budgeted 12 senior staff positions. The disciplines now represented are as follows: breeding (two in bush beans, one in climbing beans), agronomy (3), pathology (one each in mycology and virology), entomology (1), physiology (1), soil microbiology (1), and economics (1).

The germplasm specialist in the CIAT Genetic Resources Unit assists through the provision of genetic variability while nutritional and consumer preference characteristics of advanced materials are monitored by the Food and Nutrition Laboratory.

Establishment at CIAT of the world Phaseolus germplasm collection, currently containing over 27,000 accessions, has formed the base in the search for sources of resistance to major diseases and pests. These materials are utilized in a massive breeding program presently carrying out more than 1500 different crosses (parental combinations) per year. Facilitated by computer data management in which hybridization and seed movement are recorded, all lines undergo a series of evaluations in which all team members participate. These evaluations culminate with the best lines being introduced into the international testing program (International Bean Yield and Adaptation Nursery, IBYAN).

The first level of evaluation of the breeding populations (F_2 and F_3) is carried out by the breeders for disease and insect resistance, architecture, and consumer requirements. In the second stage of evaluation, which involves the whole team, the selections are tested in successive uniform nurseries. These include confirmations for disease and insect resistance, and general adaptation at two altitudes in Colombia (CIAT, Palmira and CIAT, Popayan). At the third level of the process the material is again further selected for the above characters, and for nitrogen fixation, water stress tolerance, low phosphorus tolerance, resistance to minor disease, protein content, and cooking time. Yield performance is measured annually in 200-300 new advanced lines in stressed and non-stressed conditions at three locations in Colombia. The results, containing more than 20 separate character evaluations, are published. CIAT makes these lines available as parental sources for national programs. Approximately 100 of the superior lines per year enter the international yield testing program (IBYAN). The IBYAN originally contained only germplasm bank selections, but now is composed principally of CIAT-bred lines and entries submitted by national institutions. As the capability to undertake breeding and selection activities increases among national programs, their entries will assume a more significant place in this program. Currently, over 150 IBYAN trials (or sets) are shipped each year, providing improved germplasm to all bean producing countries in Latin America, the Caribbean, and other regions of the world.

In 1975-76 the Bean Program established a time frame which it hoped to follow in achieving bean yield increases in Latin America. These projections were contained in a Bean Program position paper. To date results have been consistently better than predicted. Some selected highlights are given below.

a) All lines leaving the second stage of evaluation are now resistant to BCMV.

b) Improved germplasm having multiple disease resistance is now being distributed for international testing. Lines resistant to all known races of anthracnose have been identified.

c) Germplasm has been identified with tolerance to drought, extreme temperatures, all major diseases and pests, high Al, low soil P, and with maturity differences appropriate for different production systems.

d) Yield levels of small, non-black seeded experimental lines have been significantly improved. They now equal or surpass that of the initially (1976-77) superior, black-seeded germplasm.

e) Lines developed collaboratively in Guatemala for tolerance to BGMV out-yielded leading commercial varieties under heavy disease pressure, even when the susceptible local lines received heavy insecticide applications. Yields in the resistant lines were further increased with chemical protection.

f) Currently, over 20 lines originating from CIAT collaboration with national breeding programs are undergoing varietal evaluation in farm level testing or seed multiplication in national programs in Latin America and the Caribbean. Disease resistant lines have already been released in several countries. In Cuba, an estimated 5000 ha has been planted to multiply such improved germplasm while in Bolivia, 1000 ha are devoted to this purpose.

g) While emphasis has been placed on varietal improvement, the opportunity to improve agronomic practices has not been ignored. In farm level testing in Colombia, improved agronomy has increased farm yields by 50 to 100%. A low cost, non-toxic, farm level storage technology has also been adapted to beans. Diffusion of this technology has commenced in Colombia.

Such progress has only been possible as a result of the intensive training programs mounted at CIAT, and through the interest and collaboration of national program scientists. As of 1980, more than 360 national program scientists have received post-graduate training at CIAT, mainly in the form of bean production short-courses, or intensive discipline-oriented training. Availability of improved germplasm and high level training has resulted in increased support to bean research in national programs.

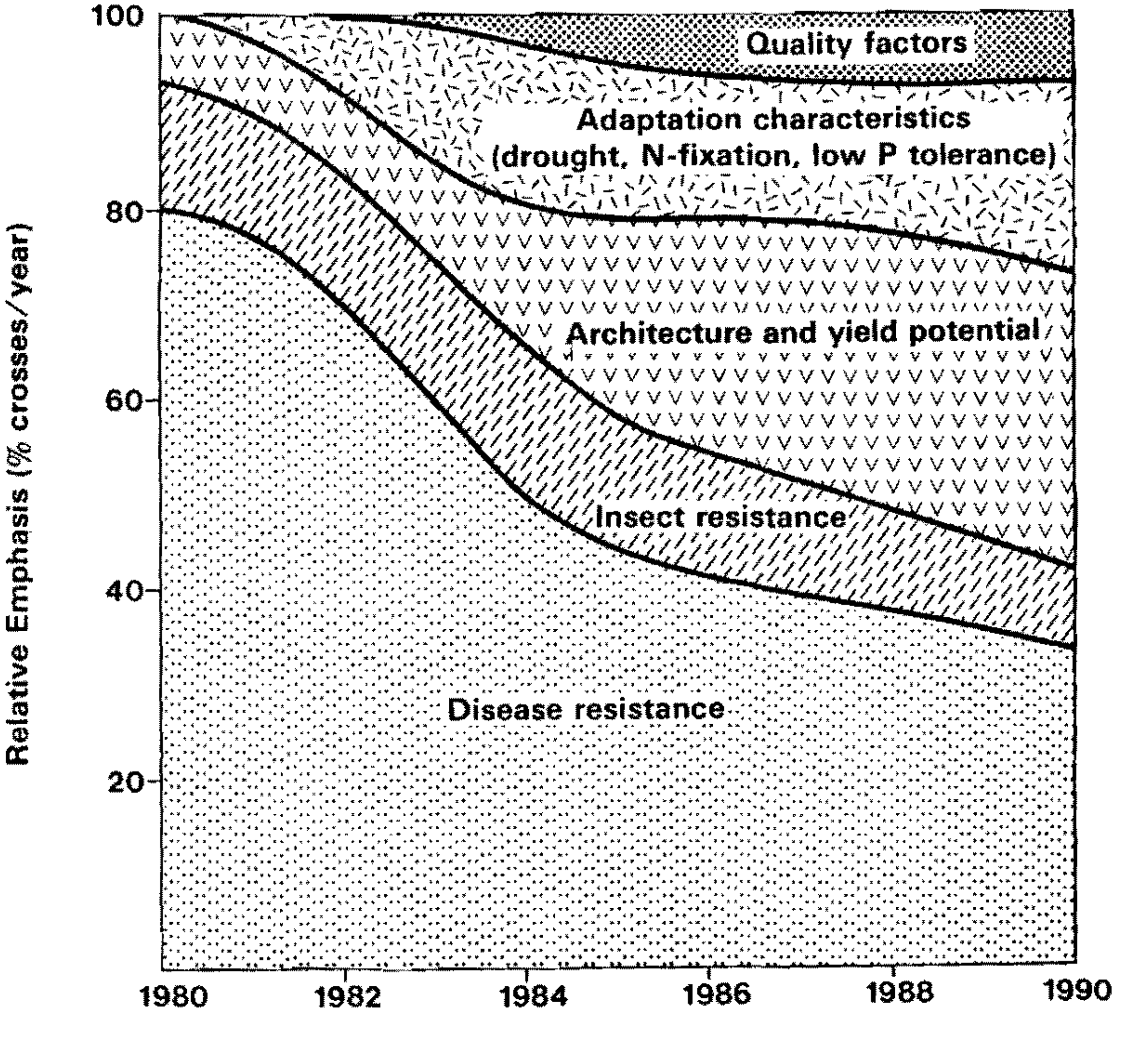
5.2.5 International Cooperation Strategy in Beans

National bean research programs have reached varying stages of development during the decade of the seventies. The situation in beans is somewhat more favorable, since in all countries where beans are important there has been some attention given to research. Most national agencies have a research staff working on beans, most of them having received training at CIAT. An active network of collaborators has been established. Further selective strengthening through training, consultative visits, and all of the other activities in the field of international cooperation will be continued through the eighties. The ultimate aim is to help move all country programs into a situation where they can become full and equal partners in the network. CIAT can then gradually adopt a research backstopping role. The role at which this progress occurs in any one country will vary considerably and some attrition is to be expected.

5.2.6 Program Research and Core Staffing in the Eighties

As suggested by Fig. 5.2 the 1980s will see progressive changes in priorities in the Program's breeding activities. However, little change in overall Program staffing levels are anticipated. Currently, all breeding lines leaving CIAT are resistance to BCMV, and various sources of resistance to anthracnose are available and can rapidly be incorporated into breeding lines. This will permit greater attention in the short term to other diseases, including rust, angular leaf spot and web blight, for which various races of the pathogen have been identified, and for which no single line is likely to be resistant over all locations. This emphasis, plus the need for additional work on common bacterial blight and halo blight disease control strategies will require the addition of a second pathologist (bacteriologist) to the team. This position is projected to commence in 1982. As the disease breeding goals are realized, a ruduction in the disease breeding emphasis of the Program should be possible with an increased emphasis on integrated disease control strategies toward the end of the decade.

Figure 5.2 Relative emphasis in the decade of the eighties in the Bean Program on various aspects of technology development as reflected in the proportion of crosses to be carried out in the breeding program in relation to general constraint areas.



Substantial variation in plant architecture and yield components has been obtained in the breeding and germplasm lines evaluated since 1976. Plant characteristics associated with higher yield are being sought and, once obtained, should permit development of lines possessing both improved yields and multiple disease resistance. The increasing emphasis to be given to bean plant architecture and yield is reflected in Fig. 5.2. A new initiative towards incorporation of snap bean characters into particular elite lines will be undertaken during the decade.

With the price of most fertilizers rising rapidly, and with credit for small farmers a limiting factor in purchased inputs, the elite lines of the future will need to be tolerant to a number of soil constraints. While such constraints will not operate in all production regions, the Program will need to develop--for regions such as Brazil and Venezuela--varieties with tolerance to moderate soil acidity, low soil P, and with increased capacity for nitrogen fixation. The incorporation of these traits into agronomically acceptable cultivars will require closer collaboration between breeders, agronomist and soil microbiologist, as well as innovative breeding methodologies.

Obviously, the increasing capability of national bean programs will influence the scope and direction of CIAT's home-based research. Training and network activities have helped to build several strong national bean programs fully capable of developing their own varieties, in relation to which CIAT should increasingly assume a backstopping role, providing these programs principally with specific genetic variability for their improvement programs, postgraduate training opportunities, and documentation. This would permit more detailed assistance to the smaller programs with breeders, agronomists and pathologists increasingly involved in the evaluation of collaborative local breeding nurseries to exploit specific adaptation, and overcome nutritional or consumer acceptance problems. Despite these tendencies to improve cultivars by, or in collaboration with, national programs, the Bean Program expects to continue producing some finished varieties throughout the eighties. This is necessary since it is expected that some national programs will not have reached a state of self-sufficiency in research.

As the Program continues to evolve, the bean germplasm bank will constantly be in use as a source for new variability. New collections will be made during the eighties to add genetic variability from regions which currently are poorly represented or in which specific desired variability is most likely present. The newly formed Seed Unit of CIAT is expected to help in the formation of a strong seed industry in Latin America to promote and make available newly developed germplasm.

5.2.7 Regional Cooperation

The Bean Program policy of in-depth evaluation of its germplasm, aided by similarity of the production conditions and constraints among its target area countries, has ensured that CIAT-derived materials are generally well adapted to other production regions. For this reason, it is not anticipated that it will be necessary to deploy research staff away from the CIAT base in Colombia. Region-specific problems such as BCMV in Central America and Brazil, the Apion podweevil in Central America, and bean fly and halo blight in Africa will be worked on in collaboration with national programs and, hopefully, with the support of the recently formed Title XII Bean Cowpea CRSP within U.S. universities.

The Bean Program projects the location of outposted regional cooperation staff to facilitate the transfer of new technology and for CIAT/national program interaction in three regions of Latin America, Africa, and the Middle East.

5.2.7.1 Central America. This region, with its numerous small national bean programs and high per capita bean consumption, will probably continue to rely on the CIAT program during this decade. Transfer of germplasm and technology from CIAT, and between national programs, can bes be served by stationing one scientist in the region. This position has been funded since 1977 via special funding, and twice has come close to interruption due to funding uncertainties. One outposted regional cooperation position is projected for 1984 at the termination of the existing Swiss-funded project.

5.2.7.2 Brazil. With 55% of Latin American bean production in Brazil, and a strong national program, a closer collaboration between both research programs will be developed to ensure two-way technology flow. Collaborative development of technology that overcomes constraints to soil Al toxicity and low P in important bean production zones in Brazil, will be emphasized. An outposted research scientist located in Brazil is projected for 1984 who will work with Brazilian scientists as part of the national bean activities, and also act in a liaison capacity with CIAT.

5.2.7.3 Southern Andean Zone. The Andean Zone is an important bean consuming zone, with production concentrated on small farms, often in higher elevations. Although production systems vary, climbing beans are important, with little previous research done in the region. There exists a great opportunity for the Bean Program to develop new technology in collaboration with these national programs in both bush and climbing beans. One outposted regional position is projected in the plan for 1986 for the Andean Zone, and will probably be located in Peru, but with responsibilities for developing collaboration in all of the countries in that sub-region, including Ecuador, Bolivia, Chile and Argentina.

5.2.7.4 Eastern Africa. Eastern Africa is the second largest tropical bean production region, with per capita legume consumption much higher than in Latin America (in some countries over 50 kg per year). CIAT materials in the IBYAN program have proved to be well adapted to African conditions and the possibility exists for major gains from limited inputs, despite the distance involved, and existing germplasm quarantine constraints. CIAT projects one outposted regional cooperation scientist for this region. Special project funding will be sought to support the initial phase of this activity, to be followed by core-funded support starting in 1983. The scientist will be primarily responsible for the network collaboration, training, and regional coordination of germplasm activity, and be expected to be the leader of a team, which would be located in the region under special project funding, probably in collaboration with FAO/UNDP.

5.2.7.5 Middle East. Additional regional cooperation activities will need to be developed for the Middle East in the decade, and one position is projected for 1986.

5.2.7.6 Bilateral Arrangements. The Bean Program will continue to use special bilateral funding as an instrument to cooperate more closely with individual national programs. At the present time one such scientist is in place in Peru.

5.3 Rice: Program Strategies and Projections

Of the 116 million hectares of cultivated land in Latin America and the Caribbean, rice is grown on 6.5% of the area. Rice is one of the most universally cultivated cereal crops of the region. The importance of the crop as a basic food staple has been increasing over the past 15 years. In some countries of the region, this tendency has been somewhat related to an apparent decline in per capita direct consumption of maize.

The area planted has increased at an annual rate of 2.4 percent, and production at 3.3 percent. These growth rates have kept pace with increase in population and income, which resulted in a yearly increase in demand of 3.5 percent. For the developing countries of the region as a whole, per capita consumption of rice has been relatively stable over the past 15 years, although dramatic increases have taken place in some countries, especially in Bolivia, Colombia, the Dominican Republic, Guatemala, Haiti, Paraguay and Uruguay. In these countries, growth rate of per capita consumption was greater than 2.5 percent per year. The aggregate figure for per capita consumption of paddy rice was 44 kg/capita in 1976-1978.

The increase in consumption has been largely satisfied within the region.

Net regional imports have remained at around 150,000 tons per year. Intra-regional trade has increased to a level of 320 thousand tons per year, 36% larger than the level in 1963-65. Based on the current growth rate of demand of 3.5% per year rice production in Latin America must be doubled by the year 2000 in order to satisfy internal demand at current relative price levels.

In order to achieve a doubling of production over the next 20 years, it is clear that research must be strengthened and strongly focused on the principle constraints. CIAT, in collaboration with national agencies in the region, has made a significant contribution to the advances already achieved.

The CIAT Rice Program is basically a regional program for the Western Hemisphere. It collaborates closely with IRRI in the world-wide program of rice research. Research on the principle regional constraints is encouraged through an active network of rice researchers which has as its main focal point for collaboration the International Rice Testing Program (IRTP) coordinated by an IRRI scientist located with the CIAT rice team.

The estimated area of rice sown in the region in 1978 was 7.4 million ha with a total production of about 15 million tons of paddy rice. About two-thirds of the production growth came from an increase in area (mainly in the upland sector) and the remainder from increases in yield (mainly in the irrigated sector).

These overall trends do not accurately reflect the situation in particular countries or with particular production systems. Some countries are experiencing accelerated growth in production and productivity, while other are making very little progress. This disparity is fundamentally a function of the predominant farming system in each country.

5.3.1 Farming Systems and Constraints

A number of quite distinct rice farming systems exist in the region, each with its own actual and potential level of productivity. Rice production is fequently, and somewhat misleadingly, divided into two main systems, namely irrigated and upland. In 1978, irrigated rice was estimated to comprise 2.1 million ha, or about 28% of the total area, with an average yield of 3.5 t/ha. Upland rice, i.e., all non-irrigated rice, covered 5.3 million ha, about 72% of the area, with an average productivity of 1.3 t/ha. This statistical division obscures, to some extent, the actual productivity of each farming system and its potential productivity through research on specific yield constraints. In order to outline more clearly the rice situation in the region the following systems have been identified.

5.3.1.1 Subsistence upland rice. The system is common in many areas at the agricultural frontier, particularly where small subsistence farmers have colonized new lands. The system utilizes no mechanisation and very few purchased inputs. Forest or scrub is cut, cleared and burnt, and rice is shown in widely separated holes with pointed planting sticks. The crop is shifted to new land after one or two harvest. Maximum family farm size is of the order of 1.5 ha, and varieties are largely unimproved land races. The system is reasonably stable but estimated productivity is low (at around 1.0 t/ha or less). The harvest is normally consumed by the farm family. Total area and contribution to national production statistics are largely unknown and are considered to be negligible.

The major constraints is a total dependence on hand labor. This limits farm size, obliges wide plant spacings, demands native varieties, and prohibits use of purchase inputs. Farm production is defined by the consumption demands of the whole family, while factors such as soil fertility, variety, weeds, and pests assume relatively minor importance as constraints.

5.3.1.2 Highly favored upland rice. This system is generally confined to areas with level topography, with over 2000 mm of mean annual rain-fall during a rainy season of 8-9 months. There are normally no marked dry periods during the rainy season. The system is fully mechanized for planting and harvesting in most areas of production. Soils are generally alluvial, slightly to moderately acid, and well drained. Modern dwarf varieties and agronomic practices are suitable, and yields average around 2.5 t/ha, with better farms consistently producing 4-5 t/ha. The system is typically found in parts of Central America, Colombia and in some areas in Brazil. The actual present contribution to area and production statistics from this system is low, but there is a very large area of unexploited land resources in the region into which this system could move.

The system has the major yield constraints: grassy weeds after two or three cycles; the blast disease (*Pyricularia oryzae*); and lodging. A variety recently released in Colombia and in other countries, CICA 8, (developed in a collaborative program between ICA and CIAT), is the most productive presently available variety for the system in a number of countries.

5.3.1.3 Moderately favored upland rice. Most of Central America and a large proportion of sub-Amazonian Brazil employ this system, which differs from the preceeding one in having a shorter wet season, with less overall rainfall, and normally with some dry spells during the growing season. Dwarf varieties are used in Central America while tall materials are used in Brazil. Yields in the two areas average around 2.0 and 1.5 t/ha, respectively. Yield variance around these averages is high due to rainfall irregularity.

The chief constraints consist of several interrelated factors triggered by mild to moderate water deficits, including soil mineral deficiencies (particularly phosphorus), diseases (particularly blast), and weeds.

5.3.1.4 Unfavored upland rice. This system is characterized by environments with irregular and low total rainfall. The system is highly mechanized, with low planting densities, and the varieties utilized are all tall materials. The system is particularly important in Brazil where a large proportion of the 4.7 million ha in 1978 fell into this category. Yield are generally low (or the order of 1 t/ha) and yield variance is extremely high from year to year and from location to location in the same year. The soils utilized in Brazil are mostly highly acid, with relatively high levels of aluminum toxicity for rice, particularly in the subsoil, even though surface liming is practiced.

The main constraint in the system is the problem of water deficits induced by dry spells during the wet season, which is compounded by the poor root development in the subsoil associated with aluminum toxicity. Blast is also more severe in the unfavored systems, and this seems also to interact with the degree of water deficits experienced. Phosphorus deficiency in most soils is a serious overall constraint, but, at least in the Brazilian case, fertilizer levels are generally adequate given the limitations imposed by the other constraints.

5.3.1.5 Rainfed lowland rice. This system is intermediate between irrigated and upland. Rainwater is trapped and held by field levees. Nevertheless, water deficits and/or deep flooding are common. Dwarf varieties are grown in certain areas where the water control procedures are adequate, but tall varieties generally predominate. The crop may be transplanted or directly seeded, and purchased inputs are few. Rainfed rice is important in coastal Ecuador, on the northern coast of Colombia, and on the island of Hispaniola. The total regional importance of the system is low. Average yields are of the order of 2.0 - 2.2 t/ha.

Apart from the more general constraints common to all systems the main problem in this system is that of haphazard water control. This situation forces farmers into using tall varieties and, due to the risks involved, low levels of purchased inputs.

5.3.1.6 Irrigated rice. Irrigated rice covers 28% of the total area sown in 1978 and contributed 50% of the total regional production. The system is found in all countries but predominates in Cuba, Nicaragua, Colombia, Peru, Venezuela, Guyana, Surinam, southern Brazil and the countries of the Southern Cone. Average national yields range from 3 to over 5 t/ha. The system continues to hold a comparative advantage in maintaining and further increasing national yields and stability of supply. This situation applies to many new production areas being developed, particularly in northern Brazil. Increasing production costs are starting to divert farmers to alternative systems in many countries.

The important region-wide constraints include rice blast, straw strength/lodging, and, in some countries, problems associated with provision of materials with suitable grain quality. Although some countries lag in average yields, infrastructure problems in applying existing technology are more limiting than the technology itself. In the Southern Cone, where tall varieties are still grown, the problem of developing dwarf materials with sufficient cold tolerance remains to be surmounted. In addition, this area has particularly stringent grain quality requirements for the export market. In Chile, where the crop is entirely of the Japonica type, the basic constraints is lack of high yielding varieties.

5.3.2 Objectives of the Rice Program in the Eighties

As already indicated, the Rice Program is focused only on the problems of rice in the Western Hemisphere and, as such, has designed the Program to focus on the principle constraints in the region. The program will continue this focus over the next decade. The following points delineate these objectives.

a) To continue to develop, in collaboration with national rice institutions in the region, germplasm-based technology designed to overcome the principle constraints to increased production in the irrigated sector.

b) To develop, through a new initiative and in collaborative research with national institutions, new germplasm-based technology to improve productivity and stability of supply in the more favored upland rice environments of the region.

c) To continue active collaboration with IRRI in rice research, with particular emphasis on the International Rice Testing Program (IRTP).

d) To continue to help in strengthening the national rice research programs in the region through training, consultative visits, and in further supporting the active network of rice researchers which has been established over the decade of the seventies.

5.3.3 Research Strategy

The basic strategy of the Rice Program since its inception in 1969 to date has been the improvement of productivity and production in the irrigated sector in the region. This strategy was adopted for the following reasons.

a) Irrigated rice offered the greatest scope for rapid gains in yield and production;

b) The technology for irrigated rice was more easily generated and extended than in other production systems; and

c) Limited core resources did not permit a systematic attack on all of the alternate production systems.

The research on irrigated rice has focused on varietal improvement as the key element in the strategy. Tall varieties covered the entire area prior to 1968 when IR 8 was introduced. An immediate increase in productivity of 2 t/ha confirmed the strategy to work exclusively on dwarf materials for this system. The focus has been on varieties combining dwarfing, strong stems, insensitivity to photoperiod, long grain with clear endosperm, resistance to the Sogatodes leaf hopper, and resistance to blast disease. More recently, varietal objectives have included earliness and improved adaptability to acid soils.

Once improved dwarf lines and varieties were produced, research was extended to define appropriate cultural practices for the high yielding varieties. Seeding rates and methods, fertilizer practices, and timing of weed control were emphasized. CIAT involvement in this research was necessary since the marked change in yield potential implied a rapid re-evaluation of associated agronomic practices. Imvprovement of varieties and cultural practices have continued, with emphasis in recent years on reduction in production costs through combinations of land preparation by puddling, reduced seed and fertilizer rates, and enhanced disease and pest resistance. Collaborative research with the International Fertilizer Development Center (IFDC) on improving the use of nitrogen fertilizer efficiency has recently been initiated, since nitrogen prices are one of the chief factors contributing to higher production costs in the irrigated sector.

The unexpected adoptiton of the newer dwarf varieties in recent years in the highly and moderately favored upland systems allowed the Program to modify its original strategy. Entries for nurseries and regional yield trials, especially for the two upland systems, are selected from the advanced irrigated breeding lines and distributed internationally for continued local selection and evaluation by national programs. The Program has concentrated on the two principal biological constraints in virtually all systems, namely Sogatodes, and rice blast. Thus, CIAT has contributed directly to upland systems while focusing on irrigated varietal development.

CIAT has planned, and has now been approved, to expand activities in upland rice. A full description of the proposals for CIAT direct involvement in this sector are contained in a special report[1] prepared for a TAC Subcommittee.

In defining the strategies to be adopted over the next decade for the various production systems, different approaches are evident. The following strategies for each farming system have been developed.

5.3.3.1 Highly favored upland rice. The varietal component of the technology required for an expansion of this system in the region can be largely satisfied through selection of lines from the existing breeding program. Selections combining slow blasting type resistance to *Pyricularia* and clear grain endosperm will be evaluated in representative sites in collaboration with national programs in the Plochic Valley of Guatemala (ICTA) and in Urabá and La Libertad of Colombia (with ICA). Evaluation of direct seeding in combination with herbicides will be undertaken jointly with ICA and the Colombian Rice Federation in order to develop agronomic practices with wider applicability. CIAT will emphasize this sector because of its production potential and low production costs.

5.3.3.2 Moderately favored upland rice. The varietal component for the areas under the system will require a special research effort due to the more severe nature of the constraints. A collaborative program in Brazil and/or other countries is desired in order to provide an opportunity for screening and selection under the actual production conditions. This type of program would allow two generations a year of breeding material to be screened (e.g., from April to September in Colombia, and from November to March in Brazil). An exchange of segregating and advanced lines by collaborating programs would thus halve the time require to breed new materials. Research in mutation breeding at CIAT has already indicated that dwarf lines can be produced in the M1 generation produced from tall materials, with some adaptation features for the soil and climatic constraints in this sector. Early generation selection will also continue in Guatemala, Costa Rica, and Panama, in collaboration with national institutions.

5.3.3.3 Unfavored upland rice. Severe drought stress, combined with acid soil problems, is not found in Colombia, and CIAT has no comparative advantage for direct involvement in this system. The Brazilian national program will continue to direct substantial resources to this

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[1] Upland Rice Research for Latin America: A Report to the TAC Subcommittee on Upland Rice. CIAT, December, 1979.

difficult problems. CIAT will collaborate through the provision of materials with slow blasting characteristics and shortened mutant versions of acid soil and drought tolerant materials. Obviously, any gains made for the more favored areas will have some application in the less favored system.

5.3.3.4 Rainfel lowland rice. Water control, the limiting production factor, must be improved locally at regional, community and farm level. The potential contribution from civil engineering far exceeds that of research on other components of the system. As improved water control is achieved in this system then further use can be made of existing technology from the irrigated sector. CIAT involvement will continue through the provision of improved germplasm.

5.3.3.5 Irrigated rice. This system will continue to receive major attention. Stable resistance to blast can be expected to increase regional yields by 0.5 t/ha, and a similar gain is expected from even better dwarf plant types with improved lodging resistance. Introduction and evaluation of Korean Japonica dwarfs to Chile could have a dramatic effect on production in that country. With the projected placement of an outposted scientist in a Southern Cone country, CIAT will be able to better contribute to the development of cold-tolerant dwarfs for those environments.

5.3.3.6 New production system research. The vast savanna (Llanos) of Colombia, Venezuela and elsewhere receive high rainfall, but the soils are extremely acid and infertile. The CIAT Tropical Pasture Program is developing pasture animal components for a stable production system for this vast area of underutilized lands. Although no rice is produced on these lands there is a clear need for a crop component in the pasture system to facilitate land preparation for pasture establishment. As in Brazil, upland rice could become a pioneer crops enabling an economically sound development of the Llanos area. A minimum input upland rice system built around acid soil and blast-tolerant cultivars using minimum tillage techniques is a researchable possibility. To this end mutant dwarfs of upland land races and tall materials known to be tolerant of aluminum toxicity will be evaluated for yield potential with a target yield of the order of 2.0 to 2.5 t/ha. Agronomic evaluation of tillage techniques including sod seeding will be investigated at the Carimagua Station. Emphasis will be placed on the integration of this research with the on-going pasture research program.

5.3.4 Accomplishments of the Program

The excellent early base of collaboration established by the CIAT Rice Program with ICA in Colombia has allowed the research to have a very rapid impact, and not only in Colombia. In addition, the strength of IRRI has provided an extremely important component contributing to the successes achieved. In the cooperative program with CIAT, ICA has released seven dwarf varieties with high yield potential. All of these varieties are now grown internationally. Breeding lines from CIAT have resulted in an additional 25 to 30 dwarf varieties released by national programs in the region. These varieties, considered together, are now grown on about 1.5 million ha annually in the irrigated, highly favored and moderately favored upland sectors. The introduction of these new varieties, together with improved cultural practices, have been associated with one to two tons of additional rice per hectare.

The surge in production in countries with these farming systems has equalled or exceeded population growth, and nearly all countries have reached effective self-sufficiency. Rice consumption continues to increase as a result of rice having become cheaper in relation to alternative foods. A detailed analysis[1], of the impact of new rice technology in Colombia has shown that the economic benefits of the large production gains have largely captured by low income consumers.

CIAT has provided professional training to a total of 211 rice researchers from 23 countries in the region in production agronomy, breeding and pathology. Consequently an effective regional network of cooperators exists for continuing interchange and evaluation of technology and information. The Rice Program emphasizes regional activities, including IRTP nurseries, monitoring tours, production courses within countries, and biannual research worker conferences at CIAT.

Factors that indicate continuing contributions include proven, high yield technology for irrigated and more favored upland systems, extensive land resources ideal for rice, and abundant water supplies. Research over the next decade should lead to a marked increase in productivity in rice in the region, particularly in those systems at the more favored end of the spectrum.

5.3.5 Research Staffing Projections for the Eighties

The rice team projects a core research team of six scientists as adequate to address the production constraints in irrigated rice and in the alternative systems. These research problems are not entirely mutually exclusive.

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[1] Scobie, G.M. and R. Posada (1977). The impact of high yielding rice varieties in Latin America: With special emphasis on Colombia: CIAT series JE-01. April, 1977.

Some technology resulting from research on one system will be useful in others. Concentrated attention on the more favored systems will produce results useful in the most difficult farming systems, i.e., subsistence upland rice, unfavored upland rice and rainfed lowland rice. The predictability of significant research contributions to these latter systems is not high. The Rice Program will be alert to research findings having direct applicability to those systems. The six-man research team would comprise the following.

5.3.5.1 Irrigated rice breeder. Based at CIAT, this breeder will continue and extend research on lodging resistance in dwarf varieties, the development of early maturing varieties for water-scarce areas, stable resistance to the blast disease, and improved grain quality to satisfy market demands. Research will continue on the maintanance testing for *Sogatodes* resitance to ensure that the pest does not revert to an economically important constraints. Since the CIAT location is not ideal for evaluation under these constraints, selection will be intensified at ICA experiment stations and other areas in Colombia. Crossing, preliminary yield evaluation, *Sogatodes* evaluation, and other supporting research will continue at CIAT.

5.3.5.2 Upland rice breeder. This scientist was appointed in 1981 to develop a breeding program concentrating on varietal development for the favored to moderately favored systems. Emphasis will be placed on stable resistance to blast, and tolerance to acid soils (aluminum toxicity and phosphorous deficiency). Grain quality and *Sogatodes* resistance will be similar to that of the irrigated rice breeding program. The work will include research on moderately tall to tall materials, as well as dwarfs. Selection and early generation yield evaluations will occur at La Libertad in Colombia and, possibly, in Brazil in collaboration with EMBRAPA.

5.3.5.3 Rice agronomist. Agronomic research will continue in both the irrigated and upland systems. Shifts in production emphasis in irrigated areas to more marginal soils indicate a need to evaluate and research those problems of general applicability. In addition, research on the general agronomic problems in upland rice will begin as these become evident over the decade. This would include evaluation of the agronomic practices necessary for the new germplasm which could be of different plant type to the land races now being utilized.

5.3.5.4 Upland rice physiologist/agronomist. Upland research is concerned with many production constraints not found in irrigated rice. A major research effort will be mounted on screening methods for the evaluation of drought and acid soil tolerances. The physiologist/agronomist may also assume leadership in the development of a low-cost production system for upland rice on infertile savanna soils. The position for physiologist/agronomist is projected for 1983.

5.3.5.5 Rice pathologist. Pathology will continue to concentrate on the rice blast disease, specifically on methods to detect and evaluate slow blasting in distinct growth stages, and on methods to include required levels of disease pressure in populations and lines. Maintenace, research and monitoring will continue among the minor diseases to avoid situations that could elevate them to the level of economic constraints.

5.3.5.6 Rice economist. The economist will help the other scientists of the team to search for the best allocation of the research resources among different rice cropping systems. He will evaluate rice production potential at the country level in tropical Latin America and the Caribbean. Also conducted will be surveys of the main rice production areas, area planted, yield and production per cropping system (irrigated, rainfed, favored upland, and unfavored upland), stratified according to relevant environmental boundaries. The role of a CIAT-wide agroecological research group which is proposed for the eighties in this plan will be important in delineating existing and potential production areas and the environmental constraints which apply to those areas. The economist will also evaluate the effect on prices and the potential gains from present and expected production increases by income strata in urban and rural areas. The international trade possibilities associated with expanded rice production in selected countries will also be analyzed by considering domestic and international demand conditiqns. The rice economics position is projected for 1982.

5.3.5.7 IRTP specialist (IRRI liaison scientist). This scientist holds a crucial role within the rice team. His duties involve the selection, distribution and evaluation of germplasm nurseries from IRRI. Nurseries for distinct purposes are sent to all developing countries in the Western Hemisphere. Additionally, special nurseries of elite CIAT breeding lines are distributed and evaluated with the scientist's assistance. The position requires extensive international trabel to promote national use of promising nursery materials, either as parents for crosses or as direct commercial varieties. The growing volume of nurseries and locations, couples with CIAT expansion into research in upland systems, make it doubtful that only one research scientist can continue to handle this responsibility. Since all IRTP activities in the region are funded by IRRI, consultations as to the future expansion of the program will be held with that organization in the near future.

5.3.6 Regional Cooperation

International activities in rice have been handled largely through the IRTP scientist, international travel by all staff, and a heavy commitment to training of national program workers at CIAT. This strategy was reasonably satisfactory while the Program concentrated on irrigated rice, since, to a large extent, such technology sells itself.

Nevertheless, weaknesses are apparent. National yields in irrigated rice decline with distance from Colombia. The reasons appear to be a mixture of technological deficiencies combined with local inadequacy of support to farmers (credit, seed, technical advice marketing, and so forth). The programmed expansion into upland rice will soon create a new demand for CIAT services. Finally, some countries, i.e., those in the Southern Cone, have not adopted HYV technology for several reasons, including specific production constraints not researchable at CIAT. For these reasons, a strong case is building for consideration of some outposted staff activity. CIAT projects the placement of one outposted regional scientist to be located in a southern Andean country with responsibilities for coordination of collaborative research with CIAT. This position is projected for 1984.

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Chapter 6: LAND RESOURCES RESEARCH

The abundance of underutilized land resources in tropical Latin America seems inconsistent with the existence of a large sector of small farmers. In most countries, the coecistence of intensive farming, both large and small scale, and significant underutilized areas is explained by a combination of two factors: (a) the low or fragile fertility status of the soils in the agricultural frontier, and (b) the low level of infrastructure development in these areas. Given the available technology crop production is not profitable in these areas without sizeable subsidies. This is because productivity is low under the poor fertility conditions, and soil amendments are not feasible due to high input and transportation costs.

The tropical and subtropical areas of America have nearly a billion hectares of significantly underutilized savannas and forests, 75% of which are occupied by acid and infertile soils, (i.e., Oxisols and Ultisols). These areas have great agricultural potential since they have abundant solar radiation with adequate rainfall and favorable temperature regimes for extended growing seasons. Topography and soil physical properties are also generally favorable. CIAT, through its Land Resources Division, clearly recognizes this distinct and promising feature of tropical America.

In order to contribute to the development of ecologically sound, stable, and productive systems for these tropical and subtropical areas, CIAT aims to contribute to the broadening of the resource base of Latin American agriculture through a low-cost/low-input approach based on the selection of species most adapted to local edaphic conditions.The major efforts in this context are in tropical pastures, upland rice and cassava. Research strategies and projections for upland rice and cassava were presented in detail in the previous chapter. In this chapter strategies and projections for the Tropical Pastures Program are outlined, followed by a brief discussion of CIAT's future role in hosting research efforts for other international institutions on other crops of potential importance, such as sorghum and soybeans, two crops of increasing economic importance in the region. A brief comment is also made on CIAT's role in hosting research efforts of other international institutions on key factor components for the frontier areas, such as phosphate rock and other critical constraints related to soil management. Finally, the role, strategies, and projections of the Agroecosystem Analysis Unit of CIAT are outlined.

6.1 Tropical Pastures: Program Strategies and Projections

The cattle population of tropical Latin America is estimated at approximately 190 million head, or about 20% of the world total. Per capita beef consumption in tropical Latin America (16 kg/year) is significantly higher than in Africa and Asia, and about 2/3 that of Europe.

During the last two decades consistent increases in production have been recorded in most countries of the region. However, production growth, with few exceptions, has lagged behind demand growth[1]. As a result, beef prices increased in real terms in most countries during the period. These price increases have serious income distribution implications, since the proportion of family income spent on beef is extremely high among low-income urban consumers.

A study conducted by CIAT[2] using data from the Family Budget Survey of twelve Latin American cities[3] showed that the lowest income group (quartile) in these urban centers spends 6-18% of their family income on beef, representing 10-26% of total food expenditures. A similar situation is encountered for milk and milk products: low income families spend 4-12% of their income (or between 7-19% of the food budget) on dairy products. These latter percentages are expected to be even higher in rural areas.

The extremely high income elasticities estimated for the low-income quartiles in the twelve cities (between 0.8 and 1.3 for beef, and 0.8 and 1.6 for milk) are a clear indication of the strong preference among the urban poor for these commodities. Hence, beef and milk should be considered staple foods and wage goods in tropical Latin America. However, as income increases in the region, demand for beef and milk is expected to continue to increase faster than production thereby resulting in further price increases, with a consequent negative effect on both the diet and the income of the poor.

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[1] CIAT, Latin America: Trend Highlights of CIAT Commodities, Internal Document Econ. 1.5, April 1980.

[2] Rubinstein and Nores, "Beef Expenditures by Income Strata in Twelve Cities of Latin America", CIAT, Internal document, Mimeo, June 1979.

[3] Survey conducted by ECIEL, Brookings Institution, and also by FIPE, University of Sao Paulo, during the period 1968-1972.

Such trends can be counterbalanced if appropriate livestock production technology is developed for the vast, underutilized land areas existing in the region. In fact, utilizing these areas can contribute to solution of the food problem in two ways: (a) by releasing more fertile land for crop production, and (b) by increasing beef (and eventually milk) production in the region. Crop production, which demands higher soil fertility levels and more social infrastructure than pasture production, could expand in more-developed areas having high base-status soils with less competition from cattle if underutilized areas were in pastures. At the same time, cattle production could expand with little or no opportunity cost into these areas, thereby accruing sizeable net benefits to society.

The potential of these areas for cattle production is extremely high. The current average stocking rate in the acid savannas is 0.12 animals/ha. This can potentially be increased more than ten fold. In addition, beef production per animal/year could be more than doubled. These areas could also contribute significantly to increased milk production. The common concept that dairy farms are highly specialized operations is not quite valid in tropical Latin America. A large proportion of milk and dairy products consumed in the region comes from the milking of small and medium size beef herds, usually crosses of native ("criollo") and zebu breeds. This type of dual-output production system is not only found in the densely populated areas with fertile soils, but is also frequently found in frontier areas with acid, infertile soils.

CIAT's overall objectives in the Tropical Pastures Program are as follows:

a) to allow for the economically and ecologically sound expansion of the agricultural frontier in tropical America;

b) to increase beef and milk production and productivity; and

c) to release more fertile land in the more settled areas for expanded crop production,

by developing, in collaboration with national programs, appropriate, pasture-based animal production technology for the acid, infertile soil regions of tropical Latin America. Rather than attacking problem of acid, infertile soils by correcting soil deficiencies with large amounts of fertilizer, CIAT has adopted a low-cost/low-input approach based on the selection of grass and legume species adapted to those edaphic conditions.

The expected result of the program's activities is the development of pasture production systems to provide adequate year-round forage quantity and quality, complemented by cost-effective animal management and animal health practices. National research and extension institutions are both collaborators and clients; beef (and dual purpose) cattle producers are regarded as the users of the technology; while both producers and consumers are regarded as the principal beneficiaries, since the final objective is to increase production and thereby lower relative prices of beef and milk in the region.

6.1.1 Program History

The present tropical Pastures Program has evolved from an initial broad spectrum of disciplines related to animal-production through three progressive stages.

During the formative stage (1969–1974), the (then) Beef Production Systems Program emphasized the identification of problems and potential solutions in the areas of animal health, animal management, and cattle production systems. During this period a relatively small proportion of program resources was devoted to pastures and forages, and most field research was conducted in Colombia. From the information collected during this initial period it became evident that the low cattle productivity in tropical Latin America was mainly due to extreme malnutrition and nutrition-related diseases. Lack of good quality, year-round forage was identified as the most common critical constraint to increased production.

The stage was thus set for sharpening the focus of the (renamed) Beef Production Program. During the period between 1975 and 1977, the program concentrated more and more on the acid infertile savannas of Latin America. The program broadened the geographical scope of its activities to other countries while sharply narrowing its research focus by concentrating upon pasture research with the goal of removing the principal production constraints in the savanna ecosystem.

Grazing experiments carried out in the Colombian Llanos documented the limited potential of the native savannas. It became evident that the low productivity and poor quality of most native species combined with the low fertility status of the soils and varying degrees of seasonal water stress were the most serious limitations and that this resulted in low animal production and high incidence of malnutrition and disease susceptibility. Overall productivity, both per unit area and per animal unit, was found to be extremely low.

Striking improvements in herd performance on native savanna were obtained with the use of appropriate mineral supplementation. The use of well-adapted exotic grasses such as Brachiaria decumbens resulted in dramatic increases in carrying capacity and production per unit area. However, production per animal continued to be dissappointing, especially in terms of reproductive performance of the breeding herd. Protein supplementation was successful but not economically viable.

Preliminary experimental results obtained during this period with grass-legume pastures indicated clearly that if persistent associations could be found under low input conditions, they could provide an economically attractive solution to the problem. During 1978 the program consolidated along these lines. Its research structure was geared to obtain low-cost grass-legume associations for the acid soil savannas. To reflect its new focus, the program was renamed the Tropical Pastures Program, in mid-1979.

6.1.2 Area of Interest

A survey of the regions of tropical Latin America with acid, infertile soils was initiated in 1978 to classify land resources in terms of climate, landscapte, and soils in order to provide a geographically oriented economic perspective to the Program's area of interest and to serve as the basis for its research strategy. Total wet season potential evapotranspiration (TWPE), a measure of energy available for plant growth during the wet season, was shown to provide a quantitative way to account for native vegetation distribution. An analysis of the survey data led, in 1979, to a subdivision of the area into five major agroecological zones. These five major ecosystems are shown in Figure 6.1 and are as follows:

a) Tropical well-drained savannas

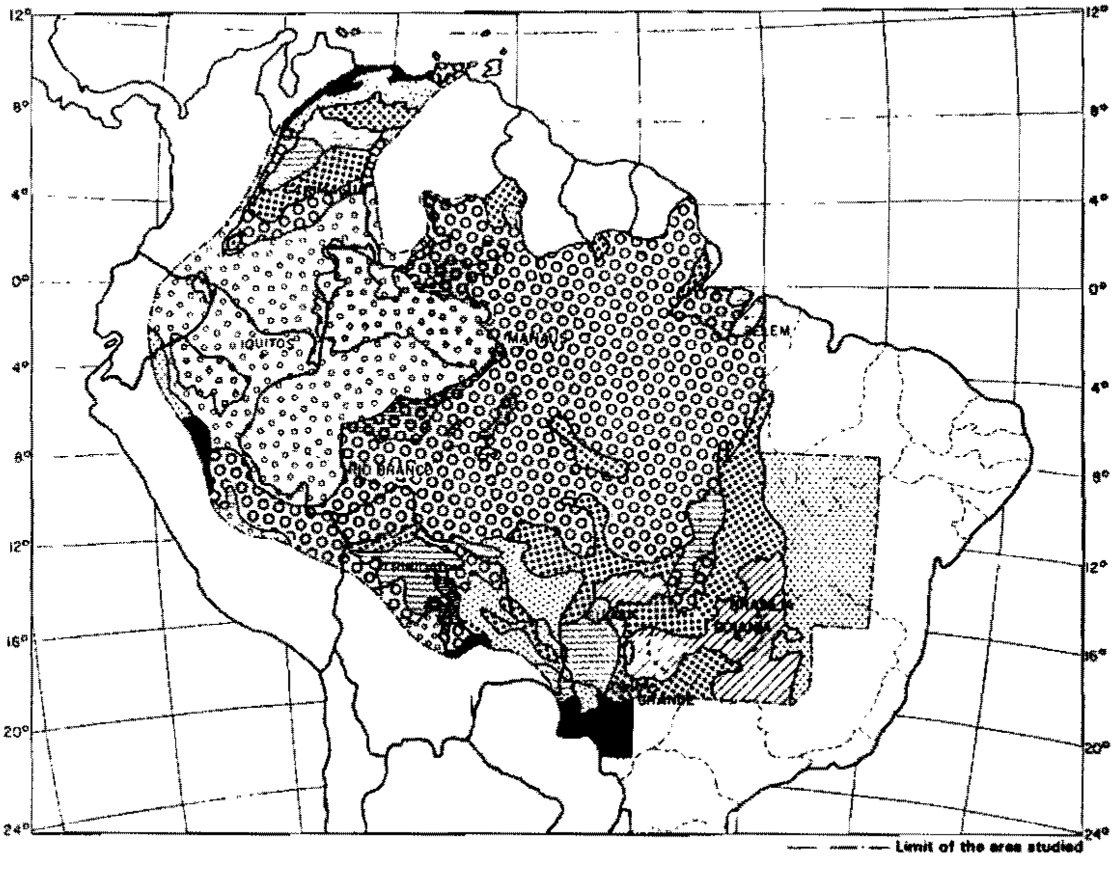
a).1 "Llanos" type. This ecosystem is represented by the well-drained savannas of Colombia, Venezuela, Guyana, and Surinam, and the savannas of Roraima and Amapá in Brazil.

a).2 "Cerrados" type. The primary area is the Brazilian Cerrado, and its extension into Paraguay and Bolivia.

b) Tropical poorly drained savannas

b).1 Regions. Representative areas include the Beni and Bolivia, the Pantanal in Brazil, the Casanare region in Colombia, the Apure region in Venezuela,

Figure 6.1



AGRO—ECOLOGICAL ZONES OF TROPICAL PASTURES PROGRAM

(Sketch map based on computer printouts of the land resource evaluation studies)

- WELL DRAINED ISOHYPERTHERMIC SAVANNAS (MOSTLY "LLANOS") TWPE* 901 - 1060 mm, 6-8 months wet season, WSMT** > 23.5°C
- WELL DRAINED ISOTHERMIC SAVANNAS (MOSTLY "CERRADOS") TWPE 901 - 1060 mm, 6-8 months wet season, WSMT < 23.5°C
- POORLY DRAINED SAVANNAS. (Found in lowlands of Tropical South America, in varying climatic circumstances)
- SEMI—EVERGREEN SEASONAL FOREST TWPE 1061 - 1300 mm, 8-9 months wet season, WSMT > 23.5°C
- TROPICAL RAIN FOREST TWPE >1.300 mm, >9 months wet season, WSMT > 23.5°C
- POORLY DRAINED FOREST REGIONS
- DECIDUOS FORESTS, CAATINGA,***etc.
- OTHERS***

* Total wet season potential evapo-transpiration

** Wet season mean temperatures.

*** Not included within Target Area of Tropical Pastures Program.

b).2 Islands. Flooded savanna "islands" are found throughout forest areas.

c) Tropical forests

c).1 Seasonal forests. Vast areas in the Amazon and Orinoco basins in Brazil, Peru, Bolivia, Colombia, Venezuela, Guyana, Surinam, and in the Atlantic coast of Central America are included.

c).2 Rainforests. Areas in the upper Amazon basin of Ecuador, Colombia, Venezuela, northeast of Peru and northwest of Brazil are included.

This subdivision of the Program's area of interest helps to understand the differential response of germplasm observed across ecosystems. While preliminary results of regional trials generally indicate wide adaptability of the most promising grass and legume germplasm, in many cases a distinct response to the different ecosystems is still shown. These differences are partially due to the varying edaphic conditions but mainly due to climatic variations. In the case of legumes, these differences are largely due to strong environmental interactions with disease and pest incidence. Thus, germplasm should be tested in each of the five ecosystems. Major emphasis has so far been placed on two well-drained savanna ecosystems through collaborative research with ICA at Carimagua in the Colombian Llanos, and with EMBRAPA at the Cerrado Center near Brasilia, where three research staff were outposted in 1978. During 1979-1980, regional trials were established in selected locations the remaining three ecosystems, to obtain a preliminary reading on the degree of adaptation of a large number of species to these distinct environments. However, major research thrusts are yet to start in these three ecosystems.

6.1.3 Advances in Research

The program has a long record of profitable research which has resulted in many advances. Major accomplishments for tropical well-drained savannas, the Llanos type in particular, are as follows:

a) The identification through surveys of farms in the area of major farm constaints to cattle production in savanna ecosystems and in depth characterization of cattle production systems in Colombia, Venezuela and Brazil (a project partially funded by GTZ).

b) The identification of several genera and species as being well adapted to the conditions of one or more ecosystems: Andropogon gayanus, Brachiaria spp., Stylosanthes spp., Desmodium ovalifolium, Pueraria phaseoloides, Zornia spp., and Centrosema spp.

c) The determination of nutrient requirements of the more promising accessions for the well-drained savannas.

d) The development of simple, low cost pasture establishment methods adapted to savanna conditions.

e) The definition of the potential productivity of a large number of pasture grazing alternatives in the Llanos ecosystem, starting with native pastures, with concurrent evaluations of planted grass pastures, and culminating in the current evaluations of numerous grass-legume associations. Various grass-legume association in low-input controlled grazing experiments have produced annual liveweight gains per animal of 200 kg and above, while yielding more than 300 kg/ha.

f) The identification and epidemiological assessment of major cattle diseases in the area, and of their relative present importance.

g) The ex-ante determination of expected profitability of various pastures systems.

h) Postgraduate training of 305 professionals from collaborating institutions of 22 countries in the region.

i) The evaluation and subsequent release by Colombia and Brazil of a new grass cultivar derived from Andropogon gayanus CIAT 621, and the delivery of large amounts of basic seed to each country.

Other accomplishments of more general applicability across ecosystems are:

j) The inventory of land resources in the area of interest, with edaphic, topographic, and climatic characterization of the region organized in a systematic and easily retrievable manner.

k) The development of a germplasm bank consisting of a total of 7200 accessions with a high proportion of material internationally collected from acid soil areas. This germplasm pool is complemented by a parallel collection of Rhizobium from the same areas.

l) The development of rapid screening techniques to determine tolerance of plants and rhizobia to soil acidity.

m) The elaboration of an inventory of pasture insects and diseases, by forage species and ecosystem, with an assessment of current relative importance.

n) The initial development of a collaborative Regional Trial Network for evaluation of germplasm in terms of adaptation, productivity and persistance throughout the area of interest.

6.1.4 Technical Constraints

In spite of these significant advances, major general constraints and region specific constraints must be overcome in order to achieve wide adaptability of results throughout so heterogeneous an area.

The savanna ecosystems in the program's area of interest are all characterized by native vegetation of very low nutritive value -the major limitation to increased animal production. The low feeding value of forages is due to a combination of species of low primary productivity and quality, and the extreme acidity and low fertility status of the soils. Throughout the area, pH varies between 3.6 and 5.0. Aluminum saturation is high, often reaching values between 70 and 90 percent. Available phosphorus levels are very low, usually below 3 ppm. Rather than overcoming this constraint through heavy applications of lime and fertilizer, the program has adopted the approach of selecting adapted species.

Lack of infrastructure is a common constraint that varies in severity and depends upon topography and distance to market. Economic conditions (on-farm input and output prices, and access to credit and extension mechanisms) vary from country to country and with distance to market. The machinery requirements and high present cost of pasture establishment and maintenance, plus erosion hazards during the establishment phase, are serious constraints to the adoption of new pasture systems.

Since all of these constraints are somewhat common to the five ecosystems, the technical solutions to the overall nutritional constraints must be low-cost/low-input,and suitable for a wide range of management levels. The variability observed in existing production systems within and across ecosystems and the need to develop alternatives for colonization programs suggest that various pasture systems are needed as alternatives. This will allow farmers to adopt those pasture solutions that best suit their particular situation in terms of relative input/output prices and access to resources, including type of land.

Other critical constraints vary from region to region. Water stress is critical in the Cerrado type savannas but is of slightly lesser importance in the Llanos type, while the problem in the poorly drained savannas is excess water. Therefore, lack of good quality forage is the major constraint in the well-drained savannas during the dry season, while in the poorly drained savannas, forage availability is the major constraint during the wet season.

The success or failure, in terms of persistence and productivity, of species adapted to the physical environment often depends on their reaction to diseases and insects. Most promising forage legume genera (e.g. Stylosanthes, Zornia, Centrosema and Aeschynomene) are natives of the Latin American tropics and of wide natural distribution. Hence, disease and insect pests which affect these forage legumes are also widely distributed in the program's area of interest. Clear evidence of differential geographical distribution of several important diseases and insects, and of differential disease and pest tolerance within species, is available from the disease and insect surveys and preliminary results from regional trials. These results suggest the need for multilocational screening of a broad range of germplasm within promising species and genera for which critical disease or insect problems have been identified and also suggest the need for introduction of exotic materials. A rigorous selection program by ecosystem is thus essential to overcome this major constraint.

6.1.5 Program Objectives, Organization and Research Strategy

Simply stated, the main objective of the Tropical Pastures Program is to develop low-cost/low-input pasture technology to increase beef (and milk) production in the acid infertile soils of tropical America. The strategy to achieve this objective is based on:

a) selection of pasture germplasm adapted to environmental constraints (climate and soils) as well as pest and diseases;

b) development of persistent and productive pastures, and basic practices for its utilization and management; and

c) study of the role of the improved pastures in the production systems and development of the complementary animal management and animal health systems components.

The tropical pastures research team is comprised of 20 senior scientists, the majority of whom (15) are based at headquarters, while two are based at Carimagua, and three are outposted at CPAC Brasilia. The scientists interact within and between three functional groupings:

Germplasm development (collection, selection and breeding) and evaluation includes agronomists and breeders basically involved in collection and agronomic evaluation, and support specialists in the areas of soil microbiology, pathology, and entomology(totalling 9 senior scientists).

Pasture evaluation and development includes agronomists and plant and animal nutritionists with activities in regional trials, soil fertility, pasture establishment and maintenance, seed production, pasture evaluation under grazing, and pasture management (6 senior scientists).

Pasture evaluation in production systems includes animal scientists, a veterinarian and an economist with activities in evaluation of pastures in alternative cattle production systems, and related animal management and animal health practices (4 senior scientists).

The activities of these three groups are focused on a dynamic flow of germplasm and the development of appropriate production technology for the most promising materials as shown in Figure 6.2. The basic strategy is that of exploiting natural variability and adaptation of species to the various ecosystems. The basic research strategy consists of a logical sequence of germplasm screening and evaluation steps geared toward achieving the stated objectives. These steps, applied up to now only in the well-drained savanna ecosystems, are as follows:

a) The collection and assembly of forage germplasm and *Rhizobium* banks based on geographically broad but ecosystem-specific criteria. Emphasis is placed upon legumes because of their inherent nitrogen fixing capacity and quality, especially during the dry season.

b) A dynamic and extensive evaluation system whereby accessions, often of agronomically unknown species, pass through a progressive series of character and performance assessments. Characteristics sought include: tolerance to extreme soil acidity, high aluminum saturation and low base status; adaptation to low phosphorus soils; nitrogen fixation potential (in legumes); resistance to diseases and insects; tolerance to burning and drought; vigor, productivity and good distribution of yield; seed production; ease of establishment and spreading; freedom from toxins and oestrogens; and high forage quality.

RESEARCH STEPS IN THE TROPICAL PASTURES PROGRAM BY ECOSYSTEMS

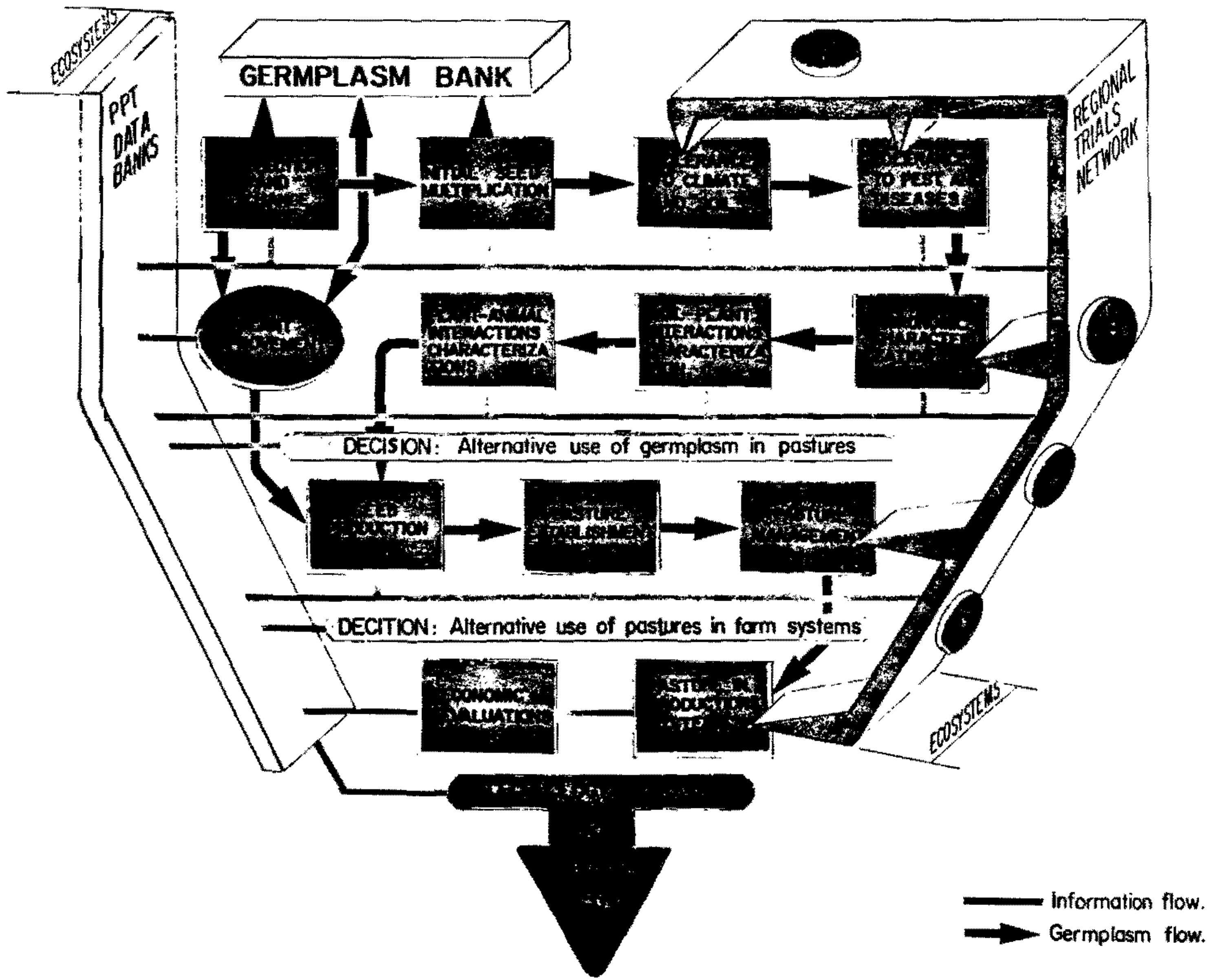


FIGURE 6.2

c) The determination of minimum nutrient requirements for each species and the development of low cost methods of establishment and maintenance, as well as grazing management strategies required for best pasture persistence and animal productivity.

d) The estimation, for each type of pasture (usually grass-legume associations), of a profile of animal productivity potential per unit area and per animal unit, with associated economic input/output values.

e) The selection and formation of cultivars, candidates for release by national programs, and the production of basic seed with development of production technologies to assure seed availability. This includes the definition of seed production systems and determination of environmental requirements for satisfactory commercial seed yields.

In summary, initial emphasis is upon collection, evaluation of growth patterns, and assessment of reaction to acid infertile soil conditions, followed by determination of reaction to diseases and insects within each ecosystem, and finally, evaluation after exposure to competition and grazing. Concurrent with the forward progress of this evaluation process there is a continuing reduction in the number of accessions utilized. While thousands of accessions enter the process, only a few will finally qualify as cultivars.

As illustrated in Figure 6.3, germplasm accessions are classified in five categories which reflect the degree of promise of accessions moving through the systematic screening and evaluation sequence. Periodically experimental results are used to promote those accessions which meet desired requirements to a higher category where they will form the basis for planning far the next phase of the evaluation. The relative ranking of accessions within species is done separately for each ecosystem. Requirements for progression to a higher category vary with the species, depending upon the principal limitations of the species. The limiting constraint of each species is used as the promotion criteria, e.g.: in *Stylosanthes* spp., resistance to anthracnose and steamborer; in *Zornia* spp., resistance to *Sphaceloma* and seed production capacity; in *Desmodium ovalifolium*, tannin content and palatability; in *Centrosema* spp., acid soil tolerance and tolerance to bacterial blight and *Rhizoctonia*.

The germplasm bank (Category I accessions) is maintained at Palmira as seed and/or single potted plants, and at Quilichao as spaced plants in the field. Activities in these locations emphasize identification,

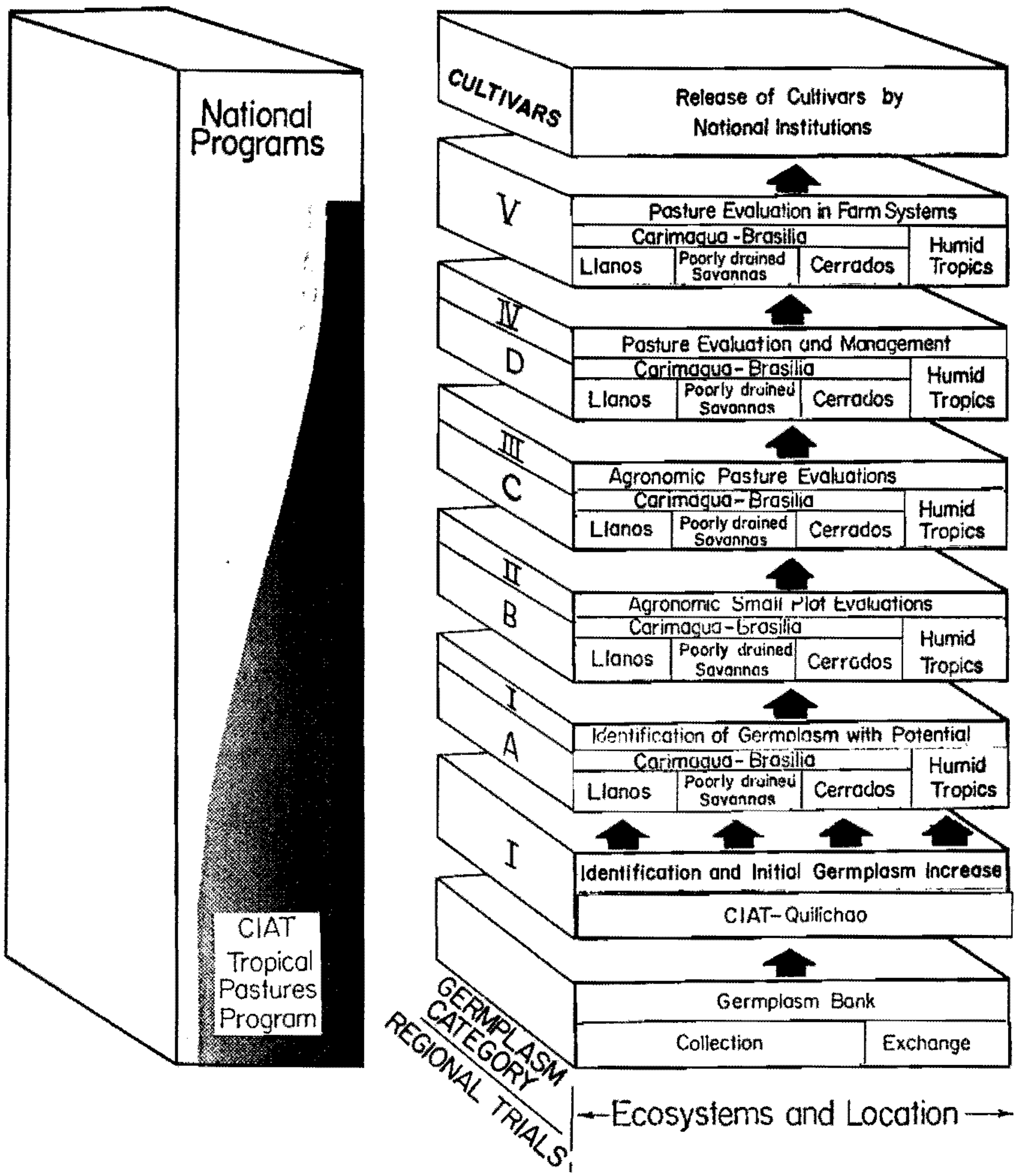


Figure 6.3 Germplasm Evaluation Sequence

maintenance, multiplication and initial characterization of materials. All accessions (Category I) are evaluated for adaptation to edaphic conditions in introduction gardens at both Carimagua and Brasilia. Selected accessions are also evaluated in preliminary Regional Trials (Type A) in the various ecosystems. Category II accessions undergo agronomic evaluation at both Carimagua and Brasilia, and some of them are retested at additional selected locations (Regional Trial, Type B).

The basic strategy is to exploit the vast natural variation existing within and among species rather than to generate additional variability through plant breeding. Thus, plant breeding is used as a problem-solving approach only after extensive germplasm evaluation has identified promising species and ecotypes, and there is a reasonable probability of incorporating a missing characteristic by genetic manipulations. Within species subject to genetic improvement by plant breeding, (e.g. Stylosanthes spp., Centrosema spp., Leucaena leucocephala) individually bred lines may be nominated to different categories in the evaluation, but breeding populations are handled independently of the germplasm bank.

Selected accessions advanced to Category III status, are associated with grasses, and placed under heavy intermittent grazing to assess persistence, competitive ability, and dry matter productivity. These evaluations are conducted at both Carimagua and Brasilia and are planned at some Regional Trials C locations. In addition specific grass-legume mixtures are grazed under different intensity and maturity to determine relative palatability of associated species. In Category IV the objective is to evaluate the pasture in terms of potential animal productivity and determine the appropriate grazing management of the pasture. Measurements are made of sward botanical composition trends over time, presentation yields, animal grazing preference, and species in vitro nutritive value, in order to explain the recorded animal productivity (kg/ha/yr and kg/animal/yr). Finally, in Category V the objective is to complete a profile of species and varietal evaluation, to obtain simple technological packages prior to release of the cultivar by national programs, and to define the best pasture utilization under different production systems.

6.1.6 Projected Developments in the '80s

Projection for the decade are based on two factors:

a) Progress made by the program toward the stated objectives will result in relatively more emphasis on the advanced stages of pasture evaluation and outreach, and

b) Better knowledge of the area of interest and of germplasm performance will result in systematic organization of the Program's germplasm evaluation strategy within each major ecosystem.

These two developments will lead to considerable changes in emphasis within the overall pastures program but will result in only minor changes and addition to the core research staff. Major changes are projected in the relative allocation of staff time to principal activities and ecosystems. While during the first half of the decade emphasis will be maintained in research activities, a gradual increase of outreach activities is planned during the second half of the decade, requiring almost one third of the staff time toward the end of the period. Research emphasis will continue in the well-drained savanna ecosystems, but new research activities will begin early in the decade in the poorly drained savannas and in the humid tropics (Figure 6.4A).

6.1.6.1 Evoluation of emphasis within the research program: Allocation of staff time to germplasm development and evaluation will be maintained during the first half of the decade, but it is expected to decline during the second half as promising germplasm is upgraded in status (Figure 6.4B). Also, consistent with the advancement of germplasm status, more staff time will be devoted to pasture development and evaluation in both controlled experiments and actual production systems.

Germplasm development and evaluation.- Exploiting natural variability will continue to be the basic strategy of the program. Therefore germplasm collection will play a critical role throughout the period. In order to increase cost effectiveness of the overall program, emphasis in collection will increase during the first half of the decade but is expected to decline toward the end of the decade as key species are identified and the program's collection needs become more ecosystem -and target-specific (Figure 6.4C). As the promising key species are identified for each major ecosystem collection will focus upon these particular genera and species, and upon specific goals, (e.g. tolerance to anthracnose in *Stylosanthes* spp., tolerance to *Sphaceloma* in *Zornia* spp.).

Even though most of the collection activities will be in areas of tropical Latin America with acid infertile soils, some specific collections will be done in South East Asia, in areas with similar soils. These collections will focus on genera such as *Desmodium* and *Pueraria* that have proven adapted to acid soils in general, and to the humid tropics in particular. In the case of the grasses, emphasis will be placed on obtaining through germplasm exchange as much variability as possible in genera such as *Brachiaria*, *Panicum*, and *Andropogon*,

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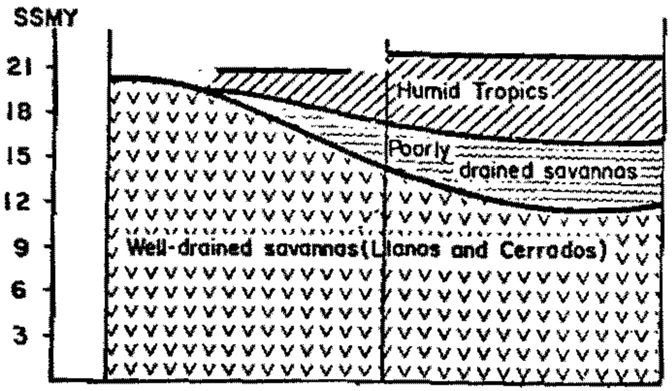
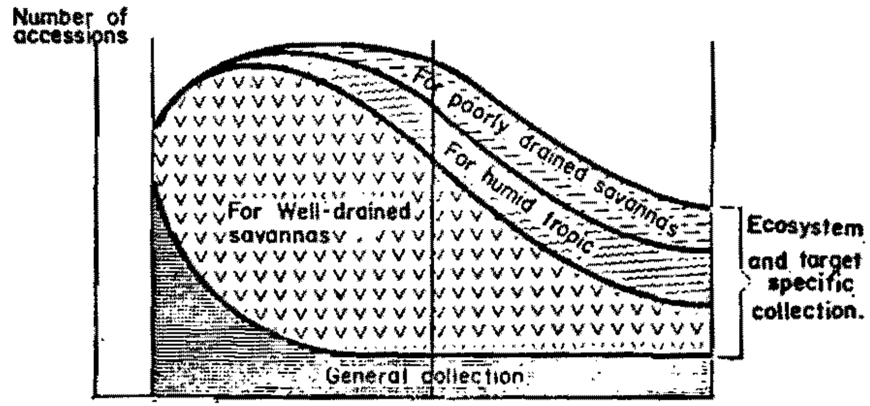
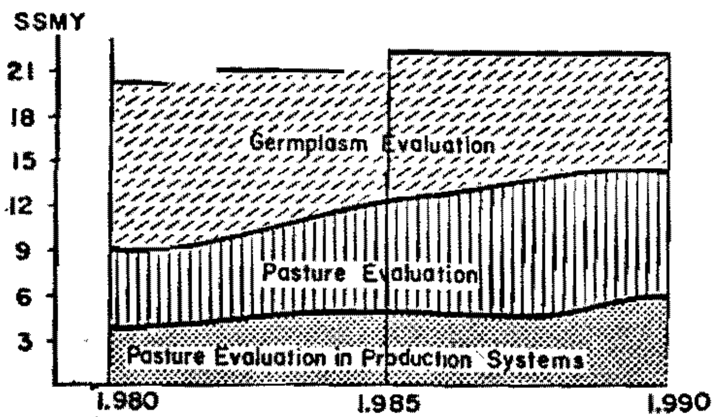
Figure 6.4 Allocation of senior staff time to (A) evaluation activities in the respective ecosystems; and (B) different technology development activities. Plus relative Program emphasis on different ecosystems in relation to (C) collection activities; and (D) number of associations evaluated under grazing.



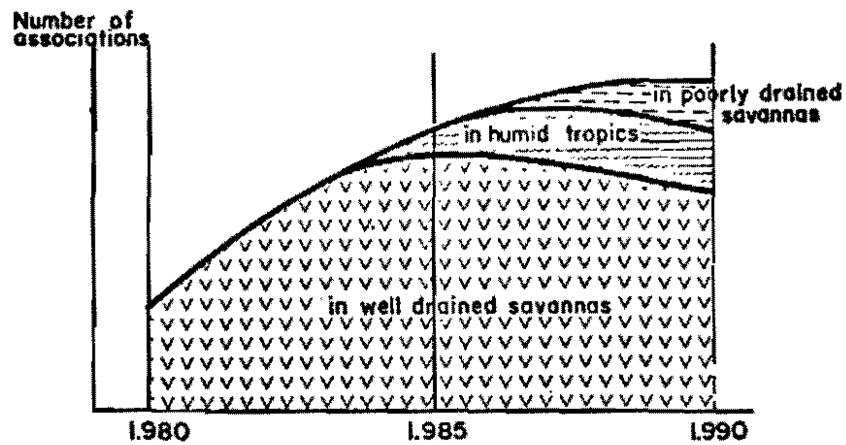
A. Allocation of Senior Staff time to evaluation in each ecosystems



C. Nature of collection activities



B. Allocation of Senior Staff time to major activities.



D Number of associations evaluated under grazing which have shown general adaptation to the edaphic conditions of the area of interest.

The agronomists will continue screening for promising species in each of the well-drained savanna ecosystems. When well-adapted species are identified, emphasis will be shifted to the identification of lines with superior overall performance. The pathologist and entomologist will assist in the identification of accessions more tolerant/resistant to the diseases and pests that economically affect such species.

Genetic advances in some key species will be made not only by introduction and selection, but also by plant breeding, where appropriate. Even though emphasis will be on exploiting natural variability before undertaking plant breeding, relative emphasis on breeding material is expected to increase particularly during the second half of the decade. As a natural evolution of the selection process within some key species, plant breeding will be used when desirable characteristics are missing and there is a reasonable probability of incorporating these characteristics by making specific crosses.

As promising lines are identified and cultivars approach release, there will be a series of related implications: (i) the need to provide documented summaries of experimental performance and potential productivity of these new cultivars, since the species may be totally unknown; (ii) the need to collaborate with national institutions in providing practical recommendations on pasture establishment methods, stocking and management practices; (iii) there will additionally be the need for seed production and processing technology to assist in the rapid and successful commercialization of seed production, implemented in liaison with national agencies that control cultivar release.

Pasture evaluation and development.- The present emphasis upon agronomic evaluation of a large number of accessions (Categories I, II and III at both Carimagua and Brasilia) will identify an increasing number of accessions for evaluation under grazing conditions (Figure 6.4D). It is expected that the need for expansion of these activities will be partially met by reassigning responsibilities within the present team, and partially by initiating more grazing experiments in cooperation with national institutions.

Once an adapted, productive pasture is defined for a region, either as a mixed or a pure stand, the need arises for defining low cost and efficient establishment methods that provide adequate stands for persistence and productivity. Seedbed preparation, minimum fertilizer requirements, forms of application for alternative nutrient sources, seeding densities and methods, and pasture management systems are among the practical issues with which the program must deal at the time of cultivar release. Soil fertility status will be monitored under grazing in order to determine (minimum) fertilizer maintenance requirements for persistence and stability of the association.

Pasture evaluation in production systems.- The present monitoring of existing production systems in selected subareas of Colombia, Brazil, and Venezuela will be expanded to include a more representative area in Venezuela, a poorly drained savanna area in Colombia and a dual purpose production area in Panama. The resulting diagnosis of on-farm production constraints, and the set of farm production and economic parameters will provide a data base that combined with the experimental data generated by the program, should suffice for simulation of alternative pasture uses in the various production systems identified. Modelling will be used with the specific objective of anticipating the expected outcome of alternative uses of various pastures in different production systems relevant to the region.

On-farm validation of improved pasture technology -planting new cultivars into pasture on a small portion of a farm and using this for those animals with highest response capacity- has already been initiated in on four farms in the Colombian Llanos. As cultivars are released, this activity is expected to increase throughout the decade in a few selected locations and in close collaboration with national programs. It should provide a means for validation of pasture persistence and productivity under farm conditions, and also for validation and improvement of modelling activities.

6.1.6.2 Evolution of outreach and feedback activities: Outreach and research activities are intimately mixed since national research institutions are both the program's collaborators and clients with the collaboration starting very early in the research process (Figure 6.3). Already, in the early stages of germplasm collection and evaluation collaboration exists, but it will expand rapidly as germplasm accessions advance in status through the research process. The main constraint to expanded collaboration is the absence, in most countries, of strong pasture research programs working in areas with acid infertile soils. Existing programs tend to concentrate on more fertile soils; areas where beef and milk production have expanded in the past and where most of the cattle population is still located.

The proportion of acid infertile soils and the degree of policy commitment towards developing such areas varies considerably among tropical Latin American countries. Possibilities of collaboration, assistance required, and relevance of feedback will thus differ among countries. Using these criteria, countries can be operationally categorized into the following five groups (see also section 7.5):

a) Countries with large areas of acid infertile soils and strong development programs in those areas.

b) Countries with large areas of acid infertile soils but with less well-defined development programs.

c) Countries with intermediate areas of acid infertile soils and well-defined development programs.

d) Countries with intermediate areas of acid infertile soils and with less well-defined development programs.

e) Countries with only small areas of acid infertile soils.

Up to the present, the Program has developed a strong research cooperation with countries in the first group, the collaboration with rest of the countries has been limited to exploratory regional trials and training. Since the collaboration with national programs starts from the beginning of the research process, expanding as it advances, international cooperation will naturally expand with the advancing of the germplasm evaluation process. Thus, cooperation in research will significantly expand with respect to groups of countries "b" and "c" mainly through advanced regional trials. More specifically, the plan for the decade is summarized below.

Training.- Training is directed toward augmenting the human resource base working in tropical pastures in acid infertile soil areas. In the past, training efforts emphasized equally all disciplines relevant to animal production. Since 1978, the emphasis has gradually shifted toward tropical pastures in acid infertile soils. The objective of the short and intensive training courses given annually is to achieve during the decade a "critical mass" of research workers for key locations in cooperating countries.

The short, intensive courses will be followed by postgraduate research internships to provide professionals from key locations, with the skills and experience in research methods and techniques for effective evaluation of germplasm adaptation and pasture persistence and productivity. These training efforts will be complemented by other research network strengthening activities such as thesis research opportunities in tropical pastures for M.S. and Ph.D. candidates, and short-term, in-country research courses in those countries and subregions with large areas of acid infertile soils.

Regional trials.- Germplasm exchange and testing through the network of regional trials constitute another important outreach/feedback activity and will be substantially expanded throughout the decade. Germplasm will continue to be distributed on request for research purposes, and exploratory regional trials (Type A) will be carried out in all countries in the network regardless of the extent of their acid soils. This type of trial will be conducted in all five major ecosystems using the tentative broad list of germplasm material for each ecosystem.

The full series of regional trials for the two types of well-drained savannas will be extended to cover all countries with moderate to large areas of these ecosystems. As research in the two other ecosystems (poorly drained savannas and humid tropics) starts early in the decade, and as promising material for each ecosystem is identified, the full series of regional trials will start at selected sites of the countries with moderate to large areas of similar characteristics.

6.1.6.3 Relative ecosystem emphasis.- Until now, the program focus has been upon the well-drained savannas with principal emphasis on the Llanos type savannas as at the Carimagua Research Station. Research in the Cerrado type savanna started in 1978 with the outposting of senior scientists to work in germplasm utilization. This program commenced in 1980, with regional trials (type A) in the humid tropics and the poorly drained savannas, but so far these are exploratory compared with the research underway in the well-drained savannas. New research activities will start early in the decade in the humid tropic and poorly drained savannas; thus, by the middle of the period the program will be active in all ecosystems. The primary emphasis, however, will remain on the programs in the well-drained savannas. These will require over two-thirds of staff time at mid-decade and will still utilize more than one-half by 1990 (Figure 6.4A).

The poorly drained savannas.- This type of ecosystem is found throughout the lowlands of tropical Latin America in the form of small to relatively large "islands" within the other ecosystems. Small areas of poorly drained pastures are found in varying degrees on almost every farm, while typical examples of large areas are the Beni region of Bolivia, the Pantanal in Brazil, the Casanare in Colombia, and the Apure in Venezuela. Lack of abundant, good quality forage that will persist under flooding during the wet season is the common constraint in this important and extensive ecosystem, which has generally higher stocking rates than the well-drained savannas.

New thrusts in germplasm evaluation and soil fertility/plant nutrition for this area will begin in 1982. Germplasm will be concentrated on screening for adaptability and persistence on the major soils that are subject to different degrees of flooding, while simultaneous, in-depth, on-farm studies will provide a key to the role of improved pastures in different land forms. These thrusts will not require additions to the core staff since they will be conducted by agronomists from headquarters, Carimagua, and Brasilia, in close collaboration with national programs working in the area. At present it is envisioned that these activities will occupy the total equivalent of 3 SSMY by 1985 and a maximum of 4 by 1990.

6.1.6.4 The humid tropics.- An expanded germplasm evaluation effort for the humid tropics will give the Program a much-needed germplasm screening site that is characterized by acid infertile soils and more extreme environmental conditions than those found in savanna areas. This site will provide an excellent location for screening for disease and pest tolerance/resistance, which will result in better understanding of the resistance mechanisms.

The humid tropics are experiencing increasing in-migration due to the combined effects of demographic, socio-economic, and geopoligical pressures. Most existing land use patterns result in rapid degradation of soil resources. The most prevalent exploitation system relies on the replacement of the original vegetation with pastures and crops. However, due to a lack of adapted forage species and the absence of a clear understanding of the dynamics of soil fertility levels after clearing, the productivity of the pastures tends to diminish rapidly due to loss of stand and weed invasion. Their useful life span is often no more than four to seven years. However, well-managed, adapted legume-based pastures maintained at minimum fertility levels are efficient at recycling nutrients and provide excellent erosion protection.

There is an urgent need for a broader range of adapted forage species and appropriate pasture development/management technology for these regions. It is estimated that more than half of the 6-8 million hectares of cleared Amazonian forest is in a state of degradation. The recovery of the areas already cleared is one of the main objectives of this new thrust of the Tropical Pastures Program.

Two outposted research scientists will be assigned to work with a research team of a collaborating institution, probably located in a "seasonal forest" ecosystem. The two positions are:

- Outposted Research Agronomist, to commence duties in mid-1981. Objectives will include major germplasm screening plus coordination of a series of regional trials within the two humid tropic ecosystems.

- Outposted Research Pasture Development Agronomist, to commence duties by January, 1983. Objectives will include strategies for renovation of degraded pastures, plus alternative strategies for pasture establishment and maintenance and related soil fertility/plant nutrition studies.

These two staff members will receive operational support from present staff, especially in the areas of germplasm evaluation, pathology, entomology, microbiology, plant nutrition and seed production. In many ways, activities within the humid tropics will effectively complement savanna-based programs, broadening the ecological base for testing germplasm and technology. Significant economies of scale can be realized, and valuable time can be saved, by providing low-cost/low-input solutions to the urgent problem of degrading pastures in the humid tropics of Latin America.

6.1.6.5 Staffing patterns in the eighties.- While a natural result of the progress made in research and knowledge of germplasm performance is that considerable change in research emphasis will occur during the decade, only minor changes and additions to the core staff are envisaged.

Total staff members.- In 1980 the Program staff includes 20 scientists. Although five additional staff positions are proposed for the decade —three in regional cooperation and two in research— net additions to program staff will be only three since the other two positions are to be provided by phasing out existing positions. A peak of 23 will be reached in 1986, remaining constant until the end of the decade.

Research staff.- As described above, two senior staff will be located in a humid tropic location. Two research staff positions currently located at Brazil will be phased out in 1985 and 1986 respectively, concurrent with the initiation of more intensive regional cooperation activities. As the natural consequence of research advances in Llanos ecosystem, discipline orientation of the staff located at Carimagua will change from soils and agronomy to pasture utilization and cattle production systems, but the number will remain constant.

As previously explained, from 1982 there will be an increasing involvement of the headquarters-based research staff in activities related to the poorly drained savannas and the humid tropics. Again, this does not imply changes in staff members. Total research staff will increase from 20 to 21 during the period 1982-1984, decreasing to 20 thereafter.

Regional Cooperation staff.- From zero in 1980, this staff category will encompass a maximum of three positions by 1986 and remain constant until 1990. The first two appointments are proposed for 1983 (1985 at the latest) followed by a third appointment in 1986. These proposed positions are as follows:

a) Central America and Caribbean: This staff member will respond to the needs of a region which includes no less than nine countries with nationally significant areas of acid, infertile soils utilized essentially in beef production. Activities will relate to regional trial coordination, on-farm validation trials and inter-regional technology transfer. The scientist will be located in Panama or Costa Rica and is required by not later than 1985.

b) Cerrado: This scientist will assist in the coordination of regional trials throughout the very extensive areas of the Cerrado ecosystem and the adjacent, poorly drained savannas (e.g. Pantanal). The position will be filled in 1985, assuming significant advances in the Program's pasture technology development. This will coincide with a reduction of one core research position. The total number of staff positions in Brazil will then fall to two in 1986; one in research activities, predominantly in pasture evaluation, and the other in outreach and regional trials.

c) Subtropical South America: This position relates to extensions of the Brazilian shield into both Paraguay and Bolivia. The scientist could be located in either country and is programmed to start in 1986. While the primary function will be to coordinate regional trials, a secondary function will be to provide liaison to national research teams working in the "chaco regions" of Bolivia, Paraguay and northern Argentina where there is interest in testing CIAT's germplasm in distinctly different ecosystems.

6.2 Other Systems Components for the Frontier

6.2.1 Crops

In Chapter 6 the role of cassava and upland rice as crop components for production systems in acid infertile soils was discussed. Two crops of great economic importance in Latin America (soybeans and sorghum) are not present research targets at CIAT. As discussed in Chapter 1, the two crops have shown unprecedented growth in areas sown and total production in the past ten years. The growth in production has been stimulated by a growing demand for animal feed, particularly for poultry. This demand has largely been generated by increased consumption of poultry among the middle and upper income strata.

Growth in the area planted with cassava and upland rice has taken place on the best agricultural lands available in the tropical countries of the region. Various inventories of soil resources in these countries clearly indicate the scarcity of prime available land in most of these countries, in contrast with the vast areas of less-fertile, usually acid soils which are presently underutilized. In both crops the basic germplasm pool, from which the currently utilized varieties and hybrids were derived, was developed on the more-fertile and less-acid soils of temperate latitudes.

As a regional center in tropical America, CIAT plans to continue its policy of collaboration with other institutes that play a role in the region and fit into the basic philosophy of the center. At present, CIAT hosts subprograms from three other international institutions with staff based at headquarters: from CIMMYT (Andean Zone Maize), IFDC (Phosphorus Project) and IRRI (IRTP Liaison Scientist). Negotiations to host programs of international institutions working with sorghum and soybeans are in progress, and it is hoped that both crops will be served by a small group of one or two scientists dedicated to the task of assembling and screening germplasm, and of varietal development for the acid soils of the tropics. Similar negotiations are underway (AID-Title XII Soil Management CRSP) for the location of one senior scientist at Carimagua to assess the potential of other crop species for production under acid soil conditions. In this way CIAT may be able to make a contribution without expanding its commodity mandate or committing its financial resources.

6.2.2 Factor Research

The most critical constraints to plant growth on acid infertile soils are high aluminum levels and low available soil nutrients (mainly phosphorus followed by potassium, calcium, magnesium and sulphur). Except in a few instances, it may not be economical to correct these soil deficiencies, due to high transportation costs and low productivity. High subsidies are currently required in order to induce production in most regions. The pasture and crop research described above aims at developing adapted plants with low fertility requirements. However, economically efficient nutient sources are a necessary complement to the low nutrient requirement strategy.

While these soils are lacking in nutrients, considerable phosphorus and lime deposits exist in several tropical Latin American countries. Even though distances between these low fertility regions and the mineral deposits are not large in many cases, high transportation costs necessitate that fertilizer volumes be kept low, and thus, agronomic efficiency of the nutrient sources must be relatively high.

Research on rock phosphate was initiated in 1978 through the IFDC-CIAT special project funded by IDRC and UNDP. While this project, hosted at CIAT, does not concentrate exclusively on frontier soils, its main focus is on efficient utilization of rock phosphates in acid soil, a medium that provides for significantly improved agronomic efficiency of these P sources. Research on this important factor component is expected to continue, including other more efficient modifications of the indigenous rock phosphate resources, with IFDC backstopping in the development of the fertilizer production technology.

6.3 Agroecosystem Analysis Unit

To be cost effective CIAT's commodity programs require systematized information about their respective target areas in two main phases of their research activities; research strategy design and technology evaluation and transfer.

Specific research goals and priorities must initially be defined and constantly re-evaluated in the light of knowledge of existing conditions in each program's target area. A good understanding of the land and climatic resources within which agricultural production takes place; their variability and how representative they are, is necessary for success in generating adaptable, seed-based technology. This is particularly valid for CIAT commodity programs because of the variability in ecosystems in terms of soils and climate in Latin America and the strong germplasm-ecosystem interactions in all CIAT commodities.

In the case of pastures, persistence is very much affected by disease and pest tolerance/resistance. Not only have most of the adapted forage legumes which the Program regards as highly promising (i.e. Stylosanthes, Zornia, Centrosema) originated in the tropics of Latin America but their natural enemies have also originated there. Therefore these species present strong gene-environment interactions in terms of disease and pest tolerance. Results from regional trials strongly support this observation. The same considerations apply to both cassava and beans, since both of these commodities have their center of origin in Latin America. Moreover, these two commodities are grown in a very wide diversity of cropping systems. Information from international trials suggests that a large interaction between genotype, cropping system, and climatic and edaphic factors exists. In both crops a complex of biological constraints which tend to occur under similar ecological conditions and vary in their severity depending on the cropping system also exists. In rice, particularly in upland rice, a far better definition of target areas and their critical constraints is required before major steps are taken to "fine tune" research priorities.

Target area analysis and evaluation also appear as critical components in the technology testing and validation stage. The availability of purposely collected and organized data on each program's target area will not only help in achieving objectives, but will do so in the most cost-effective manner. Sites for regional trials, international nurseries, and for on-farm, validation, benchmark studies should be selected in terms of the representative quality of the various subecosystems. Better ability to extrapolate information to similar ecosystems will make network testing more useful. Better ability to associate germplasm to a given type or range of ecosystem will also significantly reduce the burdens of cooperating national institutions and increase confidence in networking with CIAT. The need to gather this type of information was identified by the TAC stripe review on farming systems research as the major gap in FSR at CIAT.

Thus, the overall objective is a better understanding of the agroclimatic zones and cropping systems and their present and potential interactions with the germplasm, in order to provide, within each commodity program: (a) an analytical framework for problem identification and setting program priorities; (b) a better understanding of agroecosystem-specific problems and resource potentials; (c) a sharper focus of the commodity program's priorities; (d) an objective, quantitative basis for technology evaluation, feedback and transfer; and, overall, (e) a more cost-effective and efficient way of carrying on with the tasks of both CIAT and the collaborating national institutions. The experience gained in the special study in land evaluation conducted by the Tropical Pastures Program, and in the study of climatology conducted by the Bean Program, are clear evidence of the usefulness of this endeavor.

The agroecological study unit is to collaborate with each commodity program in the collection, analysis and synthesis of relevant climatic, edaphic, and crop system data on their respective target areas. The unit will be integrated by two senior staff: an agroclimatologist (starting 1982) and a land system specialist (starting 1983). Rather than adding specialists in these disciplines to each of the four programs, a small central unit will provide this expertise. Agroeconomic, economic and other disciplinary inputs will be provided by the specialist in the respective commodity programs.

Chapter 7: INTERNATIONAL COOPERATION STRATEGIES AND PROJECTIONS

The principal goal of international cooperation activities at CIAT is to provide for collaboration in research and inter-institutional technology transfer. As described earlier, the key partner of CIAT are the counterpart research programs in each collaborating country. It is these institutions which are continually encouraged to define their needs and aspirations in relation to CIAT; thereby, they determine to no small measure the direction and emphasis of the research programs at CIAT.

Given the cooperative nature of the relationship between the national research programs and CIAT, and given the key role of national programs in the technology generation and dissemination process, CIAT is most interested in working with the national counterpart organizations in strengthening their research capacity, and thereby to assume an increasingly larger responsibility in the research process at it relates to the commodities in CIAT's mandate.

The cooperative activities between CIAT and its national counterparts takes on various forms. Collaborative activities as they relate to the exchange of germplasm, international/regional testing networks and collaborative research are discussed in this document in the context of the individual research programs. This Chapter concentrates chiefly on those international cooperation aspects which fall within the direct management responsibility of International Cooperation.

7.1 Strengthening of National Commodity Programs and Development of a Research Network through Training

Research capability is largely a function of well trained scientific manpower. Its lack, shortage or loss constitutes serious limitation to generating, adapting and validating improved technology in national programs.

In the decade ahead, training will continue to constitute the principal means by which CIAT collaborates with national programs in helping to build up their capability to cooperatively as well as independently, conduct research on the commodities in CIAT's mandate.

Practically all of the training opportunities offered by CIAT are commodity based and are on the postgraduate level. Below are outlined the principal considerations governing CIAT training activities in the decade ahead.

7.1.1 Types of National Organizations relevant for CIAT Training

The task of program building is large and requires the establishment of priorities. CIAT has chosen to give first priority to commodity research programs in government research institutions. Second level of attention goes to universities, but only those that have active research projects on the commodities in CIAT's mandate. Third priority is assigned to selected leadership staff in extension and development organizations to help link research with extension, and private industry. It is expected that in the course of the '80s, increasing emphasis will be given to universities as they become more active in research and as the need for an increased role for the international centers and national research institutions in the university teaching curriculum becomes more articulated. This emphasis will be expressed by training university staff engaged in the teaching of production courses which include CIAT commodities, and by helping develop didactic material for such courses. It is believed that this will have a significant multiplication effect on the utilization of CIAT's technology and will contribute to the increased productivity and production of the corresponding commodities.

7.1.2 Selection of Training Candidates

Since the primary purpose of training is to strengthen national organizations in carrying out research on commodities in CIAT's mandate, participants must be actively working in a national research and/or development organization that certifies the continued employment of CIAT-trained professionals and outlines the type of activity the candidate will be engaged in after the training period. The prerogative to pre-select rests with the respective national institutions. Final selection of candidates is done through mutual consultation and agreement. The type of CIAT training is always determined on the basis of the stage of development a national commodity effort is in, and the particular needs and priorities expressed by the national program. In all cases, though, the selection of training candidates is oriented to form research teams for each commodity in CIAT's mandate, or, alternatively, to train professionals that are to bridge the gap between research and extension on the national level.

7.1.3 Countries of Origin

As the prime concern of CIAT is the tropical Latin America countries, some 80 percent of past training participants (or a total of some 1,700 professionals during the period 1969-1980) have been selected from this area. In the next five years, participants from Asia and Africa are expected to increase to approximately 10 percent of the yearly total as regional cooperation expands to these areas. Nevertheless, throughout the eighties, the large majority of CIAT training participants will continue to be selected from the tropical Latin American countries.

7.1.4 Funding of Training Scholarships

Currently, approximately one-third of the scholarships for CIAT training participants are core-funded. The other two-thirds are either special project funded or are financed by the respective national institution. This ratio of core vs. external funding is expected to continue throughout the '80s. This will allow CIAT to have available limited funds to finance scholarships for CIAT-based training for representatives of national institutions that do not have the necessary resources to support their training candidates while at CIAT. At the same time, it stimulates an active, financial participation in CIAT-based training both on the part of collaborating national institutions that have access to resources for training at an international center, as well financial participation on the part of donor agencies that are interested in providing resources for manpower-development purposes.

7.1.5 Thesis versus In-Service Research Training

A large proportion of current training opportunities provided by CIAT are in the area of non-degree training. Realizing that such training has limitations in that it often does not result in commensurate professional and leadership opportunities offered to the ex-training participant upon returning home, the Center will strive to arrange for increased opportunities for thesis research in conjunction with cooperating universities. However, it must be considered that candidates for graduate thesis work are scarce in numbers and that some Latin American countries require relatively short but intensive practical training to allow young graduates to perform efficiently in areas of practical agronomic research, validation of technology and technology transfer. Restricted budgetary and manpower resources do not yet allow these countries to assign their personnel for training during long period of time. Therefore, non-degree-related in-service training is expected to continue to be in high demand for some time.

7.1.6 CIAT Assistance to In-Country Training

Certain types of training, especially for research personnel with large responsibilities in extension and for leading extension personnel, can best be conducted in the countries. To the present, CIAT has collaborated with 13 countries in the planning and conduct of some 31 in-country courses on research and production of commodities in CIAT's mandate. Throughout the '80s, CIAT expects to continue to provide, on request, and within available resources, training in methodology and new technology to assist country programs in conducting courses to further strengthen their technology validation and transfer capabilities in the area of CIAT's commodities.

7.1.7 Relative Magnitude of CIAT Training Activities

At the present time, CIAT annually is receiving some 280 professionals for training at the Center. Their length of stay ranges from one to 12 months (selected thesis students stay for longer periods), with an average length of stay of four months. It is expected that the annual contingent of CIAT training participants in the first half of the '80s will remain at approximately this level. In the latter half of the decade of the '80s, it is anticipated that while the number of professionals to be trained at CIAT will decrease somewhat, there will be a parallel gradual evolution to higher revel, research-oriented, longer-term training. At the same time, more production-oriented training will be emphasized through collaborating with national organizations on in-country courses.

It is projected that during the decade of the '80s, around 15 percent of the Center's budget and an average man-years of training participants per senior staff member will be invested in the training of personnel from collaborating national research institutions.

Training activities at the Center is highly decentralized and takes place within the commodity programs under the supervision of senior staff personnel who devote between 10 and 15 percent of their time to training. Training is coordinated center-wide by the Training Office staffed by a senior staff coordinator and a contingent of professional support staff personnel that liaise between the Training Office and the respective commodity programs. This form of centralized coordination and decentralized execution assures an effective integration of training with research, at the same time that it provides for a CIAT-wide application of unified training standards.

7.2 Conferences for Mutual Consultations and the Further Development of Research Networks

CIAT has long recognized the value of international and regional conferences/workshops as a means of (a) focusing attention on a given research issue, the establishment of priorities involved and definition of interinstitutional collaboration in dealing with these; (b) consulting with national counterparts on selected CIAT program strategies and mutual coordination of research work; and (c) consulting, on a regular basis, on the nature and operation of commodity-based research networks.

All three types of conferences will be continued throughout the '80s. While the first two types of events will be scheduled as the need arises, it is anticipated that one network workshop in each of CIAT's commodities will be held every other year.

As the organization and conduct of conference events requires considerable investments in term of financial inputs and scientists' time, conferences will only be held when they are considered necessary in achieving the objectives of the Center. In any case, as a rule of thumb, core-financed conference events will never exceed .75 percent of the total core budget in any one year. In addition, cosponsorship with other international organizations will be sought whenever the subject of a conference is of such nature that if falls into their interests or mandates.

7.3 Interpersonal Technical Consultation

On the part of CIAT, technical consultation with national programs is made possible through the travels of the Center's senior scientists and directorial staff. An average of 15-20 percent of their time is spent on visiting research projects of cooperating members in the various research networks. Upon request, CIAT may also provide advice on organization and development of national programs related to the commodities in CIAT's mandate. Demand for such visits is expected to remain high in the eighties; yet, no substantial increase in time allocated for consultations is planned as this would conflict with on-going activities.

CIAT encourages professional program staff and leaders of national programs to periodically visit CIAT and its programs as a means to provide its collaborators with first-hand information on CIAT development.

7.4 Communication and Information Support

A principal output of an international research center such as CIAT is a massive amount of technical information on the context of agricultural research as it pertains to CIAT, on new production technology, and on research methodology. In an effort to systematize this information and to make it available to the research and development community both on the national level as well as to other regional and international institutions, CIAT maintains an important effort in the development and production of technical message packages which include the following publication series.

Annual Report. The technical annual report of CIAT is published in the form separate reports each for the major research programs of the Center. Also, a yearly "CIAT Report" is published.

Newsletters. Commodity-specific newsletters are published periodically. They contain information on (a) developments with the respective CIAT commodity program; (b) new technology (both CIAT-and non-CIAT generated); and (c) commodity related work in cooperating national programs.

Technical Publications. This series includes the publication of conference proceedings, monographs, production manuals, field problem guides, and others.

Audiotutorial Units. These are audiovisual training materials that provide technical information on the commodities within the mandate of CIAT for didactic purposes. These materials are for the use at CIAT as well as within countries (i.e., universities, national research institutions).

Public Information Materials. Selected materials are produced to inform a more generalized public of the purpose and the nature of CIAT.

It is anticipated that throughout the decade of the '80s, the volume of CIAT's communication products will continue to increase and that the utility of the CIAT message products to their intended audiences will progressively be enhanced.

CIAT will continue to explore innovative alternatives in the use of message channels in attempting to improve the effectiveness of CIAT messages addressed to its various audiences. Nevertheless, as the most important audience is the collaborating research scientists on the national level, CIAT will always assure that its forms of communication are compatible with available communication infrastructure on the national level.

In the technical information field (i.e., documentation and library services), over the years CIAT has acquired international recognition for its timely delivery to research scientists in national programs of agricultural information services. These services include abstracts, tables of content, photocopying of research documents, specialized literature searches, annual cumulative bibliographies, plus the publication of monographs containing synthesis of technical information in selected fields.

CIAT recognizes that timely technical information services to research scientists at CIAT itself and at the national level is vital to the task of improved agricultural production technologies. In the decade ahead, CIAT will systematically build up its documentations services of research work in the fields of cassava, tropical pastures, beans grown under tropical conditions, and rice, in Latin America. At the same time that these selected documentation efforts will be further developed and integrated with large, comprehensive agricultural information systems (e.g., AGRINTER), the more general information services provided by CIAT which are not directly linked to research and development on CIAT's commodities, will gradually be diminished to the point where they will be phased out by the mid-'80s. This latter development is in recognition of the fact that in the non-CIAT mandated commodities the Center does not have a comparative advantage in providing technical information services. Rather, the responsibility for the provision of such services must gradually be assumed by other regional and national information-related organizations.

Presently, CIAT assigns a total of four senior staff positions in the area of communication and information as described above. (It must be pointed our that a considerable portion of the on-going work in the area of communication/information is devoted to the direct support of CIAT programs in general and thus only indirectly impinges on international cooperation activities). During the planning period under consideration here, neither the number of senior staff positions nor the relative proportion of resource allocation to communication/information activities is expected to change significantly.

7.5 International Cooperation Activities in Relation to the Needs of given National Programs

The mix of international cooperation services to be provided to any one national counterpart organization will generally depend on the level of development of its research program in the respective CIAT commodities. For discussion purposes, different levels of program developments can be defined as follows:

Group I: Advanced national commodity programs that have clearly defined their research and development strategy and are equipped to carry out these strategies;

Group II: Developing national commodity programs in a dynamic state of growth and development of their activities;

Group III: Developing national commodity programs at an incipient stage of development, staffed by personnel with low academic degrees and levels of training;

Group IV: Organizations that do not have a formal program on the CIAT commodity involved but whose country has good potential for production of that commodity;

Group V: National commodity programs that because of economical and/or other circumstances are in a state of decline and need revitalization.

Clearly, CIAT's efforts to strengthen national commodity efforts must be adjusted to the different needs of these national programs as their stage of development moves along the continumm described above. Table 7.1 provides a generalized overview of the types and relative emphases of

Table 7.1. CIAT international cooperation services to national programs: a generalized scheme[1]

Program classification[2]	TRAINING					GERMPLASM			TECHNICAL CONSULTATION		INFORMATION SERVICES			CONSULTATION ON NATIONAL PROGRAM PLANNING	
	Ph.D. M.S. thesis	In Service	Methodology + Special Techniques	Short research courses at CIAT	Short Production courses in countries	Exchange level[3] I	II	III	Research staff visits	Workshops & Conferences	Network newsletters	Program publications	Documentation Services	Research	Economic Analysis
Group I	***[4]	*	***	***	****	****	***	*	***	****	Yes	****	****	**	*
Group II	*	**	**	***	***	*	**	***	****	***	Yes	***	****	****	***
Group III	*	***	o	o	o	o	*	****	**	**	Yes	***	****	**	****
Group IV	o	o	o	o	o	o	o	*	o	*	Yes	**	**	o	**
Group V	**	***	*	***	**	**	**	**	**	***	Yes	***	****	**	***

1 While all CIAT international cooperation services are available upon request by collaborating national programs, the present scheme gives an indication of the expected demands of national commodity programs at different levels of development.

2 For definition, see text.

3 Level I = Germplasm Bank Accessions;
Level II = Seg. Populations;
Level III = Finished varieties.

4 Relative Emphasis:
**** = High;
*** = Medium;
** = Low;
* = Very Low;
o = None.

different international cooperation services that are rendered to collaborating national programs at the various stages of development.

7.6 Outposted Personnel

Outposted personnel refers to any CIAT staff stationed outside of Colombia. Outposted personnel represents a very important component of international cooperation services and their number is expected to grow considerably in the decade of the '80s. The Center distinguishes between three types of outposted personnel: outposted staff for research; regional cooperation staff; and bilateral contract staff.

7.6.1 Outposted Staff for Research

In principle, research staff will be posted outside of CIAT only when three conditions are met: (a) the research problems to be solved are of significant importance of a given region (i.e., normally CIAT will not post permanent core funded research staff to conduct research relevant to only one country); (b) the research problems to be solved occur in conditions which are not adequately represented in any site within CIAT's host country and therefore require the outposting of research staff to a representative site outside of Colombia; and (c) there is a strong regional or national research organization in the area which itself assigns high priority to the solution of the research problems at hand and is in a position to provide effective research support to the outposted research staff. Since the research conducted by this type of scientist is an extension of CIAT's commodity research programs, it is understood that these scientists would preferably be funded through the core budget. CIAT's plan for the '80s calls for outposted research staff in cassava (one position to start in 1983) and tropical pastures (a maximum of five positions).

7.6.2 Regional Cooperation

Regional cooperation staff are outposted to strategic locations in order to serve regions in which a particular commodity is important. While in recent years a modest effort was made to serve selected regions through a few special project-funded regional cooperation staff, it is believed that the '80s ar the time for maximum expansion in regional cooperation staff: now that an ever increasing amount of technology becomes available, stronger cooperation with selected regions becomes imperative. Until such time that CIAT has added the full contingent of regional cooperation staff outlined below, the Center cannot be considered as fully developed.

A distinction is made between regional cooperation staff in the Western Hemisphere, and regional cooperation staff outside the Western Hemisphere.

7.6.2.1 Within Western Hemisphere. These staff are assigned to a specific country or regional program. Their major role is to assist in the inter-institutional transfer of technology in a given commodity and to provide feedback into the research process, thus making them essential links in the technology generation/technology transfer continuum. In close collaboration with national programs in their respective regions they conduct or encourage research on problems of special importance to that area. They expedite and help organize international nurseries and other collaborative trials in the region, and they assist in the selection of participants for training at CIAT and in the development of in-country training courses. Due to their relative proximity to CIAT headquarters, outposted cooperation staff within the Western Hemisphere will always maintain CIAT as their "second" headquarters and thus will visit CIAT at periodic intervals.

As a rule, regional cooperation staff outposted within the Western Hemisphere shall be core funded. Nevertheless, the funding situation at any one time may be such that given positions must be financed through special project funds. The long-term plan of CIAT calls for a total of eight regional cooperation staff positions in the '80s (3 in beans; 1 in cassava; 1 in rice; and 3 in tropical pastures).

7.6.2.2 Outside the Western Hemisphere. These staff are posted to major regions outside Latin America and the Caribbean in which a given CIAT commodity is of great importance and which have a potential to benefit from new CIAT production technologies with but a minor research effort in the adaptation of this technology to the regional conditions. Scientists posted to such regions are to be located at strong international, regional or local research programs which themselves assign high priority to the commodity research/development effort under consideration, and which can provide sufficient infrastructure for training, quarantine, varietal selection and seed multiplication. The principal role of scientists posted outside the Western Hemisphere is to provide an organizational framework that allows for the regional adaptation and validation of new production technology, and to stimulate active collaboration in this process on the part of national programs in the region. In general terms, CIAT scientists posted outside of the Western Hemisphere cover a larger geographic area than their counterparts within the Western Hemisphere. They will organize a greater portion of training on a regional basis and select candidates for furhter research training at CIAT only for selected disciplines for which adequate training is not available in the region.

While it is preferable to include these long-term positions in the core budget of CIAT, it is possible to consider special project funding for outposted staff outside the Western Hemisphere. For the '80s, a total of four core-funded regional cooperation staff outside the Western Hemisphere are projected; two positions in beans; and two postions in cassava.

7.6.2.3 Bilateral Contract Staff. These staff are appointed as local components of national or sub-regional research teams at the request of individual countries or small groupings of a few countries. They serve on a temporary basis (usually three to five years), and their purpose is to strengthen the institution they are assigned to in their field of activity while national staff complete their training to fill such positions. Bilateral contract staff will normally be working chiefly with one of the commodities for which the Center has responsibilities, and will maintain very close ties with the respective program in CIAT.

Since these types of appointments will depend on special project fund availability and are of a temporary nature, it is neither possible, nor desirable, to project precisely for which countries funds will become available and which meet the criteria established by CIAT for considering CIAT bilateral contract staff (Criteria are listed in the CIAT publication CIAT's Strategy for Outreach Services, Series 12E-1, 1979). It is anticipated, however, that no individual commodity program will, at any one time, be involved with more than three countries or engage more than five such bilateral contract staff.

Chapter 8: NEW CORE INITIATIVES

In this plan CIAT projects two initiatives which are to be incorporated into core funding during the decade. Both are highly complementary to the on-going activities of the Center and are regionally oriented towards the Western Hemisphere. These initiatives are with respect to the Agroecosystems Analysis Unit and the Seed Unit.

8.1 Agroecosystems Analysis Unit

The project which has been in operation since 1978 using core funds for visiting scientists has been described in Chapter 6. The rationale for the Unit has been outlined and its role as a CIAT-wide activity clearly defined.

8.2 Seed Technology and Training

In 1979, a special project funded by the Swiss Development Cooperation, was initiated at CIAT, with the objective of assisting in the strengthening of national seed-related activities in the region and in providing CIAT with a means for decreasing the time span that takes for new germplasm to reach the farm level, through the provision of seed production and processing capacity in the commodities within the mandate of CIAT.

Initially, it was planned that this activity, i.e., the Seed Unit, would be phased down at the end of five years of special project funding to a level which could be maintained with existing core resources. However, the highly positive response from the national programs evident in the first two years of the project has led to a reconsideration of these earlier plans. A continuing need for additional seed-related activities at CIAT over the decade has been demonstrated. The Seed Unit has thus been projected for incorporation into the core budget during the decade.

8.2.1 Objectives of the Seed Unit

The principal factors limiting progress in national seed programs and the industry are lack of trained personnel, often unclear and inconsistent policies by governments, limited supplies of breeder and basic seed for transfer to the seed industry, problems in producing, processing and storing of good quality seed, and weak marketing systems. Under these circumstances the role of seed related activities at an international center needs to be defined clearly since the manifold problems outlined above cannot only be solved at that level. The Unit has thus defined its objectives as follows:

(a) To strengthen seed programs and local enterprises through the training of, and technical collaboration with, seed technologists in the region.

(b) To help national programs to stimulate use of the most promising materials of the basic commodities.

(c) To encourage research on seed related problems limiting seed production and distribution, and in improving technical communication among seed technologists in the region.

8.2.2 Seed Strategy for the Eighties

During the first phase of the program considerable attention has been given to the training of seed technologists at the introductory level since there are only a limited number of personnel specifically trained in seed technology. In the main, personnel in these programs have received a normal agricultural training in which seed related activities were not emphasized. A number of basic courses were mounted in which, to the end of 1980, 123 seed technologists have received a broad based training in all aspects of seed production, processing, marketing and quality control. In the second phase of the training program increased emphasis will be placed on more advanced specialized courses and workshops addressed to particular needs, such as the production of breeder and basic seed, organization and operation of seed program activities at the national level, seed quality control, seed drying and processing, and seed marketing. In these courses participate both leaders of public and private sector programs.

In the area of technical collaboration, the Seed Unit projects increased activity in providing assistance to national seed programs in accelerating the use of improved hybrids and varieties. This collaboration will include assistance in the formation of seed associations and new local seed enterprises. Much of this activitiy will be channeled through professionals who have had previous contact and training with CIAT. The Unit will support efforts by sub-regional groups and national programs in offering short courses designed to multiply the total training effort at the local level.

In the area of seed production and processing the Unit proposes to continue to support the CIAT commodity programs by multiplying, and making available, breeder and basic seed of the most promising materials to national programs and other interested organizations in the region. In this operation CIAT does not propose to distribute commercial seed directly to farmers since the basic objective of the Unit is to encourage these activities at national level.

As part of the activities in breeder and basic seed production CIAT has already established links with other international centers, particularly CIMMYT and ICRISAT. The objective of these linkages is to assist these centers in their collaboration with national programs, through production and dissemination of promising materials in the region.

With respect to research on seed related problems CIAT is helping to identify priority areas for research in seed technology with relevance to the region and to the commodities in the mandate. In the introduction of new pasture species many problems of production, harvesting, storing, and quality evaluation need to be addressed, since these species are entirely new to the seed industry, and basic seed technology for these species has not been developed. In the other commodities, i.e., beans, cassava and rice, there are particular areas of research which are necessary to facilitate improved seed production and distribution. Within the resources of the Unit, and in collaboration with the CIAT commodity programs and national institutions, a stronger research effort is projected for the eighties to provide answers to some of these problems.

The provision of information services on seed related activities, including documentation and audiotutorial teaching materials, is an integral part of the proposed plan in order to encourage professionalism and good communication among the seed community in the region.

8.2.3 Projected Seed Activities in the Eighties

At present, the Seed Unit staffing consists of two senior scientists and supporting personnel, provided entirely by the special project funding. Funding for the present phase of the project will terminate in 1984. CIAT proposes to continue seed related activities as a separate Unit over the decade of the eighties. On the termination of present funding, it is hoped that some continuing assistance from the present donor can be provided.

Two senior core funded senior scientist positions are projected for the Unit to commence in 1985 and 1986. In addition, the existing senior seed scientist in the Tropical Pasture Program will be associated with the Unit. One of the projected positions will be required in the area of seed technology (processing, quality control and enterprise management), and the other in the general area of seed production and allied research. The position in Tropical Pastures will continue to be dedicated to the problems associated with all aspects of seed technology in the pasture species under investigation, for which methodologies are still lacking.

Continued assistance from special project funding will be required for the provision of funds for training, workshops, conferences, and technical collaboration activities, to maintain the level of activity in the present project. Within the limits set by the budget guidelines for the Center, and earlier and larger côre involvement by CIAT cannot be contemplated.

Chapter 9: BUDGET IMPLICATIONS

The budgetary implications of the long-term plan as presented in the previous pages are principally a function of the projected man-years of senior scientists. Table 9.1 presents a break-down of actual senior staff positions in the period 1978-81, and projections of core-financed positions for the decade of the eighties. Figure 9.1 presents a graphic summary of actual and projected senior staff positions in the areas of research, research support and administration, and regional cooperation.

(NOTE: Budget projections are under preparation).

Table 9.1. Core-financed senior staff positions for the period 1978-1981, and projections for the period 1982-1990

	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90
Research: Headquarters-based													
Beans	11	11	12	12	13[1]	13	13	14[17]	14	14	14	14	14
Cassava	9	9	10	10	10	11[7]	11	12[18]	12	12	12	12	12
Rice	3	3	3	4	5[2]	6[8]	6	6	6	6	6	6	6
Tropical Pastures	17	17	17	17	17	16[9]	16	16	17[24]	17	17	17	17
Swine	2	2	–	–	–	–	–	–	–	–	–	–	–
Research: Outposted													
Beans	–	–	–	–	–	–	–	–	–	–	–	–	–
Cassava	–	–	–	–	–	1[10]	1	1	1	1	1	1	1
Rice	–	–	–	–	–	–	–	–	–	–	–	–	–
Tropical Pastures	2	2	3	3	4[3]	5[11]	5	4[19]	3[25]	3	3	3	3
Regional Cooperation													
Beans	–	–	–	–	–	1[12]	3[14,15]	3	5[26,27]	5	5	5	5
Cassava	–	–	–	–	1[4]	1	1	2[20]	3[28]	3	3	3	3
Rice	–	–	–	–	–	–	1[16]	1	1	1	1	1	1
Tropical Pastures	–	–	–	–	–	–	–	2[21,22]	3[29]	3	3	3	3
Administration & Support													
Administration	6	6	7	7	7	7	7	7	7	7	7	7	7
Agro-ecosystem Analysis	–	–	–	–	1[5]	2[13]	2	2	2	2	2	2	2
Communication/ Information	4	4	4	4	4	4	4	4	4	4	4	4	4
Data Services	1	1	1	1	1	1	1	1	1	1	1	1	1
Genetic Resources	3	3	2	2	2	2	2	2	2	2	2	2	2
Laboratory Services	–	–	1	1	–[6]	–	–	–	–	1[31]	1	1	1
Seed Unit	–	–	–	–	–	–	–	1[23]	2[30]	2	2	2	2
Station Operations	1	1	1	1	1	1	1	1	1	1	1	1	1
Training Office	2	2	1	1	1	1	1	1	1	1	1	1	1
TOTAL	61	61	62	63	67	72	75	80	85	86	86	86	86

1982

1 Addition of one bean pathology position
2 Addition of one rice economics position
3 Addition of one forage agronomy position for humid tropics
4 Addition of one regional cooperation position for Asia
5 Addition of position for agroclimatology
6 Deletion of position for biochemistry

1983

7 Addition of position for virology
8 Addition of position for upland rice physiology/agronomy
9 Temporary deletion of one headquarters-based research position
10 Addition of one breeding position for sub-tropics
11 Addition of one pasture renovation/establishment position for humid tropics
12 Addition of one regional cooperation position for Eastern Africa
13 Addition of one position for land systems analysis

1984

14 Addition of regional cooperation position for Central America and Caribbean
15 Addition of regional cooperation position for Brazil
16 Addition of regional cooperation position for South Andean zone

1985

17 Addition of position for program coordinator
18 Addition of position for program coordinator
19 Deletion of one research position in the Cerrado
20 Addition of regional cooperation position for Central America and Caribbean
21 Addition of regional cooperation position for Cerrado
22 Addition of regional cooperation position for Central America and Caribbean
23 Addition of position for seed production specialist

1986

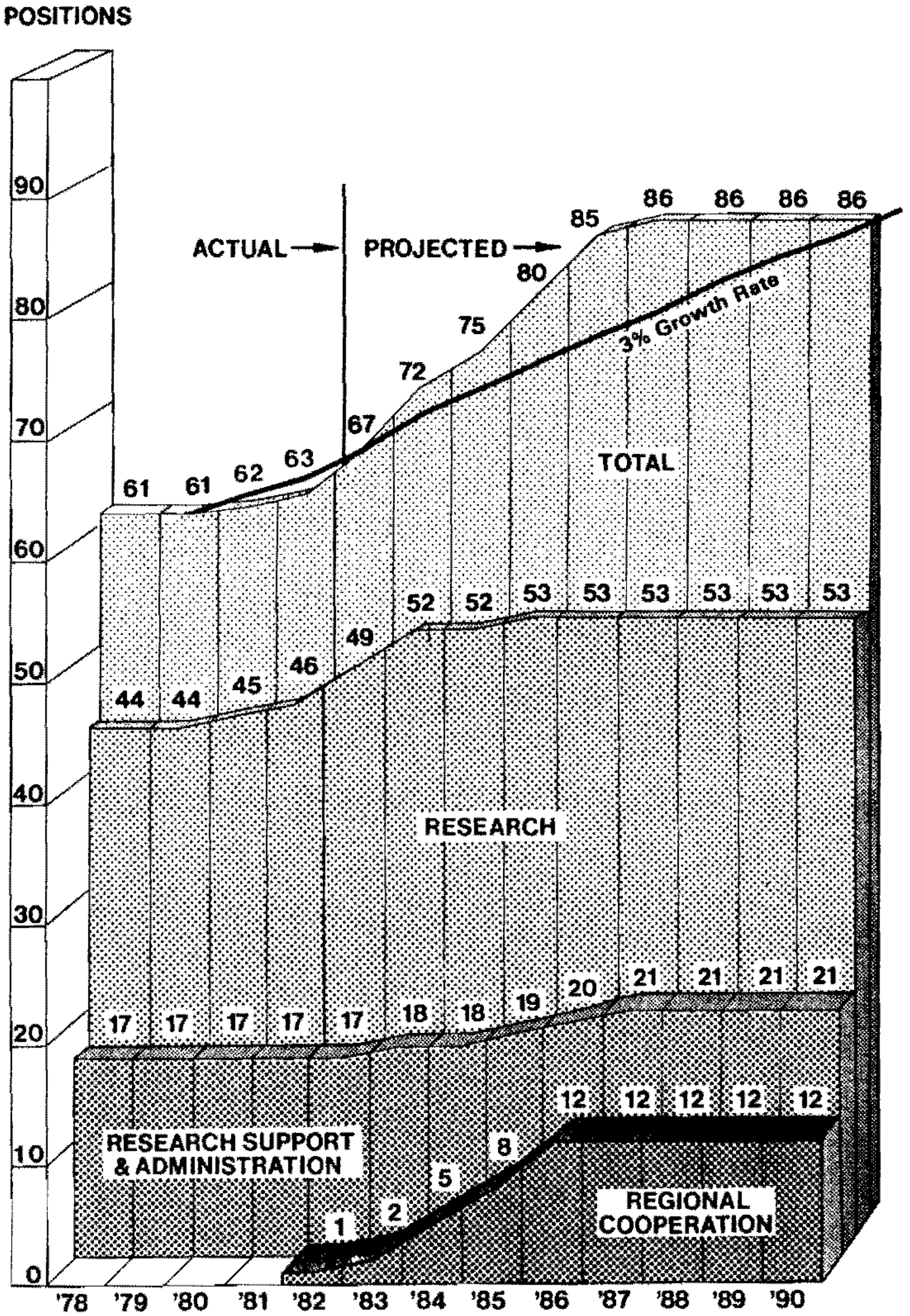
24 Reinstatement of headquarters-based research position temporarily deleted in 1983
25 Deletion of one research position in the Cerrado
26 Addition of one regional cooperation position for Middle East
27 Addition of one regional cooperation position for South Andean zone
28 Addition of regional cooperation position for Africa
29 Addition of regional cooperation position for sub-tropics of Latin America
30 Addition of one position for seed technologist

1987

31 Addition of position for the coordination of laboratory services

Figure 9.1

ACTUAL (1978-1981) AND PROJECTED (1982-1990) CORE-FINANCED SENIOR STAFF POSITIONS



APPENDICES

APPENDIX 1

Growth rates of the demand and supply of food in Latin American countries, 1966-1977

Country	Population[a]	Per Capita Income[a]	Food Demand: Income Elasticity[b]	Food Demand: Growth[c]	Total Food Production[d]	Food Production by Small Farmers[d,e]
Mexico	3.5	2.8	0.51	4.8	4.0	1.8
Caribbean	2.1	1.8	0.21	2.5	1.4	2.5
Costa Rica	3.0	2.9	0.51	4.5	4.6	3.6
El Salvador	3.3	1.8	0.62	4.4	3.9	4.3
Guatemala	2.5	2.8	0.53	4.0	5.0	3.2
Honduras	2.3	1.8	0.62	3.4	2.3	1.9
Nicaragua	2.7	3.5	0.76	4.4	3.9	3.8
Panama	3.1	3.8	0.52	4.1	3.4	2.1
Central America	2.8	2.8	0.46	4.1	3.9	3.1
Venezuela	2.9	2.2	0.40	3.8	4.6	2.2
Bolivia	2.8	2.7	0.47	4.1	2.4	2.0
Chile	1.9	0.6	0.44	2.2	2.8	2.2
Colombia	2.6	2.7	0.51	4.0	3.4	4.2
Ecuador	2.9	3.8	0.47	4.7	1.7	2.9
Peru	2.9	2.5	0.62	4.5	1.1	1.7
Andean Countries	2.6	2.1	0.49	3.5	2.6	2.8
Brazil	2.7	4.2	0.50	4.8	4.7	2.6
Argentina	1.3	2.5	0.27	2.0	2.3	0.8
Paraguay	2.8	2.1	0.47	3.8	3.7	2.2
Uruguay	0.6	0.4	0.37	0.7	0.1	3.3
River Plate Countries	1.3	1.9	0.30	1.9	2.2	1.6
Latin America	2.6	3.0	0.34	3.6	3.6	2.5

a/ 1960-1975.

b/ Estimated from the proportional weights of average consumption of vegetable and animal products and the FAO income elasticities of demand.

c/ Calculated as $d = p + Ey\ y$ where d is the rate of demand growth for food, p is the rate of population growth, Ey is the income elasticity of demand for food, and y is the rate of income growth.

d/ 1966-1977.

e/ The small farmer crops were defined by the USDA as maize (except in Argentina and Uruguay), rice (except in Colombia), potatoes, sweet potatoes, cassava and pulses.

Sources:
1966-70 data based on Economic Research Service, "Agriculture in the Americas: Statistical data", pp. 1-8. (10).
1971-77 data based on Economics, Statistics and Cooperatives Service, Indices of Agricultural Production for the Western Hemisphere, 1968-1977, (11).
The income elasticities of demand were estimated from Food and Agriculture Organization of the United Nations (FAO), (16).

APPENDIX 2

Nutrient availability and requirements: Daily per capita calories and grams of protein in mean national consumption, 1972

Country	Calories			Proteins		
	Availability	Requirements	Supply as a Percentage of Requirements	Availability	Requirements	Supply as a Percentage of Requirements
Mexico	2687	2330	115	65.6	38.1	172
Central America	2103	2280	92	55.0	35.6	154
Caribbean	2453	2280	108	55.9	35.6	157
Venezuela	2388	2430	98	62.6	36.7	171
Tropical South America[a]	2193	2420	91	52.4	38.0	138
Brazil	2537	2390	106	63.2	38.7	163
Southern Cone[b]	3113	2630	118	93.8	38.8	242

Source: Food and Agriculture Organization of the United Nations, Provisional Food Balance Sheets, 1972-74 Average, Rome, 1977.

a Bolivia, Colombia, Ecuador, Paraguay and Perú.

b Argentina, Chile, Uruguay.

APPENDIX 3

Estimated a percentages of the population consuming inadequate amounts of calories in various Latin American countries (1973)

Country	Below Minimun Caloric Levels (%)	Below 90% of Recommended Caloric Levels (%)
Honduras	60	50
Ecuador	70	61
El Salvador	72	61
Colombia	61	46
Dominican Republic	58	44
Guatemala	69	48
Brazil	45	31
Mexico	34	22
Jamaica	30	21
Perú	53	41
Costa Rica	34	20
Panama	51	38
Chile	33	10
Uruguay	33	20
Venezuela	56	47

Data are available from the Food Balance Sheets of FAO on mean caloric consumption and FAO/WHO have made estimates of caloric requirements. The distribution of the population by caloric consumption utilizes income distribution data and the functional relationship between calorie consumption and income.

Sources: S. Reutlinger and H. Alderman, The Prevalence of Calorie Deficient Diets in Developing Countries, World Bank Staff Working Paper No. 374, Washington, D.C., March 1980, pp 27 and 28; for further details see S.Reutlinger and M. Selowsky, Malnutrition and Poverty: Magnitude and Policy Options, World Bank Occasional Paper No. 23, John Hopkins, 1976.

APPENDIX 4

Sources of calories by individual foods:

Percent of total calories, 1972-74

Country	Sugar	Maize	Wheat	Rice	Cassava	Potatoes	Oils	Beans	Beef	Meat
Mexico	14.7	37.3	11.4	1.9	0.0	0.4	8.2	5.1	2.2	5.4
Central America	16.1	36.0	7.0	5.6	0.8	0.3	8.6	4.6	2.2	5.4
Caribbean	16.9	6.7	16.1	13.3	2.6	0.4	8.3	2.1	3.1	5.7
Venezuela	18.3	16.2	15.1	5.0	1.9	0.8	8.0	1.3	5.8	9.3
Tropical South America	18.3	12.5	11.0	9.9	4.0	5.3	8.4	1.1	3.6	5.6
Bolivia	12.7	16.8	19.2	4.9	4.3	10.3	6.9	0.7	3.7	6.9
Colombia	24.6	12.9	5.7	12.5	3.7	3.6	7.1	0.8	4.3	5.4
Ecuador	18.3	11.9	8.8	9.2	2.8	5.5	10.4	2.2	2.5	4.4
Peru	14.8	9.3	18.1	8.6	2.8	9.3	9.9	1.5	1.9	4.7
Paraguay	8.3	18.1	10.2	3.6	14.4	2.6	8.7	5.1	8.8	12.6
Brazil	17.1	9.2	10.7	15.5	9.4	0.8	7.9	7.6	4.3	6.7
Southern Cone	13.1	1.3	30.9	2.0	0.3	3.6	12.2	0.6	11.1	16.0
Argentina	12.9	1.1	27.2	1.7	0.4	4.6	12.2	0.3	13.4	17.9
Chile	13.3	1.7	42.9	2.4	-	3.7	9.2	1.8	3.9	6.2
Uruguay	12.3	2.2	27.2	3.5	-	3.9	8.7	0.2	14.3	20.4

Source: Food and Agriculture Organization of the United Nations, Provisional Food Balance Sheets, 1972-74, Rome, 1977.

Note: Since not all food commodities are included, the columns will not sum across to 100%.

APPENDIX 5

Sources of proteins by individual foods:

Percent of total protein supplies, 1972-74

Country	Maize	Wheat	Rice	Beans	Beef
Mexico	39.0	12.7	1.5	11.4	7.8
Central America	35.7	7.5	4.7	12.1	9.1
Caribbean	7.3	18.5	10.9	2.9	5.9
Venezuela	13.4	19.0	3.8	3.2	16.8
Tropical South America	10.3	13.2	8.4	2.8	11.5
Bolivia	16.6	21.7	3.7	1.7	10.6
Colombia	14.4	7.0	11.3	2.4	14.7
Ecuador	13.8	10.6	8.1	4.4	8.3
Peru	9.3	22.5	6.6	3.8	6.6
Paraguay	17.0	10.0	2.5	12.0	19.8
Brazil	8.2	11.4	12.2	20.1	13.8
Southern Cone	1.1	28.5	1.3	1.4	29.8
Argentina	0.8	23.3	1.2	0.6	34.4
Chile	1.6	43.6	1.8	4.1	8.3
Uruguay	1.6	23.1	2.3	0.5	28.9

Source: Food and Agriculture Organization of the United Nations, Provisional Food Balance Sheets, 1972-74, Rome, 1977.

Note: Since not all food commodities are included, the columns will not sum a cross to 100% .

APPENDIX 6

Food budget allocation by commodity group in ten Andean cities, 1967-69

City	Incomes Categories[a]	Beef	Milk	Chicken	Pork	Bread and Related Products (%)	Wheat	Rice	Corn	Potatoes and Similars	Dry Vegetables
Bogotá	0	11.3	10.2	0	0.1	9.6	0.8	5.7	2.6	10.9	1.5
	1	14.6	9.3	0.1	0.01	10.1	0.5	6.1	1.9	11.2	2.1
	2	15.2	9.9	0.2	0.4	9.9	0.5	5.6	2.0	8.8	1.7
	3	14.6	11.1	1.3	0.3	8.7	0.6	5.1	1.0	3.4	1.5
	4	12.7	10.8	3.0	1.3	7.8	0.3	2.3	1.0	3.4	1.5
Barranquilla	0	17.8	9.3	0.2	0.6	6.7	0.1	11.1	1.9	5.0	1.8
	1	17.3	10.1	0.4	1.0	6.3	0.1	10.3	1.6	4.2	2.0
	2	18.0	10.2	0.8	0.8	6.9	0.1	9.2	1.5	3.6	1.7
	3	19.1	10.8	2.7	0.8	6.9	0.1	7.5	1.4	3.0	1.9
	4	18.7	11.0	3.5	0.9	6.9	0.3	6.3	1.2	2.5	1.9
Cali	0	24.2	5.8	0.1	0.9	5.3	0.2	9.6	2.2	5.8	5.6
	1	21.5	8.1	0.6	0.5	6.1	0.2	8.6	2.0	5.1	4.6
	2	22.1	9.8	1.1	1.4	5.5	0.4	6.9	1.5	3.8	3.9
	3	21.0	12.3	1.6	2.4	6.4	0.2	5.5	1.1	3.3	3.0
	4	16.9	13.0	3.0	2.6	6.2	0.3	4.5	1.1	2.2	2.3
Medellín	0	21.1	9.5	0	0.3	3.9	1.8	7.0	6.3	6.0	6.8
	1	21.6	11.1	0.02	0.7	5.2	0.2	5.7	4.7	6.0	5.9
	2	21.2	10.6	0.3	2.5	5.4	0.3	5.1	4.4	4.7	5.3
	3	18.8	12.3	0.6	4.2	6.0	0.4	4.2	3.3	3.7	4.4
	4	15.0	13.4	2.5	6.3	6.9	0.6	2.8	2.0	2.6	2.7
Santiago	0	10.2	6.4	2.0	0.2	16.8	1.2	2.4	0.2	4.1	1.8
	1	9.8	7.8	2.4	0.6	15.7	1.4	2.1	2.3	4.2	1.9
	2	9.9	8.1	3.3	0.5	13.7	1.1	1.9	0.3	3.4	1.4
	3	9.3	8.7	4.5	0.7	12.1	1.0	1.7	0.2	2.9	1.3
	4	5.5	7.3	3.9	1.0	9.7	0.6	1.1	0.03	1.2	0.7
Quito	0	8.7	8.1	0.5	0.4	9.8	0.8	5.7	2.7	7.8	0.6
	1	12.9	10.6	0.07	0.4	12.2	0.7	7.2	1.9	7.4	0.5
	2	13.6	10.4	0.8	0.3	11.2	0.6	5.7	1.6	6.2	0.6
	3	15.7	13.3	2.0	0.7	10.9	0.5	5.5	0.9	4.3	0.7
	4	14.1	14.1	2.0	1.3	9.0	0.6	3.7	0.7	3.0	0.7
Guayaquil	0	14.0	6.0	0.5	0.2	8.0	0.4	13.9	1.1	3.3	1.6
	1	17.6	10.0	1.4	0.2	7.5	0.3	14.2	0.1	3.1	1.2
	2	18.1	11.8	2.0	0.3	7.1	0.3	12.4	0.2	2.8	1.9
	3	18.1	12.5	3.1	0.6	6.6	0.2	10.1	0.2	2.4	1.8
	4	15.7	12.7	4.9	1.1	6.0	0.3	6.3	0.2	1.9	1.5
Caracas	0	11.3	13.7	2.5	1.8	6.8	0.1	4.0	2.5	2.2	2.6
	1	11.3	13.8	3.4	2.1	6.4	0.1	3.3	0.1	2.6	3.1
	2	11.9	13.1	4.1	2.4	6.7	0.1	2.3	2.6	2.5	2.3
	3	11.5	13.3	4.4	2.4	6.8	0.1	2.2	1.6	2.1	1.8
	4	12.6	13.2	4.3	2.6	5.8	0.1	1.7	1.0	1.6	1.0
Maracaibo	0	9.0	17.8	3.4	1.3	7.8	0.1	4.1	4.0	1.6	1.7
	1	10.6	18.2	3.6	2.1	7.0	0.1	3.7	3.5	1.7	2.0
	2	11.3	17.4	5.0	1.5	7.0	0.1	3.4	3.0	1.7	1.7
	3	11.6	18.2	5.6	1.5	6.3	0.04	3.0	2.1	1.5	1.2
	4	11.9	18.4	7.9	2.6	6.6	0.1	2.4	1.6	1.8	1.7
Lima	0	22.8	10.5	2.8	0.3	8.4	0.2	5.8	1.2	3.7	0.5
	1	15.4	13.2	2.5	0.7	10.0	0.3	6.9	1.0	4.6	0.8
	2	17.3	12.3	4.7	0.4	9.2	0.1	6.9	0.8	4.2	1.0
	3	17.0	11.4	4.8	0.3	8.0	0.2	5.6	0.7	3.4	0.8
	4	17.5	11.9	4.1	0.4	6.6	0.2	4.2	0.7	2.5	0.5

a Family Income Category Code: 0: 0- 1025 (U.S. Dollars); 1: 1026-1652; 2: 1653-2759; 3: 2760-4866; 4: More than 4866.

Source: Survey data from the ECIEL-Brookings survey of consumption patterns in Latin American cities.

APPENDIX 7

Annual expenses (Cruzeiros) by food type for different income strata in the Northeast of Brazil, 1975

FOOD CATEGORIES	Less than 4.500	4.500-6.799	6.800-8.999	9.000-11.299	11.300-13.599	13.600-15.799	15.800-22.599	22.600-31.599	More than 31.599
	(Cruzeiros)								
Cereals and Derivatives	274	586	855	1.069	1.319	1.454	1.568	1.803	2.143
Rice	131	273	396	455	530	624	564	569	604
Corn	62	135	171	160	228	185	149	122	140
Wheat Products	77	168	275	430	530	618	802	1.019	1.209
Others	5	11	15	24	32	26	53	93	190
Tubers	260	413	489	467	523	544	438	460	442
Potato	1	3	5	11	16	24	38	67	133
Fresh Cassava	11	23	26	24	28	30	23	22	21
Cassava Flour	229	351	400	320	406	414	306	282	182
Other Tubers	19	36	58	62	72	77	70	88	106
Sugars	107	181	228	250	300	324	336	363	450
Legumes	314	493	557	565	663	587	525	458	435
Field Beans/Cowpeas	282	443	511	516	579	538	492	433	408
Other Legumes	32	50	46	49	54	49	33	25	27
Vegetables	47	106	152	183	231	271	329	457	703
Fruits	50	98	152	180	239	268	391	538	741
Meat and Fish	514	992	1.360	1.712	2.058	2.364	2.705	3.472	4.759
Beef	175	359	563	741	919	1.051	1.420	1.830	2.730
Pork	96	175	218	258	265	335	285	335	302
Chicken	50	114	181	234	306	331	395	540	742
Canned Meats	2	5	9	15	19	41	34	62	114
Fish	128	221	241	266	296	318	305	372	473
Others	63	117	148	199	252	288	267	333	396
Eggs	25	51	82	96	128	142	164	217	297
Milk and Cheese	78	183	284	366	497	522	582	824	1.235
Oils and Fats	49	119	175	234	304	366	392	563	806
Beverages	150	239	293	338	369	416	476	605	894
Food Outside the House	91	161	229	347	387	469	570	722	1.027
TOTAL FOOD EXPENSES	1.959	3.622	4.857	5.807	6.988	7.726	8.477	10.482	13.932
Food Expenses / Total Expenses . 100	64	64	61	57	54	52	44	38	17

Source: FIBGE, Estudo Nacional da Despesa Familiar, Despesas das Familias, Regiao V, Rio de Janeiro, 1978. p.82.

APPENDIX 8

Diet composition and nutrient cost to the consumer for calories in the Brazilian Northeast, 1975

Food Categories	Calories Per Adult Unit Per Day		Percentage of Calories (%)		Annual Cost to the Consumer of Maintaining Consumption of One Hundred Calories from Each Food[a] (Cruzeiros)	
Cereals and Derivatives	518		26.8		48	
Rice		242		12.5		42
Corn		108		5.6		35
Wheat Products		161		8.3		65
Others		7		0.4		114
Tubers	496		25.7		23	
Potato		2		0.1		250
Fresh Cassava		13		0.7		46
Cassava Flour		454		23.5		20
Others		27		1.4		52
Sugars	210		10.9		30	
Legumes	311		16.1		48	
Field Beans and Cowpeas[b]		280		14.5		44
Other Legumes		31		1.6		38
Vegetables	10		0.5		520	
Fruits	35		1.8		157	
Meat and Fish	179		9.3		246	
Beef		74		3.8		273
Pork		46		2.4		126
Chicken		13		0.7		462
Canned Meat		2		0.1		250
Fish		23		1.2		296
Others		21		1.1		224
Eggs	10		0.5		260	
Milk and Cheese	67		3.5		142	
Oils and Fats	84		4.4		74	
Beverages	10		0.5		900	
TOTAL	1.930		100		76	

a Calculated from the ENDEF data on annual expenditures per family by dividing these expentidures by an estimated 3.5 adult equivalents in the mean family of five and then dividing these expenditures by the number of calories per adult day. When multiplied by 100 these cost are the cruzeiro costs of obtaining 100 calories/day of each item during the entire year for one adult. Expenses on meals outside the house were not itemized; hence, they could not be categorized. However, they were only 5.7% of total food expenditures and would probably be biased towards the higher quality food and beverages hence, their omission would bias downward expenditure data on high quality foods and beverages but not substantially effect the comparisons of the low cost calorie staples. The calculation is made in the following manner:

$$\frac{\text{Expenses/Family-Year}}{\text{Adult Equivalent/Family}} \times \frac{1}{\dfrac{\text{Calories}}{\text{Adult Equivalent/Day}}} \times 100 = \frac{\text{Expenses/Year}}{\text{100 Calories/Day}}$$

b Cowpeas and field beans are given the same Portuguese word. Cowpeas predominate in Northeastern production but field beans are preferred by urban consumers. Consumption is probably about equally divided between the two in the Northeast.

Source: Calculated from Fundacao Instituto Brasileiro de Geografia e Estatistica (FIBGE), Estudo Nacional da Despesa Familiar, Despesas das Familias, Regiao V, Rio de Janeiro, 1978, p.82 and FIBGE, Estudo Nacional da Despesa Familiar, Consumo Alimentar Antropometria, Regiao V, Rio de Janeiro, 1978. p.21.

APPENDIX 9

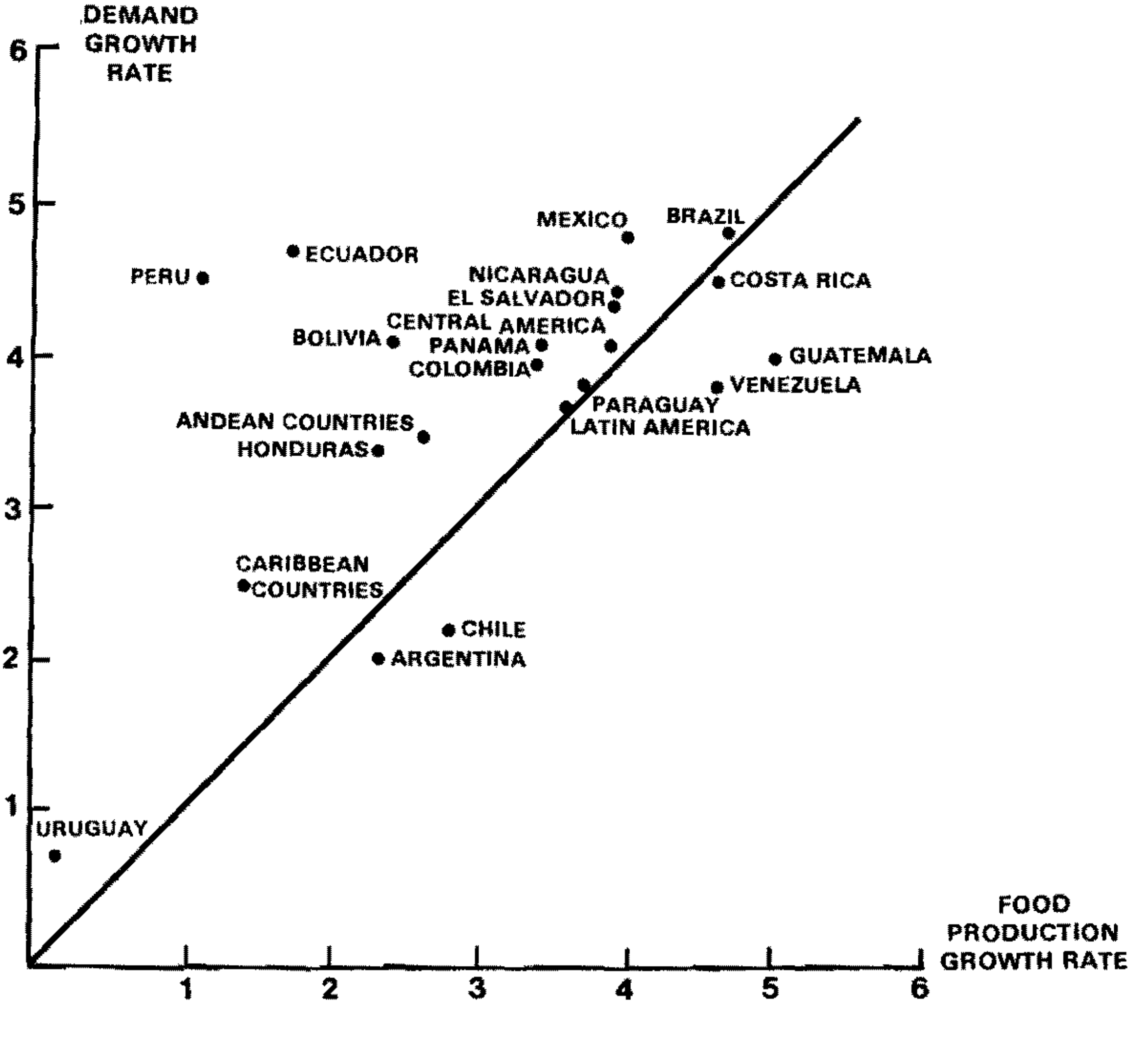
Diet composition, protein sources, and protein unit cost to the consumer in the Brazilian Northeast, 1975

Food Categories		Proteins Per Adult Unit Per Day (Grams)		Percentage of Proteins (%)		Annual Cost to the Consumer of Maintaining Consumption of One Production per Day from Each Food (Cruzeiros)	
Cereals and Derivatives		13.20		21.7		19	
	Rice		5.12		8.4		20
	Corn		2.81		4.6		14
	Wheat Products		5.10		8.4		20
	Others		0.17		0.3		49
Tubers		2.59		4.3		45	
	Potatoes		0.05		0.08		100
	Fresh Cassava		0.07		0.1		86
	Cassava Flour		2.11		3.5		43
	Others		0.36		0.6		39
Sugar		0.08		0.1		789	
Legumes		21.23		34.8		6	
	Cowpeas and Beans		19.09		31.3		6
	Other Legumes		2.14		3.5		6
Vegetables		0.40		0.7		130	
Fruits		0.51		0.8		107	
Meat and Fish		18.04		29.6		24	
	Beef		7.46		12.2		27
	Pork		1.69		2.8		34
	Chicken		2.23		3.7		26
	Canned Meats		0.13		0.2		38
	Fish		4.45		7.3		15
	Others		2.08		3.4		23
Eggs		0.79		1.3		32	
Milk and Cheese		3.43		5.6		28	
Oils and Fats		0.20		0.3		310	
Beverages		0.51		0.8		177	
TOTAL		60.98		100		24	

Source: FIBGE, Estudo Nacional da Despesa Familiar, Consumo Alimentar Antropometria, Regiao V, Rio de Janeiro, p.21 and FIBGE, Estudo Nacional da Despesa Familiar, Despesas das Familias, Regiao V, Rio de Janeiro, 1978. p. 82.

APPENDIX 10

GROWTH RATES OF DEMAND AND PRODUCTION OF FOOD IN THE LATIN AMERICAN COUNTRIES 1966 - 1977



APPENDIX 11

Agricultural research expenditures and expenditures on research as a percentage of the value of agricultural product, by region. 1965 to 1974

Region	Total annual expenditures (millions of 1971 constant US$)			Percentage of total research expenditures to value of agricultural product		
	1965	1971	1974	1965	1971	1974
Western Europe	407	671	733	1.4	2.0	2.2
Eastern Europe & USSR	627	818	861	1.5	1.7	1.8
North America & Oceania	806	1203	1289	1.9	2.6	2.7
Africa	114	139	141	1.3	1.4	1.4
Asia[1]	356	610	646	1.2	1.8	1.9
Latin America	73	146	170	0.6	1.1	1.2
Total	2383	3588	3841			

1 Excluding China

Source: Boyce, J. and R. Evenson (1975)

APPENDIX 12

Research and extension manpower resources relative to the value of agricultural product, 1951 to 1971

Region	"Quality Adjusted" scientist/man-years per 10 million dollars agricultural product			
	1951	1959	1965	1971
	------ in constant 1971 US Dollars -------			
Western Europe	0.85	0.94	0.89	0.91
Eastern Europe & USSR	0.22	0.39	0.70	0.86
North America & Oceania	0.91	1.90	1.17	1.10
Latin America	0.26	0.26	0.33	0.34
Africa	0.46	0.46	0.55	0.63
Asia[1]	0.56	0.69	0.84	0.92
	Extension workers per 10 million dollars agricultural product			
Western Europe	-	7.36	7.14	7.71
Eastern Europe & USSR	-	-	-	-
North America & Oceania	-	3.75	3.33	3.64
Latin America	-	3.24	4.29	9.05
Africa	-	29.46	53.16	63.89
Asia[1]	-	41.30	47.76	53.31

1 Excluding China

Source: Boyce and Evenson (1975), Table 1.6