CIAT is a nonprofit organization devoted to the agricultural and economic development of the lowland tropics. The government of Colombia provides support as a host country for CIAT and furnishes a 522-hectare site near Cali for CIAT's headquarters. In addition, the Colombian Foundation for Higher Education (FES) makes available to CIAT a 184-hectare substation in Quilichao and a 73-hectare substation near Popayán; the Colombian Rice Federation (FEDEARROZ) also makes available to CIAT a 30-hectare farm—Santa Rosa substation—near Villavicencio. CIAT co-manages with the Colombian Agricultural Institute (ICA) the 22,000-hectare Carimagua Research Center on the Colombian eastern plains and carries out collaborative work on several other ICA experimental stations in Colombia; similar work is done with national agricultural agencies in other Latin American countries.

CIAT is financed by a number of donors, most of which are represented in the Consultative Group on International Agricultural Research (CGIAR). During 1985 these CIAT donors include the governments of Australia, Belgium, Brazil, Canada, France, the Federal Republic of Germany, Italy, Japan, Mexico, the Netherlands, Norway, the People's Republic of China, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America. Organizations that are CIAT donors in 1985 include the European Economic Community (EEC), the Ford Foundation, the Inter-American Development Bank (IDB), the International Bank for Reconstruction and Development (IBRD), the International Development Research Centre (IDRC), the International Fund for Agricultural Development (IFAD), the Rockefeller Foundation; the United Nations Development Programme (UNDP), and the W. K. Kellogg Foundation.

Information and conclusions reported herein do not necessarily reflect the position of any of the aforementioned entities.

CIAT in the 1980s revisited

A medium-term plan for 1986 to 1990

Centro Internacional de Agricultura Tropical

CASSAVA PROGRAM

Introduction

Cassava is grown throughout the tropical areas of the world. In terms of production measured in grain equivalents, it is one of the most important crops in South America, Asia and Africa. In tropical South America it is of almost equal importance to rice and maize. In Asia cassava is—after rice, which is the dominant crop—among the most important crops grown in the tropical areas. In tropical Africa, cassava is the dominant food crop (Fig. 8).

Despite its importance in the developing world, cassava has received scant attention from national research agencies. Within the CGIAR system, however, cassava receives funding at a level commensurate with its importance in the developing world. It should be noted, however, that while many other crops have considerable backup research carried out by research organizations in developed countries, this does not occur in the case of cassava.

Characteristics of the Crop

Cassava is grown in a wide range of tropical environments, ranging from savanna and rain forest ecosystems through the highland tropics up to altitudes of about 2000 meters above sea level, and in subtropical areas with cool winters.

The cassava plant has certain inherent characteristics that make it well adapted for low-input agricultural systems under the more marginal conditions of the tropics. Research at CIAT has shown that the plant's direct stomatal response to air humidity leads to very high efficiency in the use of water and also allows it to conserve water during the dry season. This mechanism also allows the plant to survive under conditions of uncertain rainfall. Furthermore, under stress conditions, top growth is greatly reduced while the harvest index is increased. This characteristic leads to efficient use of limited resources such as nutrients and water. Mycorrhizal associations, which occur naturally, greatly increase phosphorus absorption on soils extremely low in this essential

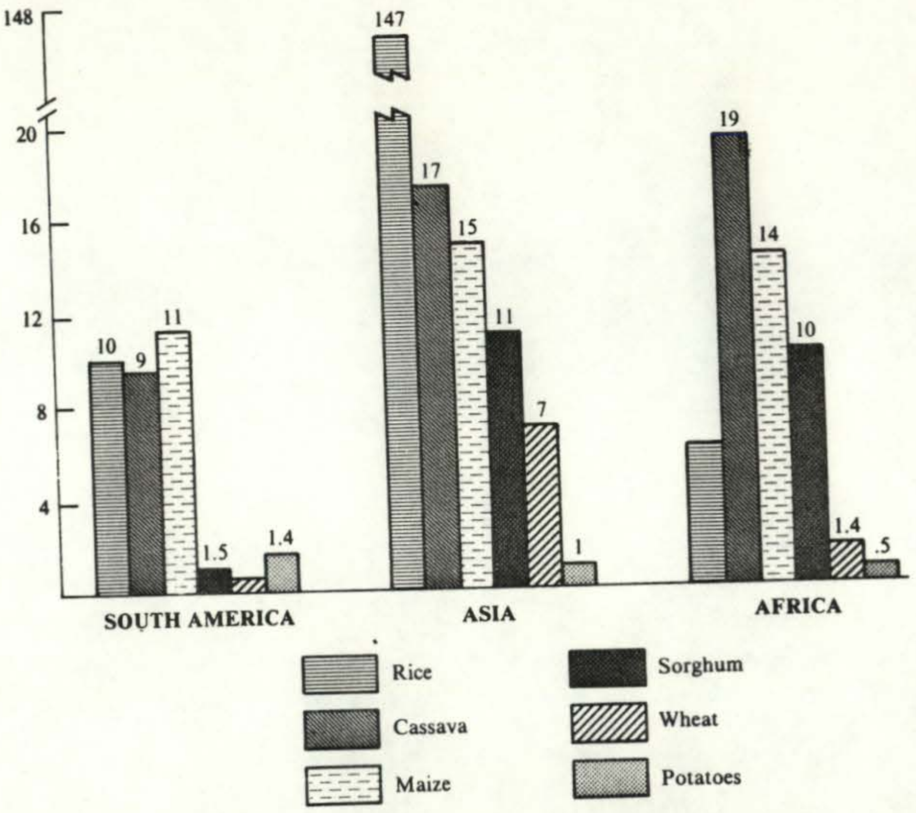

Figure 8. *Importance of various food crops in the tropics. (Data presented as millions of tons of grain equivalents).*

nutrient. In these soils, low pH and its associated high levels of aluminum are common. Cassava is naturally tolerant of such conditions. The continuous simultaneous growth of leaves and roots in the plant results in no critical periods, thereby giving the plant high levels of tolerance to sporadic pest attacks. This physiological tolerance to disease and pest attack is reinforced by high levels of stable resistance to diseases and pests in some clones. Where host plant resistance to pests has not been found, the long growth cycle of the crop has allowed effective use of biological control agents.

Another important characteristic of the plant is that the economically useful part—i.e., the roots—is not used as planting material for the subsequent crops. Thus when yields are low, farmers do not have to reduce their harvest further by keeping a large portion of the economic yield for planting material.

All these characteristics have made cassava an excellent crop for traditional agricultural systems where cassava is often associated with other crops, often under marginal agricultural conditions.The Brazilian situation is representative of most cassava-growing countries in terms of farm-size distribution.Data show that average farm size is highly skewed toward a small number of large farmers possessing most of the land. Rice and soybeans are produced mostly by the large-farm sector; whereas cassava is mostly produced by small farmers.

End Uses

In both Latin America and Asia, most cassava is used for human consumption, either as traditional dry cassava products or as fresh cassava. In Asia considerable amounts of cassava are processed for the production of starch; however, much of this starch is later used for making specialized foods. Of the cassava destined for human consumption, by far the greatest amount is for the lower income groups. Even in tropical Asia, where rice is the dominant crop, cassava makes a substantial contribution to the diets of the lowest income groups.

The final objective of any effort to increase crop production must be to ensure that this production is effectively utilized. In the case of a perishable root crop such as cassava, this factor is of paramount importance. In defining cassava research strategies, particular attention is given to a very important characteristic of the crop—its multiple end uses. The more important end uses are discussed briefly as each has implications for developing the overall research strategy.

Fresh Cassava for Foodstuffs

Fresh cassava is consumed throughout the lowland tropics. The basic premise of most commodity programs in the IARCs is that by improving yields, unit production costs can be decreased, not only allowing farmers to increase their income through the increase in total production but also giving consumers access to cheaper food supplies. In the case of dried cassava or cassava starch, this policy has a good chance of working because production costs are the major component of the total consumer price (Fig. 9). In the case of fresh cassava, however, production costs are only a small part of the total consumer price; hence the major constraint on achieving increased farmer incomes and lower consumer prices with fresh cassava is its high marketing margin. Nevertheless, a major question is whether consumers

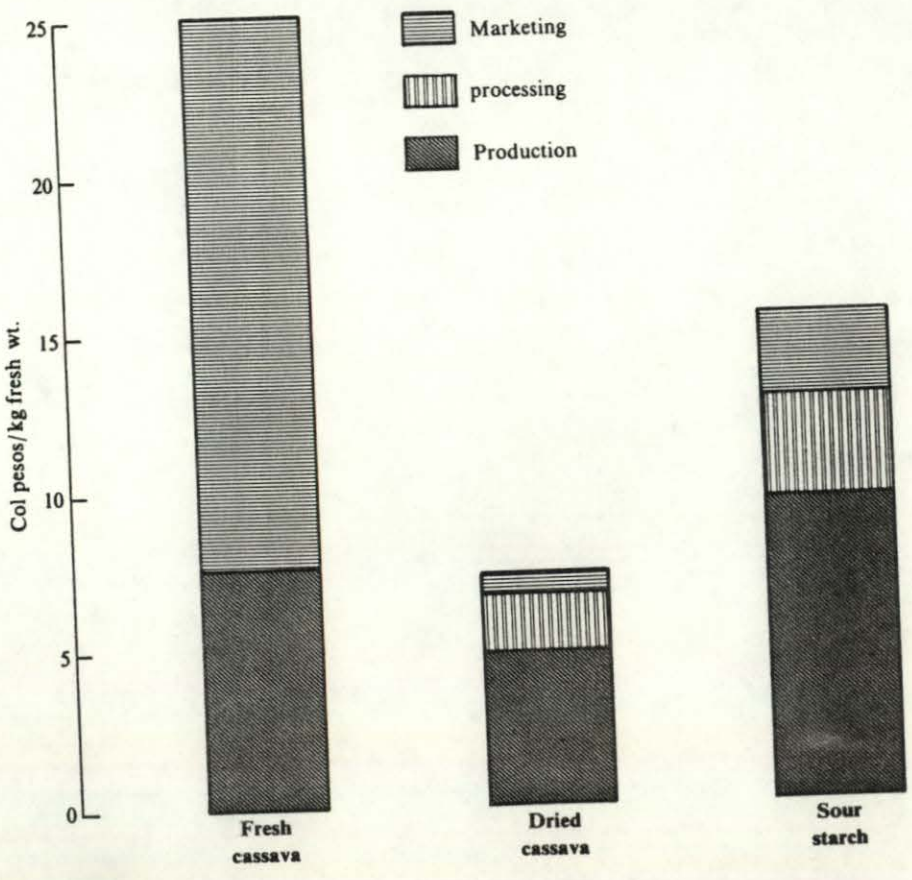

Figure 9. *Breakdown of consumer costs of cassava for different end markets.*

will purchase more cassava if marketing costs decrease and hence prices to the consumer decline. This question has been analyzed, and the data suggest that at least in urban areas, fresh cassava is reasonably elastic in its demand.

Cassava consumption tends to be lower in urban areas than in the rural areas. It could be hypothesized that as the developing countries urbanize, demand for fresh cassava might decrease. Consequently, aggregate demand might not be quite so elastic as it appears from consumer budget surveys. Why does consumption decrease in the cities? One reasonable hypothesis would be that as incomes increase, people prefer to purchase food other than fresh cassava. Nevertheless, recent data from Colombia indicate that this is not normally the case. A survey of consumer attitudes toward cassava and other crops on the North Coast of Colombia indicates that consumers find cassava equally as desirable or tasty as potatoes and rice (Table 8). In addition, the same proportion of consumers said they would buy more cassava if it were cheaper, as in the case of potatoes and rice. The large difference in preference is due to factors related to the convenience of cassava as a food. Cassava is highly perishable and therefore risky to buy.

Analysis of the data from the North Coast survey suggests that if the convenience factor score of cassava were increased to 50% of a crop such as yams, for example, then urban consumption would increase by 50%. Hence there is excellent potential for increased consumption if

Table 8. **Consumer attitudes to cassava and other starchy staples on the North Coast of Colombia (data presented as present positive responses).**

Question	Crop		
	Potato	Rice	Cassava
Is quality a risk?	13	3	76
Is it difficult to store?	17	1	95
Is product tasty?	66	55	67
If cheaper, would you buy more?	42	31	38

cassava were to become a more convenient food. CIAT has developed a simple technique that involves dipping cassava into a fungicide (Mertect) solution, followed by packing it in polyethylene bags. With this technique, the roots can be stored for periods of up to two weeks; and the quality of the stored cassava is virtually identical to that of the fresh roots directly after harvest. Moreover, fungicide residues are well below the accepted limits of the US Food and Drug Administration (FDA); and thiabendazole, the active ingredient of Mertect, is approved as a medicine. Thus a technology now exists which can easily change the convenience of cassava as a food.

Not only will this storage technology make it possible to increase the convenience of cassava as a food, thereby shifting the demand curve to the right, but it also has the potential to decrease marketing margins significantly. Marketing margins in cassava are high, partly because of the extreme risk involved in handling such a perishable crop and partly because of oligopolistic market structures for such a high-risk, low-volume commodity. If perishability is reduced and a storage element introduced, then the marketing margin can be decreased, which can be represented as a shift to the right of the supply curve. As a result, savings to the consumer and an increase in the farmers' gross income as a result of a more competitive market structure can be expected.[44] If this technology were adopted in Latin America, there could be very significant savings for consumers on the one hand and increased income to farmers on the other (Table 9). Similar benefits could be expected if this technology were adopted in Asia and Africa.

Table 9. **Expected benefits of adopting new cassava storage technology for consumers, producers and marketing intermediaries in Latin America and the Caribbean.**

	Million US$/year
Consumer savings	120
Farmers and intermediaries' income	80

[44] W. Janssen and C. Wheatly, 1985, Urban cassava markets:The impact of fresh root storage, Food Policy, August 1985.

Traditional Dry Cassava Products

The processing technology for these traditional products is generally rather effective. Demand is, however, inelastic and is expected to increase at about the same rate as population increases. As these are the products that are consumed mostly by the abjectly poor in the tropics, any decrease in price of fresh roots leading to a decrease in the price of the final product could have significant social benefits for the lowest income strata of the population.In this case, therefore, the research strategy is to concentrate on reducing the costs of the raw material—the fresh roots.

Innovative Dry Cassava Products

Dry cassava products can partially replace cereal flours (especially wheat) for human consumption. The demand for wheat products is highly elastic in most tropical areas. The major constraints on meeting this demand are the cost of the fresh roots, the cost of the drying systems, and the development of effective linkages between production and processing. The drying process is expensive because most of the systems that were developed for producing high-quality cassava flour for foodstuffs were developed at a time when fuel costs were relatively low. Increased fuel costs has meant that these systems are no longer economical. Even if new, more efficient drying systems were developed, it is still essential to have a cheap source of the raw material; i.e., the fresh roots.

The primary strategy for removing these constraints is once again to develop low-cost production technology systems and more cost-effective drying systems. Another major constraint to increased cassava use as a substitute for cereal flours is that many of the competing products are heavily subsidized. Research is required to give government policy makers the basis from which they can make decisions on subsidies and to inform them of the advantages, in terms of foreign exchange, that would result from the increased use of cassava as a cereal substitute.

The potential for cassava to enter these new markets is much greater now than a few years ago. This is due to the foreign exchange problems most of the countries of the developing world are encountering. The foreign exchange problem has, in fact, already had a major impact on certain government policies. For example, cassava production in Brazil increased rapidly during the sixties, during which time the relative price of cassava flour was about 60 percent of that for wheat flour. With plentiful foreign exchange because of easy international credit, the government of Brazil heavily subsidized wheat; subsidies are estimated to have reached levels of about 1 billion dollars in 1979.[45] As a result, wheat became only half as expensive to the consumer as cassava flour, which led to a dramatic decline in cassava production. More than 200 cassava flour plants in the state of Sao Paulo alone were closed because they could no longer compete. Brazil has now started to remove the subsidies on imported and locally produced wheats; similar situations are occurring in countries such as Ecuador and Peru. Thus the time has never been better to implement a program to produce cassava flour that partially substitutes for imported cereal flour.

Animal Feed. The demand for animal feed is highly elastic. The major constraints to cassava's playing a significant role in this market are the availability of roots at a competitive price and the integration of production, processing and marketing technology by small farmers so that they can enter into this growing market.

In the past much has been said about the potential for cassava to enter the animal feed market in the form of dried chips or pellets. The Thai cassava industry, for example, has grown on the basis of exports of pellets to the protected European Common Market; however, doubts have been expressed about cassava's ability to compete with grain crops on an equal basis in the tropics. The recent development of a viable commercial cassava drying industry that produces animal feed from cassava produced by small farmers in Colombia at highly competitive prices indicates that the potential to enter this market is a reality.

Program History and Accomplishments

Over the years the Cassava Program has contributed to the organized body of knowledge on cassava—its biology and behavior under different conditions, its role in production systems, and its different end uses. A summary of the major achievements follows:

[45] **A Review of Agricultural Policies in Brazil.** Report No. 3305, World Bank, 1981.

1. A file on production and consumption has been assembled from disparate sources; and after consistency checks, a systematic set of estimates of cassava production and utilization in Latin America and Asia was developed.

2. The principal characteristics of Latin American cassava production systems have been defined. Cassava is generally grown on small farms (10 ha or less) under some type of soil/climatic stress. Almost half the area planted to cassava is intercropped, primarily with maize. Few purchased inputs are used. Although much of rural consumption is based on subsistence production, about 70 percent of the production is marketed.

3. Identification of economic, biotic, soil, physiological and agronomic constraints to production and utilization have been identified.

4. The germplasm collection, which is the world's most extensive, has increased from 2500 to 3400 accessions. In vitro techniques have made it possible to incorporate Brazilian germplasm, previously prohibited from entry into Colombia by quarantine regulations. CIAT collaborates with the IBPGR and national programs to continue collections of both wild and cultivated species. The collection, traditionally maintained as a field collection that had to be continually regenerated, is now being transferred to in vitro culture for medium-term storage in the Genetic Resources Unit. In vitro techniques have also been developed to clean clonal material of pathogens such as frogskin disease.

5. More than 2500 clones from the germplasm bank have been evaluated for quality, agronomic characteristics, and disease and pest resistance in edapho-climatic zones (ECZ) 1, 2 and 4; as well as some 700 accessions for highland sites (ECZ 5) and germplasm for rain forest areas (ECZ 3). Arrangements have been made for Cuba to evaluate the entire collection in ECZ 6 over the rest of the decade. More than 40 hybrids and germplasm accessions, considered as elite materials adapted to the different ECZs are maintained in vitro for shipment to cooperating countries.

   These evaluations have shown that (a) there is extensive variability for all important agronomic traits; (b) yield potential of most accessions is low, manifested principally in the form of a low harvest index; (c) most individual clones are narrowly adapted to the conditions of the region where they evolved, although as a species cassava is adapted to a wide range of environmental conditions; and (d) levels of resistance to diseases and pests are generally inadequate for the intensive production systems envisioned for cassava in the future.

6. Prior to 1978 resistance to all major diseases was identified, and controlled screening methods were developed for several of them (cassava bacterial blight, superelongation disease, phoma leaf spot and anthracnosis). Since then the program has focused on the development of systems for screening for multiple-type resistance in the different ECZs where the program is working. Clones with this type of resistance have proven very stable (both in yield and resistance) during more than seven years of continuous field evaluations.

   Resistance to major pests such as mites (3 species), thrips, whiteflies, mealybugs and lacebugs is being sought. A pool of about 70 varieties with resistance to one or more pests has been formed.

7. Cassava is normally propagated through stem cuttings, limiting the rate of plants that can be multiplied yearly. Early in the history of the Program, a rapid propagation technique based on short top rooting in water was developed and has been used in Brazil, Cuba, Colombia, Mexico and the Philippines. Later the use of micropropagation techniques based on meristem culture have made it possible to increase the multiplication rate 40- to 80-fold per month. Another technique requiring less-sophisticated equipment is leafbud propagation.

8. A great deal of work has been done on cultural practices as well. The use of improved, low-input technology increased yields of local clones in Colombia to 20 t/ha (national average, 8.0 t/ha), illustrating the potential for CIAT technology to double yields at selected locations. On-farm validation trials have shown that small farmers can readily increase yields by 70 percent. The use of selected clones and hybrids in regional trials boosted yields as high as 30 t/ha.

Analysis of Production and Potential Demand

As a result of the ERP recommendations, CIAT has recently accelerated its studies of the potential demand for cassava in Latin America and the Caribbean in order to determine the future role of cassava in the agricultural economies of selected countries in Meso-America, the Andean countries, Brazil, Paraguay and the Caribbean. In addition to the direct economic factors, particular attention is being paid to social aspects including equity and creation of employment opportunities. These studies are based on the considerable body of information that has already been obtained. The Asian cassava situation has already been reviewed by CIAT, and the production and demand situation, analyzed.

Latin America

Cassava has always been a traditional caloric source in tropical Latin America. As the region urbanizes, the importance of cassava for direct human consumption depends on its market-ability and competitiveness with other caloric staples.

In contrast to the rural areas, fresh cassava is more expensive in most urban areas than the principal grain staples, primarily because marketing margins are as much as 300 percent of farm-level prices. Where cassava goes through a processing stage before marketing, as in Brazil, the dried product is generally the cheapest caloric source available in urban areas. Thus cassava is a major caloric source in national diets in Brazil, where most of the cassava is eaten in processed form; and in Paraguay, where most of the population is still rural. At the subnational level, cassava is important in regions such as the North Coast and Santander in Colombia, the jungle region of Peru, and many regions of the Caribbean. Contrary to the commonly held view in developed countries, cassava is not viewed by Latin American consumers as a nonpreferred food, only to be eaten in the absence of other alternatives.

A strategy to increase the incomes of small-scale farmers through the development of new cassava technology has been constrained by the limited demand for cassava as an urban food, except in Brazil, where other constraints have existed. As previously indicated, cassava, as a carbohydrate source with a low unit production cost, has the potential to enter alternative markets, as a wheat substitute (suitably enriched), as a carbohydrate source in feed concentrates, as the raw material in ethanol production, and as an industrial starch. Major expansion in demand in either the fresh urban market or the industrial markets depends on the relative price of cassava. Government policies aimed at cheap cereals for the urban population through subsidies on grain crops have had an adverse effect on cassava expansion. Because of the prevailing financial crisis throughout Latin America, these subsidies are being reduced; and this should have a significant positive effect on the future demand for cassava. Although there are a number of complex factors affecting cassava's ability to compete in industrial markets, the price of cassava must be reduced if it is to be competitive in industrial markets in most Latin American countries.

Lower unit production costs and thus cheaper prices for cassava can best be achieved by applying new technology. In Latin America and the Caribbean, cassava is mainly grown as a small farm crop. Major production zones include the poorer more acid soil areas, and irrigation is not normally available. About 40 percent of total production occurs in mixed cropping systems with maize, beans, cowpeas and a multitude of other crops. The technology used is generally labor intensive with very little use of inputs such as fertilizers, herbicides and pesticides. Yields average 12 t/ha (equivalent to approximately 3.5 t/ha of cereals in energy terms). Historically, there has been little research on the crop; thus there is great potential for increasing yields from their present low levels. On the other hand, introducing improved cassava production technology without complementary pro-cessing technology could satu-rate traditional markets, resulting in decreased farmer incomes. Introduction of cassava production technology in Latin America must definitely be linked to improved processing technology.

Southern and Eastern Asia

In 1984 CIAT and the United Nations ESCAP Regional Coordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops in Humid Tropics of Asia and the Pacific (ESCAP-CGPRT) organized a regional workshop to review the status of cassava in Asia and requirements for future development. The following discussion is based on that workshop.

Beyond the central role that rice plays in the food economies of tropical Asian countries, the agricultural sectors of these countries are very diverse. Cassava production and utilization systems have been adapted to this diversity. It is the differences rather than the similarities that are most striking when comparing utilization across countries. Cassava has developed within different types of land constraints, and multiple markets have evolved around the crop, with the particular market structure reflecting the overall development of the economy. The rate of development of most of these economies has accelerated over the past two decades, creating a potential demand for broadening both cassava production and utilization. The demand for cassava-based products in Asia is quite different from that in Latin America, being more buoyant. The crop has moved from being a basic traditional staple to fulfilling its role as an important basic source of energy in the form of carbohydrates.

Rapid development of the crop will depend, in most cases, on increases in yields, either to relieve land constraints or to be competitive in the emerging markets. Within the Asian context, where expansion of crop area is frequently constrained, it is natural that there should be a bias toward crops with high yield potential. Very high cassava productivity is already being achieved in certain areas; but average yields remain well below the known potential of the crop. What still remains to be determined is the means of achieving high yields across tropical Asia. Obviously, the type of technology will vary from country to country. This requires an increased commitment of national resources to develop the level of cassava research that is required in the region if these objectives are to be realized.

Given its adaptation to a wide range of upland conditions and its multiple use characteristics, cassava can provide substantial flexibility in developing appropriate agricultural policies. As has been stressed, the role of cassava in each country's economy will differ; but in each case, cassava can be the basis for meeting multiple-policy objectives. Increased cassava production with lowered costs will first be used for human consumption in fresh or dried form. In India and Indonesia, for example, cassava can play a clear role in nutrition policy. As this demand is satisfied, dried cassava may readily move into both local and international animal feed markets; the former are increasing so rapidly at present that they can only be satisfied by increased imports of cereal grains.

Because of its multiple-market potential, cassava can play a major role as a source of income generation for small-scale farmers in upland areas in all countries in the region, including India and Indonesia. Increased production will also bring socioeconomic benefits to rural areas. The level of labor used in cassava cultivation varies widely, with very intensive labor use in southern India and Indonesia. For every two hectares of cassava planted, one more person gains the equivalent of full employment for one year. Moreover, cassava processing is highly labor intensive and uses equipment that can readily be manufactured by local craftsmen; thus processing will create employment and stimulate local industry. In Thailand, for example, it has been estimated that 8 to 10 million people are receiving direct or indirect benefits from the rapid expansion of the Thai cassava industry. A further advantage in satisfying growing domestic markets by increased domestic production is the positive impact on a country's balance of payments. Further market diversification of cassava will, however, require both improved production and appropriate processing technologies, together with better integrated markets.

The Green Revolution that swept Asia in the late sixties and seventies was limited to irrigated areas. Expansion of irrigated areas is costly and, in many cases, difficult to accomplish in the near future. The next major challenge is to raise crop productivity and farmer incomes in the upland areas. With probably limited prospects for further major growth in the world demand for rubber, palm oil and coconut oil; with growing domestic markets that could absorb cassava products; and with a growing regional market for carbohydrate sources for livestock, cassava is a major, if not **the** major crop in a position to foster income growth in the upland areas of tropical Asia.

Sub-Saharan Africa

Although Africa has slightly more than half the world's area planted to cassava, it produces only 37 percent of the world crop. Yields tend to be low, ranging from 5 to 9 t/ha in the four major producing countries—Zaire, Nigeria, Tanzania and Mozambique. However, as there are more than 7 million hectares planted to cassava, total production is close to 50 million tons.

In Africa the only important end use of cassava is for human consumption. Cassava provides an average of 230 calories per person per day. Levels of consumption in Zaire and the Congo are much higher—more than 1000 calories per day; i.e., about 55 percent of total caloric intake. In areas where rainfall is uncertain and/or locust attacks are common, cassava is extremely important as a famine relief crop. Of the cassava destined for human consumption, a little more than half is consumed after processing into such products as gari and fufu; the rest is consumed in fresh form.

The importance of cassava in Africa as a basic food staple is unquestionable, but the future demand situation as the continent develops has yet to be studied carefully. Although normally considered a subsistence crop, cassava can be found in both rural and urban markets throughout tropical Africa. Although it is impossible to make an accurate estimate of how much cassava is traded and how much is consumed by the growers themselves, it is certain that a significant proportion of African production enters the market economy; and this amount will likely increase as Africa urbanizes. Because of the very high rates of population increase, demand will surely increase over the coming years.

At present, production technology is largely based on traditional low-input agricultural systems. As bush fallow periods are shortened, cassava has become more popular because of its ability to fit into these systems. However, recent problems with cassava bacterial blight, mealybugs and green spidermites in Africa suggest that a substantial research effort is required just to maintain present low levels of production, let alone increase them.

Program Objectives and Strategies in the Eighties

At the beginning of the sixties, the role of the IARCs was considered to be that of providing technology based on improved varieties for almost direct application to farmers' fields. This strategy was highly successful in the case of irrigated wheat (CIMMYT) and rice (IRRI), grown under relatively homogeneous conditions with heavy use of inputs to overcome specific local constraints. In the case of small farmer crops grown under marginal conditions with a wide range of different ecologies, this strategy is unlikely to succeed because much of the technology requires adaptation for location-specific conditions, and varieties must be selected with tolerance to these constraints. As a result, the IARCs involved with small farm crops grown under difficult conditions have evolved a strategy in which they form an essential integral part of a global network dedicated to crop improvement.

Program Objectives

> The overall goal of the cassava network is to increase small farmers' food supplies and income, as well as to improve food availability for the overall population. This can be achieved by converting cassava from being mainly a traditional rural staple to a major multiuse carbohydrate source.

In order to accomplish these goals, it is necessary to look at the overall research and development network and the roles of its various components based on the comparative advantages of the centers forming the network vis-a-vis the different fields of research. CIAT is the international center with global responsibility for cassava and has comparative advantages in the following areas: (a) documentation and information, (b) germplasm, (c) establishment of basic principles of improved production/ utilization systems, (d) research directed toward a better understanding of the crop, (e) analyses of the future role of cassava, and (f) training and conferences. CIAT as the regional center for cassava in Latin America and Asia has a comparative advantage in (a) coordination of the regional network, (b) training on a regional basis, (c) resolution of problems related to the peculiar socioeconomic context of the regions, and (d) development and distribution of germplasm with the characteristics appropriate to the region. The national centers in turn have comparative advantages in the following areas: (a) identification of location-specific problems; (b) establishing and recommending production practices and utilization technology; (c) testing, selection, multiplication and release of varieties suitable for local conditions; (d) implementation of development projects; and (e) transfer of technology to users.

It should be noted that new approaches to development, new scientific discoveries, and other innovations of potential importance on a global

scale may be developed by national, regional or international centers. The national centers will oftentimes be the most important sources of such information; thus the comparative advantage of disseminating it on a national scale will lie within the national programs. On a global scale, however, dissemination can be more effectively carried out by international centers.

The CIAT cassava program has two main components or functions: firstly that of an international center with global responsibilities and secondly that of a center with regional responsibilities in Asia and Latin America and the Caribbean. In Asia the regional activities are closely interwoven with the CGPRT Centre, which has a comparative advantage in the socioeconomic aspects specific to Asian agriculture. IITA is also an international center, but its function in the case of cassava is that of a regional center, serving the vastly important needs of Africa. CIAT's objectives and strategies, first as a global center and secondly as a regional center, are outlined below.

Global Strategies

In its global capacity, the Cassava Program will provide the following major inputs into the overall research and development efforts of the network:

1. Maintenance of the world cassava germplasm collection, and from this base, the provision of elite gene pools with known characteristics to regional and national programs; coupled with this effort will be the development of improved breeding methodology.
2. Development of the basic principles for establishing improved production and utilization systems, together with the research methodology required to adapt such systems to local conditions.
3. Carrying out of basic research directed to understanding the crop and its interaction with environmental stresses better.
4. Analysis of the future potential role of cassava in the economy of the developing world.
5. Provision of services based on the world's cassava documentation and information center.

6. Organization of training opportunities and meetings for cassava workers from national and regional programs.

The following basic activities outline the program's projected plans to fulfill its global mandate.

The Role of Cassava in the Economies of the Developing World

The economics section has carefully analyzed the status quo of cassava production and utilization in the Americas and Asia. From this base the future role of cassava is and will continue to be analyzed in the light of new production and utilization technology. Careful attention will be paid to how cassava can contribute to countries' meeting social goals such as increased employment and equity, as well as economic goals such as foreign exchange savings.

In order to achieve these goals, the economics section will collect, collate and analyze secondary data on cassava production and utilization at a global level. Where data are lacking or totally deficient, primary data will be collected on a limited scale. The main constraints to cassava productivity will also be studied in order to understand the economic factors affecting the viability of integrated production, processing and marketing programs utilizing dried cassava for the feed industry and composite flours and fresh root storage systems.

In addition the economics section will make both an **ex ante** and **ex post** analysis of the socioeconomic benefits of investment in cassava research. The former will include the development and use of simulation models, and the latter will be based on monitoring the diffusion of cassava production and utilization technologies.

Basic Understanding of the Crop

In order to improve production, a basic understanding of the plant and its reaction to various stress factors is required. Because of budgetary restrictions, however, the plant physiology section was suspended for two reasons: (a) Great advances have already been made in the field of cassava physiology, and (b) it is an activity in which continuity of effort is not essential. It is proposed that this section be reinstated in 1988 in

order to continue research to define the optimal varietal characteristics for different water regimes, screen for tolerance to long days (photoperiod response), define plant types for differing soil fertility levels, and develop techniques for synchronous flowering in crossing blocks. It should be noted that although this type of research will not give immediate payoff, over the long term it is essential for the program.

Germplasm Development

The ultimate objective of germplasm efforts is the adoption of new varieties by farmers as part of the technology package to increase productivity and improve the quality of cassava. The fundamental base for germplasm improvement is the world cassava germplasm bank, which now contains 3,700 accessions and should reach a level of approximately 5,000 by 1990. The germplasm bank is evaluated, catalogued and maintained by CIAT. The information on the bank is available to national programs, which can request and receive clones directly from the bank or sexual seed from specified crosses (national quarantine regulations permitting and when it is considered safe to transfer material).

The new production technology for cassava exploits the crop's productivity under marginal conditions with low inputs. This precludes using high levels of expensive, energy-consuming inputs such as pesticides, soil amendments and irrigation. Rather, new technology is based on improved germplasm, which by itself overcomes many of the production constraints. Germplasm improvement is directed toward obtaining elite gene pools for each of the major ecosystems in which cassava is grown (Table 10). These gene pools form the basic materials the national programs can use for direct selection of new varieties or for their own crossing programs.

At present major emphasis is placed on ECZs 1 and 2; in coming years, however, more effort will be devoted to ECZs 3, 5 and 6, and to providing elite germplasm to African programs through IITA. The breeding scheme involves observation of genetic material in each of the ecosystems, selection of parental materials with desirable characteristics, hybridization at headquarters, and evaluation of the progeny in the particular ecosystems to which the crosses are directed. As national programs have developed, emphasis has moved away from providing them with a small number of superior clones toward sending large numbers of sexual seeds from crosses directed toward combining the characteristics desired by the individual programs.

The germplasm development section will continue cooperating with the IBPGR in the selective collection and introduction of new germplasm.

Table 10. **Ecosystems for cassava production and their main characteristics.**

General description	Mean temperature (°C)	Dry season duration (months)	Annual rainfall (mm)
Lowland tropics with long dry season; low to moderate rainfall; high year-round temperature	above 22	3-6	700-2000 (unimodal distribution[a])
Lowland tropics with moderate to high rainfall; savanna vegetation on infertile, acid soils; moderate to long dry season; low relative humidity during dry season	above 22	3-6	2000 (unimodal distribution)
Lowland tropics with no pronounced dry seasons; high rainfall; constant high relative humidity.	above 22	absent or very short	2500 (unimodal distribution)
Medium altitude tropics; moderate dry season and temperature	20-24	3-4	1000-2000 (bimodal distribution[b])
Cool highland areas; moderate to high rainfall	17-20	variable	2000
Subtropical areas; cool winters; fluctuating day lengths	min. 0	variable	variable (unimodal distribution)

a Unimodal distribution: one wet season and one dry season each year.

b Bimodal: two wet and two dry seasons.

Special emphasis will be placed on collection in ecosystems poorly represented in the germplasm bank. Evaluation of the germplasm will be expanded to the hot humid lowland tropics and the subtropical regions. Clones with desirable characteristics for each ecosystem will be crossed, the progeny tested in each of the major ecosystems, and elite germplasm pools developed. Selection of clones for ECZs 1 through 5 will continue in Colombia, and these clones will be distributed as advanced lines to the national programs. In the case of ECZ 6, crosses will be made at CIAT; however, the breeder in charge of this ecosystem will be specifically responsible for ensuring adequate testing of progeny and feedback on performance in testing sites such as southern Brazil. Local junior support staff will be hired to maintain the trials. The results of this work will be used to improve the germplasm sent to similar regions in other countries.

In Asia the breeder in the regional program will continue to assist national programs in selection and ensure that they receive appropriate materials from the germplasm development section at CIAT.

The introduction of AMD-resistant materials from IITA will make it possible for CIAT to provide elite germplasm for Africa. Particular attention will be paid to combining AMD resistance with mite and mealybug resistance.

Germplasm development at headquarters will comprise one senior staff position, pending the results of the demand studies. During this period breeding efforts will be largely limited to ECZs 1 and 2, with reduced efforts in ECZs 3 and 5. If the results of the demand studies are positive, the section will be increased to two senior staff positions in order to cover the full range of conditions under which cassava is grown. One scientist will be responsible for germplasm collection, maintenance and materials for ECZs 4, 5 and 6, as well as materials suitable for AMD areas (Africa and India); the other for ECZs 1, 2 and 3 and provision of crosses for the Southern and Eastern Asian region.

Major problems in a vegetatively propagated crop such as cassava are associated with germplasm storage and production of disease-free stock. The tissue culture section of the Germplasm Resources Unit has developed methods for cheap storage of germplasm as plantlets in test tubes and for producing planting stocks from meristems. These procedures will be used on a routine basis. Attention will be given to using tissue culture techniques for haploid production, protoplast fusion and, eventually, genetic engineering in support of varietal improvement, with special emphasis on production of HCN-free clones.

Production Systems

Improved germplasm is not, however, a panacea. The rate of progress in a breeding program is roughly inversely proportional to the number of breeding objectives. Hence, if progress is to be made within a reasonable time, breeding must be used only to resolve major problems. Control of the many pathogens that attack planting material should not be resolved through varietal resistance, but rather by using inexpensive chemical protectants. Moreover, some problems cannot be solved by breeding. For example, varietal resistance to the cassava hornworm has not been found, but effective biological control methods have been developed. Improved management practices of general applicability will also be developed.

Past emphasis on development of management practices has concentrated on a single crop of cassava. In the future, emphasis will be placed on how cassava fits into longer term agricultural production systems. Special attention will be paid to the long-term effects of cropping patterns and fertilizer use on productivity and on methods of erosion control and soil conservation.

Research on soil/plant nutrition in cassava will emphasize areas such as the screening of clones for adaptation to low soil fertility, elucidation of mechanisms for this adaptation, and the maintenance of soil fertility including the problem of erosion and its control. Particular attention will be paid to developing an overall understanding of how fertility can be maintained by modifying cropping systems. Mycorrhizal research will continue to be integrated into all these activities with support from extracore sources when appropriate. The overall objective of the section is to develop principles that can be extrapolated to other ecosystems, rather than to concentrate on more site-specific research.

Entomological research on pest control in the crop has concentrated on mechanisms of host plant resistance and biological control. The serious

pest problem in cassava worldwide, the difficulties related to chemical control in a long-season crop, and the fact that Latin America is the center of origin of many of the pests are all factors that determine that CIAT must continue to show leadership in this area. Work of the section will concentrate on developing integrated control of major pest complexes (particularly mites and mealybugs, which are very serious pests in Africa); assessment of new pest problems that could be faced in new areas where cassava production may expand; collection and evaluation of natural enemies, and development of rearing techniques; and the evaluation of host-plant resistance. A collaborative project with IITA is under way to advance aspects of identifying and collecting natural enemies in the Latin American region.

Plant pathology research has concentrated on fungal and bacterial diseases. More recently, work on virus diseases is being emphasized. Pathological research will concentrate on the development of new cultivars (in collaboration with the breeders) and cultural practices that prevent the commonly observed degeneration of cassava varieties under high disease pressure when grown over a series of years at the same location. Specifically, activities in the pathology section will continue to describe the diseases of cassava, the pathogens and their vectors; to study climatic and edaphic factors influencing disease development; to identify genetic sources of stable resistance; to develop techniques for the production and testing of pathogen-free planting materials; and to develop methods for providing high-quality vegetative and seed material for international germplasm exchange.

Recent CIAT studies indicate that yield losses from viruses are significant in some production zones. One of the new diseases, tentatively identified as being of viral origin, is capable of causing complete crop failure. In addition, Latin American material is generally not resistant to AMD, which has not yet appeared in the Americas. Thus additional support for virology within the Biotechnology Research Unit has been projected for 1986 in order to deal with viral problems, which are relatively unresearched in cassava. It is likely that viral pathogens are transmitted continuously through cassava planting material. Research on viruses at CIAT is necessary to detect, identify and isolate pathogens in vegetative material. This research is particularly important for phytosanitary control in moving material across international boundaries and in producing disease-free seed within countries. Resistance to viral diseases through breeding will also be emphasized if other control methods prove unsatisfactory.

Utilization Technologies

A large market exists for low-cost carbohydrate sources.CIAT will concentrate on utilization research contributing to expanded demand for cassava products destined for human consumption, either directly or indirectly. Several other institutes or private agencies are involved in processing research for starch or ethanol production and the use of cassava as a substrate for single-cell protein production; thus CIAT will not duplicate their efforts. CIAT will, however, produce state-of-the-art bulletins on a wide range of utilization technologies through its utilization and documentation sections even though it is not engaged in active research in these areas.

Cassava's high perishability and lack of alternative outlets unless it is processed can lead to rapid saturation of markets and sharp farm price decreases as production increases. This often results in very low prices in one area of a country, while prices are high and demand is not satisfied elsewhere. Consequently, farmers are often unwilling to increase productivity or area planted. Improved technology that permits arbitrage or the entry of cassava into more stable markets will produce a more stable floor price, thereby breaking the vicious circle. The objective of the utilization section is to develop such technology for the following products:

1. **Fresh cassava.** Initial work has shown that simple techniques for fresh storage can be developed. Efforts will concentrate on developing this technology for commercial use, which will allow expansion of the urban market through reduced prices and improved quality and convenience of the fresh roots at the consumer level. Studies on factors affecting root quality parameters will be initiated.

2. **Cassava flour.** Cassava is used widely in a variety of flours made by traditional processes. The potential increased demand for this type of product is limited to the lowest income sectors who will be the greatest beneficiaries of improved technology. On the other hand, there is a great demand for cassava flour as a partial substitute for wheat flour in bakery products across all income groups. High-quality flours can be produced at present; however, the drying processes are capital intensive and tend to consume large amounts of energy. The program will develop solar-assisted and other drying systems that will ensure a high-quality product at a lower cost more suitable to the supply and socioeconomic conditions prevailing in the cassava-producing regions. The program will also collaborate with other agencies on the development of new products based upon high-quality cassava flour.

3. **Animal feed.** Potential demand for cassava in animal feed concentrates is great; however, there are several important limitations that make it difficult to enter this market: (a) the high price of fresh roots in certain regions; (b) lack of drying systems suitable for high-humidity areas; (c) lack of information on the economics of drying cassava; and, (d) lack of information on animal performance at high levels of cassava intake. The program's production research continues to concentrate on reducing unit production cost, and the utilization section will emphasize research to remove the remaining constraints through collaborative projects with national or other agencies.

Documentation and Information

The successful establishment of a complex network involving a large number of different entities requires an effective means of information exchange among the diverse agencies comprising the network. This allows effective transfer of new technology and methodologies and greatly reduces duplication of effort. The fundamental keystone of the network is the documentation center, which is the information bank. Its role can perhaps be compared to that of the germplasm bank in varietal improvement.

The Cassava Documentation Center at present has more than 7,000 documents related to cassava. Abstracts of this material are distributed to cassava workers, either free or at cost, depending upon the users' ability to pay for the service. In addition literature searches are provided upon request to users of the service. The center is also involved in the packaging of information. Recently a comprehensive practical book on the use of cassava in animal feed was commissioned; in those cases where the expertise exists within the Cassava Program, the staff produces monographs and bulletins that synthesize the knowledge available on themes such as intercropping or field problems of cassava. Not all the information produced by the program or other agencies is published by CIAT; for example, CIAT staff contributes articles to scientific journals, books and magazines.

For effective dissemination of information, it is not only necessary to package the information but also to ensure that it reaches those who can use it effectively. The recently established computerized profile of individual cassava workers makes it possible to distribute the information on an individualized basis, so that they receive information tailored to their own specific interests and requirements.

It is crucial to maintain cassava workers informed of the latest advances and concepts if a research and development network is to be effective. Although the aforementioned publications and services can partially achieve this objective, there is always considerable delay in information exchange. Through the cassava newsletter, which describes ongoing research and development projects as well as providing a forum for new ideas, delays are kept to a minimum.

The Cassava Program, through the Communication and Information Support Unit, will continue to provide the services outlined above.

CIAT's Regional Responsibilities

Latin America and the Caribbean

When the CIAT Cassava Program initiated activities, national cassava programs in the region were essentially nonexistent; at the most they were comprised of one or two professionals within the root and tuber program. In subsequent years several strong national programs have been established, and close links with CIAT have been formed. Most of these programs have a strong bias towards agronomy and varietal improvement and are weak in the areas of marketing and utilization. Nevertheless, as has clearly been pointed out, cassava production technology must be linked to improved processing and marketing.

CIAT will continue to assist national programs in the development of production technology through provision of appropriate germplasm, training, dissemination of research findings and advisory visits. Particular attention will be paid to assisting national programs in the selection of improved varieties by accompanying national program scientists in the selection process. This will not only facilitate the breeding process but will also provide valuable feedback for the CIAT breeding program.

The proposal to define a research group that would work within the Cassava Program on the integration of research in production, utilization, and marketing in cassava is based on the recognition that any approach without all three elements will not be functional, at least in the Latin American context. The group would work with national programs in the development of pilot projects, which requires a close linkage between research and development activities if such projects are to be viable. Failures in the past in several cassava projects have been associated with lack of attention to one or more of the above facets.

In collaboration with the national programs, this group would concentrate on the following overall activities: (a) macroeconomic analysis of cassava's potential in the particular country/project; (b) planning and organization of project structure; (c) establishment of projects and development of local adaptative research; (d) economic analysis of the pilot projects, and (e) policy recommendations on commercialization when requested by governments. The activities of each specialist in the proposed group can be summarized as follows:

The economics section will continue to evaluate potential demand for cassava products and the price at which they could enter the market, and estimate the costs of production and processing in each project. From the results of the pilot project, the economist will estimate the feasibility of moving to a commercial phase and in developing generalized methodologies for the implementation of integrated production-processing-marketing projects in cassava. The economist will also be responsible for coordinating the demand studies in Latin America, which will be carried out by postdoctoral fellows over a two-year period (1985-1986).

The agronomy section will evaluate the production potential of different regions, recommend and evaluate (with the national program scientists) cultural practices and cultivars, and integrate new production technology for cassava into local cropping systems. The agronomist will be heavily involved in training of national program staff.

The two headquarters breeders will also devote approximately one third of their time to assisting national programs in the selection of new varieties.

The utilization section will collaborate with the pilot projects in the establishment of processing plants and in on-site research to improve processing systems in the pilot projects, and work with the economist in the evaluation of the economic viability of different processing systems in each situation.

Meso-America and the Caribbean at present are not important cassava-producing areas although many of the countries are classified as calorie deficient. National cassava programs are now being developed and require considerable assistance in planning and training during their formative years. For many years these areas will depend directly on CIAT-developed germplasm; in most cases they will require finished varieties rather than sexual seed, or a large number of populations for selection. An outposted regional cooperation scientist is projected for 1987 to provide support to national agencies in the region. In the interim, a special effort will be made to obtain special project funding for this position.

Sub-Saharan Africa

Approximately 40 percent of the world's cassava is produced in Africa. Because of the great importance of cassava in tropical Africa, IITA has a strong root crops program which devotes most of its resources to improving cassava production on that continent. Recently, IITA and CIAT signed an agreement on cooperation so as to fulfill the needs of Africa better. This agreement recognizes CIAT's global mandate and responsibility for collecting and maintaining germplasm, the world cassava documentation and information service, and the cassava newsletter. Furthermore, IITA's regional responsibility in Africa and CIAT's in the Americas, Southern and Eastern Asia, and Oceania are clearly defined.

The exchange of germplasm has in the past been entirely from CIAT to IITA and almost entirely in the form of sexual seed. More than 70,000 distinct genotypes have been sent in this form and incorporated into the IITA breeding program. Most of this material was open-pollinated seed sent in order to enlarge the germplasm base of the IITA program. More recently, IITA has requested specific crosses with characteristics such as green spidermite resistance. A major problem with these crosses is their susceptibility to AMD. After a special meeting of an expert committee on quarantine, a methodology including testing of the phytosanitary status of clones in the United Kingdom, was established to transfer elite clones with AMD resistance to CIAT so that these can be crossed with mite-tolerant or highland materials and returned to IITA for testing.

Apart from the direct tangible exchange of germplasm, there is much information generated at both centers that can be useful outside their respective areas of direct responsibility. In the case of CIAT, much of the work on the basic physiology of the plant with particular emphasis on drought tolerance, propagation techniques, the new plastic bag storage technology, the epidemiology and etiology of pathogens, techniques for safe movement of sexual seed, and numerous agronomic practices can be applied in Africa. On the other hand, IITA's expertise on cropping systems and soil conservation can be applied to other continents.

Cooperation in the future will be particularly strong in the area of biological control of green spidermites and the cassava mealybug. The two institutes have already cooperated on the identification of collecting sites, development of mass rearing techniques and methods of transferring beneficial insects across national borders. Many beneficial agents collected by CIAT are now being actively tested by IITA in Africa.

IITA has also agreed to assist CIAT in improving documentation services by both collecting and distributing materials within Africa, as well as by contributing to the newsletter and taking charge of the version to be published in French.

IITA's regional efforts in Africa could be greatly enhanced through greater liaison with CIAT. This is especially true with respect to genetic resources. It is tentatively proposed to station one CIAT scientist at

IITA, starting in 1987, to be responsible for germplasm movement from the Americas to Africa and for more rapid interchange of information on research and development between the two institutes.

Southern and Eastern Asia

The overall strategy in Asia is to strengthen national cassava research and development programs through a research network of technical collaboration with CIAT and ESCAP-CGPRT, particularly with respect to the determination of overall government policies towards cassava, development of improved varieties and agronomic practices, and training of national program personnel.

The advantages of such a regional research network include (a) effective horizontal cooperation and rapid communication of new methodologies and technological advances; (b) identification and assessment of macrolevel problems that need to be solved through coordinated efforts; and (c) development of young scientists as a result of opportunities for mutual exchange of information, consultation and training.

This project envisages the placement of three senior cassava research scientists in Asia with regional responsibilities: an agronomist, a breeder and an economist.

There is a great need for a regional agronomist for the Asian cassava research network, who would be located in Thailand. In collaboration with the breeder and economist, as well as the national personnel in each country, the agronomist would be involved in the assessment of production problems; agronomic research at the national level; crop protection; and general consulting and technical assistance. A cassava breeder is already based in Thailand at the Rayong Experiment Station and is working closely with the Field Crops Division of the Thai Department of Agriculture on developing new clones suitable for Asian conditions. He is responsible for (a) seeing that national programs with established breeding programs, such as those in China, Philippines, Malaysia, India and Indonesia, obtain sexual seed from suitable crosses from both CIAT and the Thai-based regional program; (b) advising national program researchers on selection and testing procedures; and (c) assisting in the evaluation of hybrids through the process of selection and the final naming or release of new varieties. One of the Thailand-

based regional staff will be designated as coordinator. In addition to his disciplinary duties, he will also be responsible for organizing regional workshops and conferences; coordinating training programs; and facilitating information exchange.

Economic research activities on cassava will be centered at the CGPRT Centre in Bogor, Indonesia, a country in which cassava is an important crop. A series of country-by-country coordinated studies on the economics of cassava production, utilization and future potential have already been conducted. With respect to production, the cassava economist will collaborate with the agronomist and national program personnel in identifying the key constraints to increased production in the region including competition with other crops for scarce resources such as land, labor and capital. As new production technology is developed, the economist will assist in onfarm evaluations, focusing on how readily the new varieties and management practices fit into different farming systems and affect production costs.

Research in the area of utilization and demand will provide input into the broader planning of cassava development. Of particular importance is the development of an accurate, consistent set of statistics on cassava production, area planted and utilization.

Evaluation according to end use (i.e., human food, animal feed, starch) will also be undertaken to determine priorities for research in these areas. The economist will undertake a macroanalysis of (a) prices cassava will have to compete at in alternative markets, and (b) the effect of processing costs on farm-level prices, production costs and yield targets, thereby bringing together production and demand research. The economist will also assist the national programs in determining how cassava may contribute to government policy objectives based on an evaluation of the socioeconomic cost/benefit accounting of the crop's potential.

Staffing Projections

Of the projected senior staff positions, approximately 6.4 person-years will be devoted to the global functions of the Cassava Program (Table 11), all of which will be core funded. As the Latin American and

Caribbean regional center, CIAT will have a core-funded total of approximately 3 person-years senior staff time. In addition there will be 1 person-year of special project-funded time for the Meso-American and Caribbean liaison officer.

The regional center for Asia will comprise one person-year of full-time core-funded staff in the breeder position plus the two full-time special project-funded positions of the economist and agronomist. In Africa IITA is the regional center; however, CIAT projects the placement of a liaison officer in 1987 subject to further negotiations with IITA.

The program will also receive support from the CISU in terms of documentation; the GRU, in terms of germplasm maintenance and tissue culture; the Biotechnology Research Unit (BRU), for virus and basic mycorrhizal work and training services.

Table 11. **Estimated allocation of senior staff time, by person-years, to regional and global responsibilities in 1987 when program is projected to be at full strength.**

	Global	Caribbean & Latin America	Asia	Africa
Leader	0.7	0.1	0.1	0.1
Physiologist	1	0	0	0
Breeder (HQ)	1	0	0	0
Breeder (HQ 1987)	0.7	0.3	0	0
Breeder (Asia)	0	0	1	0
Entomologist	1	0	0	0
Pathologist	1	0	0	0
Agronomist (Asia)	0	0	1	0
Agronomist (HQ)	0	1	0	0
Agronomist (Caribbean)	0	1	0	0
Economist	0.5	0.5	0	0
Utilization Specialist	0.5	0.5	0	0
Liaison Officer (Africa)	0	0	0	1
Total	6.4	3.4	2.1	1.1
(% Total)	(49%)	(26%)	(16%)	(9%)

Table 12. **Approved senior staff positions in the CIAT Cassava Program for 1980-85 and projected positions for 1986-90 from core funding (CF), corelike projects (CL), special projects (SP).**

Position	Funding source	80	81	82	83	84	85	86	87	88	89	90
Headquarters based												
Leader	CF	0	0	0	0	0	1[a]	1	1	1	1	1
Physiologist	CF	1	1	1	1	1b	b	b	1	1	1	
Breeder	CF	1	1	1	c	c	c	c	1	1	1	1
Breeder	CF	1	1	1	1	1	1	1	1	1	1	1
Pathologist	CF	1	1	1	1	1	1	1	1	1	1	1
Entomologist	CF	1	1	1	1	1	1	1	1	1	1	1
Soil Scientist/Plant Nutritionist	CF	1	1	1	1	1	1	1	1	1	1	1
Economist	CF	1	1	1	1	1	1	1	1	1	1	1
Utilization Specialist	CF	1	1	1	d	d	1	1	1	1	1	1
Cultural Practices/Agronomist	CF	1	1	1	1	1	1	1	1	1	1	1
Regional Trials/Agronomist	CF	1	1	1	0[e]	0	0	0	0	0	0	0
Outreach Agronomist	SP	1[f]	0	0	0	0	0	0	0	0	0	0
Decentralized Regional Programs												
Asia												
Agronomist	SP	1	0	0	0	0	0	1[g]	1	1	1	1
Breeder	CF	0	0	0	1	1	1	1	1	1	1	1
Sub-Saharan Africa												
IITA-CIAT Liaison Scientist	CF	0	0	0	0	0	0	0	1	1	1	1
Caribbean & Central America												
Agronomist	CL	0	0	0	0	0	0	0	1[h]	1	1	1
Total headquarters		11	10	10	7	7	8	8	9	10	10	10
Total decentralized		1	0	0	1	1	1	2	4	4	4	4
GRAND TOTAL		12	10	10	8	8	9	10	13	14	14	14

a **Leader:** The full-time leader position was created in 1985 following the EPR recommendations in 1984.

b **Physiologist:** This position will be temporarily discontinued in 1985 as a major body of work has been achieved, and CIAT has opted for increased activity in the area of cassava utilization. The position is projected for reinstatement in 1988 in response to the need for further upstream research in cassava.

c **Breeders:** One breeder position was moved to the Asian Regional Program in 1983; a second breeder is projected to be reinstated at headquarters in 1987. This will allow expansion of breeding efforts in ECZs 3, 5 and 6, as well as closer collaboration with national programs in the final stages of selection.

d **Utilization Specialist:** Discontinued in 1982 as a result of center-wide budget cuts, this position was reinstated in 1985.

e **Regional Trials Agronomist:** This position was discontinued in 1982 as a result of center-wide budget cuts.

f **International Agronomist:** This position was discontinued in 1980 upon the termination of the IDRC special project for international cooperation outreach in Latin America.

g **Agronomist (Asia):** This position was discontinued in 1980 with the termination of the IDRC-funded special project. Special project funds are being sought to reinstate the position in 1985-86.

h **Agronomist (Caribbean):** A co-project is presently being negotiated with CIP, IITA and CIAT as participants in a regional network for all root crops in the Caribbean. This corelike project should come on stream in 1986-87.

This plan is written at a time when, in accordance with the EPR's recommendation, a major study of demand for cassava in Latin America is under way. CIAT's currently projected global responsibilities are in line with the EPR's recommendations—i.e., assuming that the demand studies show little hope for a growing demand for cassava in Latin America—that "CIAT should consider tailoring its program to meeting its responsibilities as a major germplasm center for the world. Such a program would take full advantage of the excellent team of scientists currently working at CIAT and would provide a major resource for training." If, on the other hand, the demand studies predict an increasing demand for cassava, particularly in Latin America, then CIAT projects the full team shown in Table 12.