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CASSAVA PROGRAM STRATEGIC PLAN

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CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL

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FORWARD

In 1989 CIAT made a major effort to redesign its strategies for the decade of the nineties. The cassava program in turn carefully evaluated its strategies. In order to do this a series of meetings were organized with the participation of cassava program staff, cassava producers, scientists, extension agents, the private sector and development agencies with a broad knowledge of different aspects of cassava production, processing and marketing. This document sets out the results of these discussions. Considerable attention is given in the document to the characteristics of the crop, the previous development of program strategies, the achievements of the program to date, and the role of cassava in economic development. The strategies that the program will use for the coming decade are then presented in the light of the previous deliberations. It is recognized that the program will continue to evolve and be flexible in modifying its strategies to meet new circumstances. Nevertheless the basis of the program will continue to be research specifically directed to assisting the rural poor.

James H. Cock.
June 1989.

THE CASSAVA PROGRAM

INTRODUCTION

Cassava (Manihot esculenta) is the fourth most important source of calories produced for human consumption within the tropics. It is a major source of calories for 500 million people, and in tropical Africa it is the single most important source of calories. In addition to being one of the most efficient crops in terms of production of carbohydrates, cassava is very tolerant of low soil fertility and drought. Furthermore, it is a very reliable crop: Frequently in Africa when all other crops fail, it is the one staple that prevents widespread starvation. These particular assets have made cassava an attractive crop for small farmers in marginal areas, and it is almost entirely cultivated by them.

Cassava, which is of Latin American origin, is now widely cultivated throughout the tropics of Asia, Latin America and Africa. Total world production has increased from 70 million t in 1960 to an estimated 140 million t in 1988, which is equivalent in energy terms to approximately 50 million t of grain. About half the world area is in Africa, which produces around 40% of total production, with another 40% in Asia and 20% in the Americas. In Africa over the period 1961-1965 to 1976-1980, cassava and maize were the only two crops that made a major contribution to increased food production.

Cassava has reached this level of importance due to the fact that it is one of the most efficient crop species in terms of production of energy with low levels of purchased inputs. The crop is well adapted to traditional agricultural systems and subsistence cultivation. In several countries, primarily in Southeast Asia, the crop has undergone a transformation and has entered the modern market economy characterized by urbanization and the demand for processed food products. These changes are only just beginning in Latin America where until only recently cassava was placed at a disadvantage to the grain crops, with which it competes, because of government policies that discriminated against it. The severe financial constraints in Latin America have radically changed this situation: Brazil in the early eighties was subsidizing wheat at a level close to US$2 billion per year, but it is now phasing out these subsidies. Similarly in Africa overvalued exchange rates in the past have frequently militated against local food production; e.g., a recent major devaluation in Nigeria has radically changed the prospects for cassava as a human food. The changing political and economic circumstances indicate a potential new role of cassava in the development process; however, in order for it to play that role, the crop must be developed not only as a subsistence crop but also as a cash crop capable of competing in a market economy.

Until relatively recently cassava received little attention from agricultural research and development agencies (Table 1).

Table 1. National and international research expenditures as a percentage of the value of product by commodity, average 1972-1979.

Commodity	Research Expenditure	Spending by IARCs	Ratio of IARC to Total
Wheat	0.51	0.02	0.04
Rice	0.25	0.02	0.07
Maize	0.23	0.03	0.11
Sugar	0.21		
Soybeans	1.06	--	--
Cassava	0.11	0.02	0.15
Field beans	0.32	0.04	0.11
Potatoes	0.29	0.08	0.21
Beef	1.36	0.02	0.02

Source: CGIAR study paper #22.

Fortunately, the CGIAR system has stepped in to fill the breach partially, playing a more important part in the overall research effort than is the case for most other important tropical staples (Table 1). Two IARCS--CIAT, with the global mandate, and IITA, with a regional mandate for Africa--spearhead this effort.

HISTORY

The Cassava Program at CIAT and the Root and Tuber Crop Program at IITA were formed at the time of the Green Revolution of rice and wheat. The wave of enthusiasm that followed the great success with these two commodities not only led to the establishment of the CGIAR system but also defined its overall strategies. These were, broadly, to apply modern science to the production of new varieties of broad adaptability that would greatly increase yields. Furthermore, the rice and wheat revolution was based on a large backlog of research, principally from Asia, Europe and the Americas. In the case of cassava, although some research had been done prior to the establishment of the centers, the scientific base for crop improvement was rudimentary. Nevertheless, the program strategy evolved in the spirit of the times and revolved around increased understanding of the crop and using this knowledge to provide a genetic solution to the problems encountered in the field.

Toward the end of the decade of the seventies, a great deal had been achieved in improving understanding of the plant; however, the goal of providing broadly adapted varieties to farmers and increasing production was not achieved. Research indicated that

in the first place, cassava was grown under such heterogeneous conditions (in contrast to irrigated rice and wheat) that an ecosystem approach to varietal improvement and concomitant agronomic practices was needed. Second, the principal constraint on increased production was often not in the area of production technology per se, but rather in the area of incentives for the farmers to produce more. Strategies were altered accordingly, with emphasis on determining potential markets for cassava and also on postharvest handling of the crop to ensure that marketable goods could be produced. Furthermore, a more holistic viewpoint of the role of the crop in the overall context of rural development was taken. The question became not "what can the Program do for cassava," but "what can cassava do for the poorer segments of the population in the developing world" and "what can CIAT as an institution do to ensure that it effectively plays that role."

In the Asian context, with a history of investment in cassava-based agroindustry, it was seen that the major constraints were on the production side, and the Cassava Program played the typical IARC role of providing germplasm, production technology, training and technical support in the region. In the case of Latin America, spontaneous development of agroindustry did not normally occur; hence production stagnated. The Cassava Program realized there was a need to become involved in integrated production, processing and marketing projects to work out, through hands-on experience, how cassava could play its role in the overall context of agricultural development.

In the case of Africa the Cassava Program's efforts have been channeled through IITA. This Center has developed disease-resistant varieties with high yield potential; however, they began to have similar concerns about the characteristics of the future demand for cassava products in Africa. To add to the considerable knowledge on cassava production systems and farmers' preferences, obtained in a series of IITA-executed collaborative research ventures in Zaire, Cameroon and Ghana, the two centers embarked on an ambitious study of cassava in Africa (Cooperative Study of Cassava in Africa, COSCA), which will later be used to refine research strategies that will allow cassava to play an important development role in the coming years.

The foregoing highlights of the Program's history indicates that its strategies have continuously evolved and been modified in the light of knowledge and experience gained with the crop. This strategic plan forms a part of that ongoing evolution.

ACHIEVEMENTS

The Cassava Program is directed towards assisting resource-poor farmers, and this is the ultimate measure of its success. Nevertheless, its progress in reaching this goal can be measured by the success of various steps in the overall process of reaching that objective. The main steps are seen as (1)

improving the knowledge base on the crop and the availability of germplasm and other biological agents; (2) the establishment and strengthening of National Agricultural Research and Development systems and the definition of effective models to achieve cassava-based development; and (3) improvement in the livelihood of the cassava producers and benefits to the consumers.

Knowledge Base and Germplasm

The Cassava Program has greatly expanded the basic level of knowledge on cassava. The major diseases and pests of cassava have been identified and described; and in many cases control measures, developed. Biological control agents have been identified and are available to NARS. Sources of host-plant resistance have been obtained through large-scale screening efforts. The physiological basis of yield potential has been described for near-ideal conditions; and the plant's reaction to stress, delineated. This information has been utilized in breeding programs to obtain improved clones and elite gene pools that are available to cooperating agencies. The nutritional requirements of cassava have been evaluated, and its dependence on mycorrhizal association, documented.

Effective soil management methodologies have been formulated, with special emphasis on erosion control and sustainable production. These findings have formed the basis of effective schemes for the long-term management of soil fertility in cassava-growing areas. In the field of agronomy, advances have been made in crop management in areas such as production and storage of good-quality planting material, fitting cassava into mixed cropping patterns, and weed control. Coupled with improved management of the crop has been the development of varieties that are tolerant of stress conditions and have high yield potential. A point of transcendental importance in this process has been the definition of the most important ecosystems in which cassava is grown and the development of specific elite gene pools for these varying conditions. This has been possible as a result of the collection and evaluation of the world's largest cassava germplasm bank and the formulation of appropriate breeding and selection methodologies.

In addition to the basic biological aspects of the crop, the Cassava Program has greatly expanded the knowledge on how cassava is produced, as well as the social and biological constraints faced by the small farmers who grow the crop. Marketing of cassava has been highlighted as a major problem in some areas due to the high perishability of the fresh roots. The demand for cassava-based products and how this affects the role of cassava in the development process have been elucidated and form the basis for the Program's research and development strategies (see section on the role of cassava in Development).

Initial studies described the rapid deterioration of cassava after harvest and showed that it might be possible to develop

simple low-cost conservation techniques. These have now been developed, and commercial use has begun recently. In addition to the fresh cassava work, technology for drying cassava under Latin American conditions has been developed; and this technology can readily be transferred to other areas. The use of dry cassava as a wheat flour substitute now appears a real possibility as a result of a recent breakthrough in processing technology that permits easy separation of the peel.

Institutions

When the CIAT Cassava Program began, the only effective national cassava program was at the Central Tubers Crop Research Institute (CTCRI) in India. Through an intense training program and continued close contact with the nascent national programs, CIAT has assisted in the task of building effective national cassava research agencies in many countries of Latin America and Asia. In addition to the research capacity, the Program has greatly assisted development agencies such as the Integrated Rural Development Program (DRI) of Colombia and the Ministry of Agriculture in Ecuador, in establishing the human resource base needed to implement cassava-based development projects.

Perhaps the best measure of the success of these efforts at supporting national programs is through the impact they have had in their own areas of influence.

Impact

The measurement of impact on a global basis is difficult in a crop such as cassava, where production is mainly in the hands of myriad small producers. A few examples given here should give the reader an idea of the sort of results that the Cassava Program, in close collaboration with its national program partners, has achieved.

Cuba. At the end of the decade of the seventies, Cuban officials decided to increase the supply of cassava to urban populations. Using the "Colombian system" of production based on CIAT technology, which lowered costs through reduced use of insecticides and irrigation but at the same time increased yields from less than 6 to 12 t/ha, the Cubans increased cassava production from an estimated 220,000 t/yr in the early seventies to over 400,000 t/yr in the mid-eighties.

Colombia. The DRI program identified marketing as a major constraint to small farmers' increasing their income through cassava production. With technical assistance from CIAT, a small-scale drying industry based on small farmers associations was established on the Colombian North Coast. There are now about 50 of these drying plants in Colombia, providing benefits to over 5,000 producers, offering employment opportunities and producing some US$2 million worth of dry cassava per year. The small farmers' positive response to a stable market has reduced

the price to urban consumers in the major market of Baranquilla, and consumer savings are estimated at about US$4 million per year in this city alone. In addition, the supply of locally produced dry cassava reduces foreign exchange for feed grain imports.

The national research agency ICA has responded to the demand for new technology by strengthening efforts on cassava and is now in the process of releasing several new varieties. Two varieties jointly tested by ICA and CIAT are now widely grown in parts of Colombia.

Ecuador. In the semiarid coastal area, cassava production was declining due to lack of market opportunities; and the national cassava program had ceased to exist. CIAT advised the Ministry of Agriculture on the setting up of plants to open up new markets for farmers cooperatives. In the province of Manabi, the area planted to cassava has increased from 7,000 to 14,000 ha in two years. Farmers associations are drying cassava; and through their Union of Processors and Producers of Cassava, they are selling cassava flour as an aglutinant and energy source to the shrimp industry. The local research organization, INIAP, has now established a cassava program to support these efforts.

Thailand. The Thai cassava industry depends on low-cost supplies of fresh roots with high dry matter content to compete in world markets. The low world grain prices led to low prices and hence to less income for the small farmer producers. The only solution in their low-cost production systems is to increase yields if they are to maintain or increase their income levels. The release of the high-yielding, high dry matter line Rayong 3, which receives a premium price, and the exceptionally rustic, but high-yielding Rayong 60 has opened new perspectives for the Thai farmers.

Indonesia. For years the country has had a small program to develop new cassava varieties, but these had achieved little impact on farmers fields. Now, a fully structured improvement program has released the high-yielding cultivar, Adira 4, which has raised yields substantially on farmers fields in Sumatra. Additional new lines are now at an advanced stage of selection and should be released shortly.

Malaysia. The national program used CIAT-developed germplasm to produce a variety with exceptional yield potential on the country's underutilized peat soils. This variety is a key component of development efforts to bring these lands into production.

Brazil. The cassava hornworm is a sporadic pest, which causes severe damage to the cassava plantations. A Brazilian student was trained at CIAT in the handling of the baculovirus that kills the hornworm. On her return to southern Brazil, she collected the virus and developed a simple technique whereby farmers could

use it for hornworm control. This control measure is now being widely used by farmers there and is spreading into other areas.

Farmers in the disadvantaged Northeast of Brazil face fluctuating prices for their production of either fresh roots or the toasted flour (farinha) they produce. With assistance from CIAT the four major producer states of the Northeast are collaborating to set up a project to stabilize prices through the development of an alternative market--dried cassava for animal feed.

Africa. IITA, located in Nigeria, has produced new high-yielding lines. The question was how to get them to farmers rapidly. Through CIAT's rapid propagation technique, adapted to Nigerian conditions by IITA and the national program, the accelerated food program was able to distribute rapidly the new high-yielding materials that are now reported to be grown on 20% of the cassava-growing area.

In Rwanda the national program, ISAR, needed germplasm well adapted to intermediate-altitude conditions. CIAT, in close cooperation with IITA, has sent elite germplasm from the Andean region, particularly suited for these conditions. Preliminary data indicate great promise for these materials.

Due to the inadvertent introduction of the cassava mealybug to Africa in the late sixties or early seventies, the cassava crops were devastated. CIAT identified the mealybug in Paraguay and opened the way for joint exploration for natural enemies by IITA and the Commonwealth Institute on Biological Control (CIBC). Now the parasite Epidinocarsis lopezii has been released in Africa and is decreasing mealybug populations and the damage they cause. The benefits of this research are certainly at least of the order of hundreds of millions of dollars with some independent estimates of billions of dollars.

These few concrete examples demonstrate the impact that cassava research and development efforts can have on improving cassava production and processing efficiency with all the benefits that this will bring to the small farmer producer and the urban consumer. It should be noted that these examples are based on years of research effort. For example, the release of Rayong 3 came ten years after the original crosses were made. In the case of the Green Revolution in wheat and rice, it was a case of putting materials in the pipeline; whereas for cassava, the pipeline first had to be built. That has now been done, and we can expect more and more benefits to flow out of it to assist the poor.

ROLE OF CASSAVA IN ECONOMIC DEVELOPMENT

The role of cassava in the food and agricultural sector changes as the overall economy develops. In the initial stages when most of the population lives in rural areas, cassava has generally served as a basic food staple. Cassava's high-yielding ability,

adaptation to drought, tolerance to disease and pest attack, and indeterminate harvest period have made it a subsistence crop par excellence, providing a secure food supply even under quite risky conditions. In many areas processed products were developed in order to eliminate the HCN in the roots, as a means of storage, and as a staple for trade. In traditional, rural cassava-consuming areas per capita consumption levels are usually very high.

In Asia and Latin America today, it is unusual to find farmers who produce cassava purely for subsistence purposes. As urban markets develop and farmers enter into the market economy, cassava shifts increasingly to a cash crop, first supplying food markets. Because processed cassava is relatively inexpensive, it often becomes the staple of the urban poor, such as farinha de mandioca in Northeast Brazil or gari in many parts of West Africa. However, these processed staples usually face a very inelastic demand in urban areas; and it is the growth of other markets such as starch and animal feed that provides the potential for further increases in demand for the crop. Unlike most other carbohydrate staples, cassava is able to maintain a significant elasticity in demand throughout the growth process by shifting into increasingly expansive alternative markets.

Nevertheless, the transition to a multimarket cassava system has often been inhibited by a number of constraints including grain price policies that discriminate against cassava; capital constraints for investment in processing; insufficient technical information; and inefficient price formation in cassava markets. Knowledge of this unexploited demand, however, opens up cassava's potential as a development tool. Potentially elastic product demand, together with competitive production costs, implies significant income-generation potential for cassava producers.

As these are almost always small-scale farmers operating under some agroclimatic constraint, cassava is a rare case where the benefits of new technology can be targeted to that stratum, which has normally remained outside the development process. The improved equity in rural income distribution will, in may cases, coincide with a positive benefit for consumers of traditional cassava products, usually the lower income strata. Thus market development, tied to improved cassava-production technology, can set in motion the type of dynamic growth that has occurred in Northeast Thailand over the past 20 years.

Development of cassava markets with elastic demand will depend upon the economy's overall stage of development, as well as on the policy environment for competing substitutes. Two points follow from this. First, the strategy adopted for the development of cassava will vary by continent; no single strategy will apply across tropical Asia, Africa and Latin America. Second, cassava has thus far remained outside the policy-making process, often to its disadvantage. Because of the increasing possibilities for commodity substitution, greater consistency in

input, credit and pricing policies is needed across commodities in order to ensure the most efficient utilization of agricultural resources. That cassava production has managed to grow despite these policies is an indication of the existing low production costs for the crop.

Cassava Economy of Asia

A multiple cassava market system is already well developed in Asia, with cassava uses spanning a range from a basic food source through dried pellets for animal feed to high-fructose syrup. Cassava is the second most important starchy staple produced in tropical Asia and is a major cash crop in the upland areas of the region. Cassava has achieved this prominence because of the responsiveness of investment, mostly in small-scale processing capacity, and because of the versatility of cassava as an upland crop. Its high-yielding ability makes cassava suitable for the needs of very intensive systems, as reflected in yields reaching an average of close to 30 t/ha in Tamil Nadu, India. Moreover, cassava is also well adapted to the more extensive systems on the agricultural frontier of tropical Asia and to the spectrum of upland areas with major rainfall or soil constraints.

Rice is the dominant calorie source in the diet of tropical Asia. Like all the other grains, cassava is a secondary staple. As a food source, cassava's main role--particularly in Indonesia and India--has been to augment the calorie consumption of the low-income strata, essentially because of its lower calorie costs. Because of its different forms, cassava has the ability, even as a food commodity, to segment its market, thereby maximizing overall market demand. In Indonesia, for example, the poor consume gaplek, a dried form of cassava. Average income elasticities suggest that gaplek is an inferior good (i.e., income elasticity is negative); but because of the positive elasticity in the lower income strata, lower prices and increased supplies of gaplek would target benefits to the very poor. Fresh cassava, on the other hand, has a positive income elasticity and is a more preferred form of consumption; nonetheless, high marketing margins and lack of convenience have limited consumption in urban areas. Finally, a very elastic demand for krupuk, a flavored toasted wafer of cassava starch consumed primarily by the high-income strata, has resulted in a positive overall growth in demand for cassava as a food.

Cassava market diversification in Asia over the last two decades has been heavily influenced by the export market. Export prices are set by a preferred (as compared to feed grains) tariff rate for cassava entering the European Economic Community (EEC). As a result there is no price integration between world markets for feed grains and for cassava pellets. In general Asian countries have found it more profitable to export cassava and utilize domestic or even imported maize in their animal feed industries. A corollary to this point is that while cassava could have competed in world feed grain markets on a cost basis, it could

not compete on a price basis; nor did it need to, as the EEC absorbed all it produced. The year of 1983, however, saw the imposition by the EEC of voluntary export restraints (quotas) on cassava. Thailand was most affected because the quota was below its export capacity. Nevertheless, through effective policy measures, cassava production and exports have continued to grow during the quota period, and farm-level prices were maintained above what could have been achieved by linking the Thai cassava market to the world maize market. Moreover, during this period, when prices of maize and cassava came into line for periods of time, cassava was utilized in the domestic mixed feed industry in both Thailand and Malaysia. This point is important as it shows that if prices are competitive, cassava will be used by feed manufacturers in Asia. As world grain prices inevitably move so as to more accurately reflect production costs the demand for cassava as a major component of animal feed rations will increase.

The world market in most Asian countries sets a price floor under domestic markets; all major producing countries, except the Philippines, have at some point, been exporters. However, in the 1980's except for Thailand, Asian countries have either reduced export levels or moved to net import positions, especially in cassava starch. Starch demand has been rising rapidly in all these countries, to the extent that countries such as Indonesia and Malaysia have had to import large amounts. Many countries have expanded demand by moving to modified starch production, and Indonesia has begun to produce high-fructose syrups based on cassava starch. Growth markets exist for cassava in Asia, to the point that production is not keeping up with demand.

To date, little improved production technology for cassava has reached the farm level. Declining costs of production could accelerate the diversification of markets in Asia, especially into the animal feed market. The market structure already in place has the capacity to absorb significant increased in production, without drastic declines in prices. This multiple-market structure allows cassava to attain a range of benefits, including simultaneous improvements in the welfare of the low-income consumer (in India and Indonesia) and in the income of the small-scale farmer in the upland areas. Cassava has already been a major source of income growth for farmers in areas such as Northeast Thailand and Lampung, Indonesia. New cassava technology could bring benefits to farmers bypassed by the Green Revolution, especially those who start from a much poorer resource base than those who benefited from the new rice technology.

Cassava Economy of Latin America

Latin American economies have undergone rapid structural change in the postwar period, accompanied by a number of adjustment problems, as reflected in strains on urban services, high inflation rates, malnutrition among a significant portion of the

urban population, a rising external debt, and high rates of unemployment. Many of these problems have been due, directly or indirectly, to the excess rate of rural-urban migration, induced by the very skewed distribution of land resources. The growing number of urban poor has induced an often contradictory agricultural policy, the two elements of which are low urban food prices and income supports to farmers (through intervention in input and output markets). Not surprisingly, policies have often had to resort to subsidies in order to fulfill both objectives.

Cassava has remained outside this policy process; yet it has been strongly affected by policies on grain substitutes. Moreover, cassava has also been affected by the shift in the locus of overall food demand from rural to urban areas. Whereas changing food consumption patterns and restructuring of food markets should have provided an opportunity for growth in market demand for cassava, the fact is that cassava production has stagnated. Unlike Asia, cassava has not been able to make the transition to a multiple market system in Latin America; traditional food markets continue to dominate in the overall demand for cassava.

Prices of substitutes and the "urbanization" of food consumption have been the major influences on overall demand for cassava in Latin America. Only traditional dried cassava products, such as farinha de mandioca in Brazil, are inferior goods; and only in Brazil do these products dominate in overall cassava demand. Even here policy has been the dominant influence on declining consumption, as the very heavy subsidies on wheat flour have completely shifted relative prices and consumption levels for the two commodities. For fresh cassava, on the other hand, income elasticities are positive (except in Paraguay), with a very significant elasticity in demand in urban areas. In this case the very high costs of marketing fresh cassava in urban areas have shifted relative prices between rural and urban areas. Per capita consumption levels are much lower in urban than in rural areas although market demand is much more elastic; and with the shift of the rural population to urban areas, average per capita consumption levels have declined. However, as the locus of consumption shifts from rural, subsistence consumption to purchased cassava, actual market demand for cassava has been increasing at a significant rate. Recent advances in storage technology for fresh cassava promise to lower marketing costs and improve consumer convenience, thereby increasing market demand even further.

Nevertheless, the major potential growth in demand for cassava exists in the market for animal feed components. Technical changes in animal production and changes in market structure for meats have made this a very expansive market in the last two decades. New breeds and the availability of protein concentrates have made cassava a major on-farm feed source for swine in southern Mexico. However, the major potential market is for dried cassava in mixed animal feeds. In most tropical Latin American countries, price interventions in the feed grain market

have curbed a potential role for cassava. However, with the devaluation of exchange rates, reduction in subsidies, and rationalization of prices in response to the 1982 debt crisis, cassava is now competitive on a cost basis with domestically produced feed grains in all major producing countries except Venezuela, where a differential exchange rate policy for feed grain imports still makes cassava uncompetitive.

Although economic growth and structural change in Latin America have fostered market diversification in many agricultural commodities, there has been little development of multimarket systems in cassava, partly due to policies on substitutes and to lack of efficient price formation within cassava markets. Developing the market for cassava as an animal feed source provides a virtually unique opportunity for developing more well-integrated cassava markets and for raising incomes of small-scale farmers in Latin America, especially those in more marginal agroclimatic areas such as northeastern Brazil, the Atlantic Coast of Colombia, or the coastal plain of Ecuador. Excess capacity exists in these systems because of limited cropping alternatives and inelastic demand for those crops that are grown. Development of a processing capacity for dried cassava puts a price floor under existing markets, providing the incentive to expand production.

Increased production in turn brings greater price stability to cassava food markets, thereby benefiting consumers. These initial interventions are organized as integrated cassava development projects, which develop the market channels, provide the credit and technical assistance for the processing technology, and extend production technology. Projects are now functioning in Colombia, Ecuador, Panama, Mexico and Brazil. Dried cassava is now being competitively produced for the feed industry in Latin America, and the benefits are being targeted to the small-scale producer.

Prognosis for Cassava in Africa

Cassava is the most important food crop in sub-Saharan Africa, providing more than 200 calories per day for over 200 million people. Cassava's central role in the African diet takes on special importance as this is the region in the world where per capita food production has been declining most rapidly. At issue in the short term is the role of cassava in reversing that trend; and in the longer term, the contribution cassava can make to overall development of the agricultural sector in Africa. Yet, analyses and data to address these issues are virtually nonexistent.

Cassava's future in Africa rests upon defining the income and employment generation potential of the crop. Any role here in turn is linked to developing marketable surpluses, on the one hand, and identifying and developing markets, on the other. These issues in turn lead to questions about the type of product

(there are a wide range of cassava food products in Africa), the demand parameters for the different products, the interventions needed in processing technology and marketing channels, and the effect of pricing policies on substitutes. Cassava has a potential role as a farm income source in current production areas, if marketing channels to growing urban areas can be opened, and as a stabilizing component in farming systems in marginal, food-deficit areas. In order to develop strategies to foster these roles, it is necessary to answer the foregoing questions. The Joint IITA/CIAT agroeconomic study of cassava in Africa currently underway has this as its goal.

PROGRAM GOALS AND STRATEGIES

The essence of the value system at CIAT is a concern for human welfare and dignity. The particular concern of the Cassava Program is rural welfare. It is the Program's belief that improved living conditions and employment opportunities in the rural sector can slow migration to the urban sector and mitigate the abject misery so often associated with rapid increases in urban population.

The Program's goals, which reflect these values, are to work with cassava, exploiting its inherent characteristic, so as to:

> **increase incomes, particularly of the less-favored sectors of the rural population, and improve overall availability and quality of food in the tropics.**

Strategies to Target the Rural Poor

In general agricultural research tends to have a built-in bias toward providing benefits to the consumer rather than the producer. The Program believes that its efforts are bound to help the urban poor, but they must be biased toward the rural poor so that they also receive benefits. An improvement in the welfare of subsistence farmers is a laudable goal in its own right; however, the Program believes that farmers will have to become more closely linked to the market economy if their welfare and livelihood are to be improved. Attention will be given to improving the conditions under which they become incorporated into the market economy; this infers that they must have salable goods. Hence the Cassava Program emphasizes technology development that finishes with a marketable product. The linkage of the rural poor to the market economy can lead to a decline in their nutritional status. In the design of new technology, attention will be paid to improving the nutritional status of the producer through such approaches as mixed cropping systems, on-farm production of animal products, and the use of the cassava leaves as a protein source. The Program believes that the crop plays a critical subsistence role in stabilizing food supplies in areas of sporadic rainfall where periodic famines occur. Special attention will be given to developing technology for these areas, particularly in Africa and Northeast Brazil.

The Program also recognizes that many of the constraints on the low-resource farmer are social and economic as well as agronomic. These socioeconomic constraints are susceptible to resolution by research that defines more effective development and economic policy options. To understand the constraints and resolve them, the Program needs close contact, not only with its clients but also with a representative sample of the beneficiaries. This must always be achieved in close collaboration with the national agencies.

In the rural areas landless labor is frequently the least-privileged sector of the population. The Program stresses technology that is relatively more labor intensive and less capital intensive, but cost effective. Furthermore, capital items should, wherever possible, be available locally. It should be noted that it is a truism that unless the productivity of labor increases, the population will not become better off. Hence labor-saving technology such as weed control systems may be developed by the Program, hopefully in such a manner that it only comes on stream as scarcity of labor increases the cost to the point where the new technology can be used rather than through displacing labor in areas of high unemployment.

Rural development can be achieved by concentrating on one commodity in an overall system and working on the other parts of the system that impinge directly on that commodity. This approach, which eventually leads to improvement in services and infrastructure and development on a broader front, is less complicated to manage than integrated rural development programs that attempt to cover all aspects. This principle is dependent upon selecting the right commodity or product for community or regional development. In certain regions cassava will be the selected commodity. Great care must be taken in choosing appropriate regions to ensure that one's efforts do indeed benefit the designated target audience. A direct consequence is the Program's strategy of concentrating its efforts in certain regions and ecosystems where it is felt that cassava can play an important role in the overall development process. While recognizing that the Program's efforts are concentrated on cassava, it must also be taken into account that cassava is rarely grown as a monoculture and that the overall system includes other crops.

As indicated above, the Cassava Program pays special attention to low-resource farmers in areas often considered marginal for agricultural production. Marginality exists at two levels--the community and the field levels. The former is normally related to factors such as the infrastructure and the general economic activity; whereas the latter is closely related to the inherent productive capacity of the field. In general terms the two levels are closely related: Where the productive capacity is low, the infrastructure and economic activity also tend to be low. Cassava, due to its inherently high productivity under poor growing conditions, breaks out of this relation and offers the

possibility of improving the livelihood of those who live in areas previously considered as "marginal." The cassava industry in Northeast Thailand is an excellent example of how this can occur. The Cassava Program will give preference to those zones with sporadic rainfall and poor soils, which also tend to have poor services and little infrastructure, but where the cassava crop has a comparative advantage in improving the welfare of the region.

In a program directed toward the rural poor, the question arises as to the level at which one considers the job has been done and the program no longer has a role to play. It is expected, particularly in certain areas of Latin America, that farm size will tend to increase as the rural population declines and that labor will become scarce. CIAT will continue to work with production systems suitable for the poor farmer. In those areas where cassava ceases to be a poor farmer crop, it will decrease its direct efforts. These areas will still be able to access the information on the technology being developed by CIAT through their local and national agencies.

Research Strategies

Cassava-based development in the long term must be founded on efficient production of the raw material for the process (i.e., cassava) and its transformation into products required by modern society. The Cassava Program will, in the coming years, emphasize research directed toward improved production and processing systems for cassava. Throughout its history, the Program has given priority to the development of production systems appropriate for the small farmer, particularly under marginal agricultural conditions. The technology is founded on improved varieties and crop management. Given the heterogeneity of the conditions under which cassava is grown, the technology has to be developed for each of the major ecosystems in which cassava is grown.

Varietal improvement is based on determining the needs of the producers and consumers of cassava, a fundamental knowledge of the crop, its interaction with the environment and biological constraints. Research will continue to increase the knowledge base in the areas of crop physiology, entomology and pathology with increased input from the social sciences. In the breeding and selection process, emphasis will be placed on the collection, conservation and evaluation of germplasm in different ecosystems. Breeding efforts will emphasize the development of elite gene pools that will be distributed to national breeding programs for final selection and release to the farmers. In the coming years CIAT will emphasize the development of more effective systems for obtaining feedback on the performance of the elite materials from both national programs and farmers themselves.

Crop management tends to be be location specific; however, certain components can be applied over a broad range of

conditions. An example of this is the biological control of the cassava mealybug, developed by IITA in cooperation with CIAT and other agencies, which has proved effective over almost the whole of tropical Africa. The CIAT Cassava Program will continue to develop the components of improved management systems such as biological and cultural control of disease and pests, improved methods of producing vegetative planting materials, and erosion control practices. In designing complete production systems, the strategy will be to work closely with national programs, in carefully selected sites that represent the range of cassava-growing systems.

The Cassava Program is shifting emphasis away from looking solely at the components of cassava technology that will lead to one good crop toward looking at the overall system in which cassava is grown with other crops, both simultaneously and in rotation. These efforts are increasingly being linked up with activities in the areas of soil fertility and conservation. Soil erosion is aggravated by poor crop performance in general, which leads to limited ground cover. Hence efforts in the areas of varietal improvement, crop protection and agronomy are directly related to the conservation of soils. The basis of soil fertility maintenance in many traditional agricultural systems is the link between arable farming and livestock enterprises. The rotation of cassava with pastures and the recycling of nutrients through on-farm, cassava-based animal enterprises will be given greater attention in the coming decade.

The development of new uses of cassava has been the moving force behind cassava-based development in Asia and various projects in Latin America. The quality characteristics of the fresh roots are often critical in determining the acceptability of the final product. The Program will emphasize research on the genetic and environmental factors controlling the quality of fresh roots. Studies on the physico chemical characteristics of cassava will continue, and this information will be used as the basis for improving existing cassava processing technology and for developing new cassava-based products. Much of this work will be done in close collaboration with food research institutes in both developed and developing countries. The final testing of new processes and products will be carried out in pilot projects developed in association with national programs.

The importance of cassava leaves in human nutrition in Africa and their potential as animal feed has not been a major focus in the CGIAR system. IITA, in its breeding efforts, has been cognizant of the importance of cassava leaves in some areas of Africa. Cassava leaves are thought to be the most important vegetable in Zaire and an important source of rural income. It is expected that the COSCA studies will provide more information on their importance and help with decisions on whether to increase efforts in this area. In the interim more information on their nutritional quality and antimetabolites will be obtained in joint efforts with other agencies. In the area of leaves for animal

feed, it is expected that CIAT will collaborate closely with Brazilian agencies that have expertise in this field.

CIAT in general is moving upstream. The Cassava Program has for more than a decade used in vitro techniques for production of virus-free materials. In cooperation with CIAT support units, it is now engaged in research on the basic biochemistry of photosynthesis, regeneration from disorganized tissue, sophisticated techniques for virus identification, and anther culture. The Program expects to be able to induce other agencies with a comparative advantage in use of modern techniques to carry out much of the needed research on critical constraints. CIAT's policy on this type of research effort is to work through the recently established "Advanced Cassava Research Network"; be closely involved in certain specific research areas and in the determination of research priorities; and maintain the capacity to use new techniques or methodologies when they become available.

One of the areas in which this network is expected to play an important role is that of the "true seed project." Production of planting material is a major problem in times of drought. Even in normal years it may be difficult to obtain good-quality planting material as (1) planting time does not coincide with harvest time and (2) material may become progressively more infested with viral and other pathogenic agents year by year. Moreover, obtaining and preparing planting material is always one of the major costs of production. Preliminary data indicate that cassava can be effectively produced from true seed, and no important viral diseases are known to be seed transmitted. The Cassava Program projects a major research effort on the production of cassava from true seed in the coming decade. This involves a broad range of disciplines to ensure success: biotechnology to produce haploid plants; advanced physiology to synchronize flowering; breeding and selection; agronomy of seed production and growing cassava from seed; and ex-ante analysis of farmers' attitudes to true cassava seed. It is important to note that this project can only be successful if it is carried out as a major integrated effort. The possibility of involving private sector research agencies as collaborators will be explored.

Work on cyanide will be emphasized in the coming years. One of the main nutritional concerns is the HCN content of the roots. In areas where nutrition is balanced and processing is effective, there are few if any problems with HCN; during drought periods in Africa, however, the general nutritional status of the population is poor and cassava on occasion becomes the only available staple. Under these conditions HCN causes severe health problems. It is frequently assumed that high HCN lines yield more; however, few hard data exist to support this view. A concerted effort will be made to understand farmers' perceptions and attitudes toward HCN in cassava so as to evaluate the possible adoption of low-HCN lines ex ante. Previously it was thought that it would be relatively simple to breed for low HCN;

however, this is not the case and a major effort of CIAT and the Advanced Cassava Research Network is needed in this area in the coming years. The HCN question will not be attacked solely through genetic means. Improved processing and postharvest handling of the crop also offer potential solutions, particularly in the shorter term. In the efforts to introduce new materials to the drier areas of Africa, it is considered dangerous, at present, to test high-HCN lines; hence testing will emphasize low-HCN germplasm. Although it is recognized that processing is capable of reducing HCN, it is felt that there is no way of guaranteeing that the complete package of high-HCN lines and adequate processing is adopted. Furthermore, the farmers' perception of the dangers of high HCN and chronic toxicity are not well defined, hence creating a severe risk of health problems through the introduction of agronomically superior lines that are high in HCN.

Working with a small farm crop such as cassava. it is recognized that many of the constraints on the participation of potential beneficiaries in long-term sustained development are of a social or economic nature. Increased wealth and the ability of the community to think beyond the needs of the next meal are prerequisites for a longer term view and the ability to address the issue of sustained development. The Cassava Program's emphasis on rural development will contribute to an appropriate social environment for the adoption of technological solutions to the problems of environmental degradation.

In recognition of this, the Program has given more emphasis to incorporating applied social sciences into its research effort in Latin America. The dividends have been great, and it is felt necessary to incorporate this expertise into our core efforts on a continuing basis. These efforts will assist in the following areas: design of technology suitable for small farmers: design of technology that relieves the women who normally process cassava of the drudgery involved; definition of social constraints on adoption of new technology; identification of new opportunities for use at the household level with special emphasis on the possibility of increasing the income of the female members of the family unit; identification of new market opportunities and mechanisms for the introduction of new or improved processes and products; methodologies for achieving cassava based rural development at minimal institutional cost; determination of the representativity of experimental sites in terms of social parameters; evaluation of consumer preferences for new product development; evaluation of the impact of new technology both ex ante and ex post; training of national program staff and providing assistance in the development of effective social science units at the national level.

The definition of target populations is carried out by the AESU at CIAT, and the resultant database forms the basis for more detailed studies specific to the programs.

On farm research, participatory research and pilot projects are all necessary for the development of appropriate technology and its evaluation. They are vital elements in providing information on the real needs of the Program's beneficiaries, as well as feedback on the effectiveness of new technologies or methodologies. They are also excellent training grounds for young national program staff. These activities have always and will continue to be carried out in close association with national or local agencies, who take the lead role in their management. Pilot projects have up to now been almost entirely restricted to the area of processing and commercialization. The success of these projects in stimulating other agencies to play a more active role in cassava research and transfer indicates that the pilot project approach should be expanded to include the testing of new production packages or technology components such as biological control systems. The Cassava Program carries out all work in this area in cooperation with national or local agencies. As this work tends to be location specific, the Program carefully chooses the work areas so as to cover a wide range of conditions. CIAT then has a comparative advantage in compiling and comparing experiences from different locations so as to elucidate general principles that are of broad application.

The pilot projects are a key component in the scaling up of technology from the micro level, normally used by the researcher, to a commercial scale. Problems, particularly those related to social influences, are often encountered in this scaling-up process, making it necessary to refine the technology.

The on-site research and pilot projects also give the Program the chance to be directly involved in seeing the impact of its work on the the livelihood of the beneficiaries, albeit only on a small scale. It is important that the staff closely identify themselves in a tangible manner with the outcome of their efforts.

Strategies for Cooperation

The Cassava Program forms part of a research and development continuum involving universities and research and development institutes in both developed and developing countries.

Close contact with a representative sample of the Program's ultimate beneficiaries, so as to ensure that its work is relevant to their needs, is obtained by working in close partnership with national agencies. This working relationship contrasts with the model of providing technology to the national research program, which then passes it to extension, and finally to the farmer with feedback on performance following the reverse path. This latter type of working relation, while it may be acceptable for resolving well-defined individual problems, leads to a tenuous and ineffective linkage between research and the complex of problems of cassava producers.

In most of the IARCs work, major emphasis is on genetic and agronomic solutions to problems; hence germplasm improvement and exchange is the most important element of cooperation. This makes the National Agricultural Research Institutes the natural partners for the IARCs as they provide new varieties and technology to farmers in most countries. In the case of cassava, genetic solutions are not always the most appropriate first intervention. Hence, although the Cassava Program works very closely with the National Agricultural Research Institutes, they are not always the primary partners.

In Asia, where both germplasm improvement and soil conservation are major areas of focus, the Program's main partners are indeed the NARIs. In the future with greater emphasis on postharvest handling, links will be forged with appropriate technical institutions in this field through an Asian postharvest network. The manner in which postharvest and production technology fits into the complex and intricate Asian cropping systems will be a new focus that will require close linkages with other types of agencies including the extension services. Emphasis will be placed on assisting those countries that have not formed part of the Asian economic miracle of the last 20 years, but which are now realizing the importance and potential role of cassava in the development of their agricultural sector.

In Africa CIAT will continue to interact with IITA, who will continue to play a lead role in direct contact with the African national programs. CIAT responds to IITA's needs and requests for backup and support in their efforts. The IITA Root Crop Program covers all areas of Africa; however, IITA has until recently concentrated efforts on the hot humid lowland tropics. CIAT has considerable experience in working with cassava in dry regions and intermediate-altitude ecosystems. CIAT, in partnership with IITA, will play a more active role in these areas, and the two centers working together will emphasize close contacts with national programs and other agencies in the testing of germplasm originating from similar ecosystems in Latin America.

Extension and development agencies have recently begun to see the role that cassava can play in rural development and have emphasized the crop. Hence they have become important partners of CIAT. As cassava-based development programs achieve success the demand for new technology arises, government support for national cassava research programs increases. Hence in a country that does not have a strong national research program, the Cassava Program cooperates with development and extension agencies and then later forges closer links with the NARI.

The realization, by Latin American policymakers, of the potential of cassava as a vehicle for rural development will lead to an increased research and development effort on the part of the national agencies. Furthermore, increasing pressure from the rural sector and pluralistic governments that pay more attention

to equity issues will reinforce this trend. CIAT will continue to provide basic information to policymakers to assist them in the design and implementation of cassava-based research and development projects. As the national efforts become stronger, the Cassava Program's relationship with national programs will become more one of partnership than that of mentor. CIAT's direct role in setting up integrated projects will decrease as the interaction among national programs in the research, training and advisory areas increases. CIAT's role as facilitator of these relationships will increase. The needs of these projects will, however, be an important factor in determining research priorities of the CIAT program. The approach of integrated production, processing and marketing projects, used in Latin America, is dependent on interinstitutional cooperation within the countries and covers a wide range of areas and disciplines. In order to utilize the knowledge and experience of these diverse agencies more effectively, it is expected that they will become more involved in regional networks, particularly with regard to training and consultation activities.

Small local or regional cooperative networks are expected to become more important and will be the keystones of any larger continental scale formalized networks that evolve. Many of the national programs in these networks have skilled competent researchers who are not able to carry out their role effectively in the network due to lack of operational funds. CIAT will assist national programs in their efforts to obtain more support.

Advanced research institutes in both developing and developed countries are often at a loss to do useful science and finish up doing irrelevant work. The Cassava Program believes that in the case of an under-researched crop like cassava with such fascinating innate characteristics as being the only known crop plant that is a C_3-C_4 intermediate, it should be relatively easy to induce advanced research institutes to do basic and strategic research on cassava.

The Program's major focus in the area of institution building in the past has been in the area of advice and training. CIAT has carried out most of these activities using its own staff resources. Now that a number of national programs have become stronger and there is considerable cassava expertise within the National Agricultural Research and Development systems, it is expected that these resources will be increasingly used for training and consultancies. Furthermore, cooperation among national programs on projects of mutual interest and the interchange of technologies developed in different countries are expected to increase. The Cassava and Training programs will play the roles of facilitators and also assist in searching for financial and logistic support for these activities. To date, CIAT has been relatively effective in transferring technical skills and abilities; however, the areas of research and development planning and the related theme of diagnosis of problems or constraints need to be strengthened.

In Latin America the record of the growers federations in support of the interests of their members has been impressive. The Cassava Program will devote part of its institution-building efforts to the support of growers organizations in the coming years. The social science input projected in the Program will be important in supporting these activities.

Strategies for Development

The Green Revolution in rice was based on the irrigated sector which by definition has good infrastructure, a high level of social organization and good linkages to markets. The problem was simply that traditional varieties gave low yields; hence the correct action was to attack the main constraint, which was the low yield potential of tropical rice and wheat varieties. In a crop such as cassava, which is naturally very efficient in biological terms, the major constraints are frequently in the areas of access to markets, infrastructure and social organization, etc. Their improvement is normally classified as development work. Some clarification of the use of the word development and its relation to research is called for. Research and development are normally linked together as the process of designing, testing and producing a prototype product. Development per se refers to the improvement of the socioeconomic conditions of a community. It is the Program's premise that development methodologies can be improved by research. The Cassava Program is not involved in development projects per se; it undertakes research on development methodologies. A particular characteristic of these development methodologies is that they incorporate the research and development of the technology package as an integral part of the overall development process, thus giving a rural development scheme the capacity to design appropriate technology for its specific needs. The Cassava Program has already shown the effectiveness of this approach; however the administrative effort that results from being closely involved with development projects is large. The Program supports the idea of CIAT's assisting in the management of bilateral development-type projects, which would provide opportunities for study and research on development processes.