CIAT 1984

A Summary of Major Achievements during the Period 1977-1983

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CIAT 1984 is published in English and Spanish and is written to inform donors, collaborators, and the interested public of the highlights of CIAT's work. Results reported in this year's report reflect major accomplishments during the period 1977 through 1983

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CIAT's International Mandate

During the early months of 1984, CIAT participated in a Management Review and an External Program Review. These reviews are an operational part of our participation in the network of international centers under the aegis of the Consultative Group on International Agricultural Research. We welcome these reviews as an opportunity to assess the progress we have made since our last comprehensive review seven years ago.

Preparing for an External Program Review requires that we look back closely at the strategies developed by each of our programs. We can then match strategies with accomplishments and measure the progress of each program, and collectively, the progress of the Center. As we have gone through this exercise in recent months, it is clear that we have made considerable progress—in some cases, outstanding progress—in seven years. By most common measures, we believe our strategies are producing the desired successes. In some instances, we can measure very real impacts on increased agricultural production and improved welfare for peoples of the target regions.

We want to share these accomplishments of the past seven years with you in this CIAT Report for 1984. We do this with pride, not only in our own achievements, but with pride also in the accomplishments of many of the national programs with which we are working. Our overall strategy as an international center has been to do well the tasks we are best equipped to do, but at the same time, prepare and encourage national programs to assume those tasks they are most qualified to fulfill. Where accomplishments we report here are most tangible, this strategy has indeed been achieved.

As an introduction to this report, I want to briefly mention the contributions we as a center are expected to make toward improved technology. This will enable us to better understand how the CIAT commodity programs and support units relate to the overall development of improved agricultural technology. Our responsibilities include: germplasm development; on-farm research; training; networking; and, outposted regional staff. Another contribution implied by this choice of functions is strong support to national programs. The national programs, however, have the critical responsibility for producing final technology tailored for specific requirements of each country.

Each of our four commodity programs is now providing improved germplasm which is being selected for commercial use by national programs. Our Rice Program has the longest history of distributing advanced and finished lines. And, as might be expected over time, these activities are showing very positive impacts on irrigated, and even favored upland rice production in Latin America and the Caribbean. Our Bean Program also has furnished an impressive number of improved materials now in commercial production. High-yielding varieties of cassava are beginning to be adopted in some countries with the first CIAT-produced hybrids now being selected. The Tropical Pastures Program, even with its recent focus on locally adapted germplasm, has provided materials for release and commercial production.

On-farm research in cooperation with national programs is helping provide answers CIAT scientists need to develop their portions of technology packages. Work by the Cassava, Bean and Tropical Pastures programs in real farming situations have helped to identify problems farmers face and are guiding us in defining what new germplasm is needed and how it is to be managed.

CIAT has been active in training since the Center began operations. The type of training offered, however, has followed the Center's evolution. When commodity programs were young, training was very general and nearly always done in CIAT. As programs matured, training has become more specific. More recently, and with the increased capability of national programs to offer their own training programs, decentralization has occurred. In-country courses, often taught by CIAT-trained instructors, are common. These courses are supported as required by CIAT staff and CIAT-produced training materials.

The increased ability of national programs to accept, evaluate and select improved technology from CIAT and adapt it to their specific needs indicates that networks are present. This is indeed true, with each of the four commodity programs now showing strong groups of collaborating scientists who participate in the technology development and transfer process. Training has contributed greatly to establishing these networks, but so too have the efforts of CIAT staff in producing and offering viable technology. It is important to note that technology transfer is occurring not only from CIAT to national programs, but also horizontally among the national programs.

Positioning regional cooperation staff within certain areas should help speed up the technology transfer process. This is the most newly established component of our strategy, and it appears to be working well. Rapid progress is being made in Central America where outposted scientists are assisting national programs with bean improvement activities. More recent postings of one bean scientist each in Francophone Eastern Africa, Brazil, and Peru are expected to accelerate our development activities in these areas. Tropical Pastures Program scientists in Brazil have made valuable contributions on germplasm adaptation in the Cerrados ecosystem. And, a cassava scientist stationed in Thailand is helping speed up improvement of germplasm flow in that part of the world.

These responsibilities or commitments we have as an international center are the common theme of the progress we are reporting this year. Each of our programs employs these activities in differing degrees. We think, however, that our results prove they are a wise choice of contributions for fulfilling our part of improved technology development with the many national programs who are our cooperators.

John L. Nickel
Director General

The Rice Program

The major accomplishments of the Rice Program during the period 1977-1983 have been the continued development and distribution of high yielding, dwarf varieties selected for irrigated production systems.

That these improved materials were being grown on 76 percent of the irrigated rice land in the region in 1981-82 indicates the Program's efforts to maintain a flow of quality germplasm have been successful. In addition, these same materials have proven to be adapted to upland conditions where water supply in the growing season is not a limiting production factor. Excluding the upland areas of Brazil, which have largely unfavored conditions for rice production, the improved, dwarf varieties are also being grown on 60 percent of the region's favored upland area. As an example of the impact provided by this technology, CIAT analyses for the year 1981 have shown that the adoption of the newer varieties, along with associated production technology, increased rice production in Latin America by an estimated 2.7 million tons, or about 20 percent, and that this additional production was valued at more than $800 million dollars that year.

Rice in Latin America

Rice provides about 9 percent of the total calories in diets of the Latin American population. In Panama, rice contributes over one-quarter (26.3%) of the total dietary calories. The crop is also very important in Brazil, Colombia, Costa Rica, Cuba, the Dominican Republic, and Peru; in each country rice provides more than the regional average of dietary calories.

Survey data from several Central American countries show that urban consumers eat more rice than do people living in rural areas. Rice is a cheap caloric source, and it is stored easily. Thus, the strong urbanization movement of the region should continue to increase the importance of rice in diets.

Rice consumption by urban dwellers is also inversely related to income; those with the lowest income may typically spend twice as much of their food budgets for rice as do people in the highest income strata. A strong latent demand for rice has also been found in several cities.

Per capita rice consumption in the region averages 51 kilograms and ranges from lows of 10 kilograms in Mexico and 12 kilograms in the temperate South American countries to 84 kilograms in Brazil.

Yields in Various Production Systems

The average yield of rice in Latin America during the 1971-1981 period was about 1.9 t/ha. This figure, however, is highly influenced by production data from Brazil. This country has three-quarters of the total area planted to rice in the region, but average yields of less than 1.5 t/ha reflect the less-favored conditions under which the crop is produced.

On the other hand, Colombia, Peru and Uruguay have average yields of more than 4 t/ha, and Argentina, the Dominican Republic, El Salvador, and Mexico have national yields above 3 t/ha.

Differences in rice production between and within countries can usually be traced directly to the type of production system in use. CIAT recognizes six main cropping systems for rice in Latin America. Arranged from the highest to the lowest yielding system, they include:

- Irrigated rice
- Rainfed lowland rice
- Highly favored upland (no water stress; fertile soils)
- Moderately favored upland (some water stress; fertile soils)
- Unfavored upland (pronounced water stress and/or infertile soils)
- Subsistence upland.

Table 1 shows the approximate contribution of each system to total rice production in the region. While only one-quarter of the total area is planted under irrigated conditions, this system accounts for almost half the region's production. Upland production systems, however, utilize 72 percent of the total land resources but provide only 43 percent of total production.

During the first half of the period devoted to this report and for several years before that, the CIAT Rice Program concentrated its work on the irrigated rice sector. Beginning in 1981 the Program began to expand its activities into upland rice.

Table 1. Summary of estimated area and yield in major rice production systems of Latin America (1981).

System	Area (million hectares)	%	Average yield (t/ha)	Production (million tons)	%
Irrigated	2 1[1]	0.24	3.5	7.4	0.46
Rainfed	0.4[2]	0.04	2.5	1.0	0.11
Upland:					
- Favored	2.1[3]	0.23	2.0	4.2	0 17
- Less-favored	3 4[4]	0 38	0.9[4]	3.0	0.23
- Manual	0 9	0 10	0.6	0.5	0 03
Total	8.9	1.00	1.8	16.1	1.00

1 IRTP, Report on the Fifth Conference. CIAT-IRRI, May 1979.

2 It includes areas in Dominican Republic, Haiti, Ecuador (Pozas System) and Brazil (Varzeas).

3 Located in Mexico, Costa Rica, Guatemala, Venezuela, Colombia, Ecuador, Peru and Brazil (non-Cerrado upland rice). It includes favored and moderately favored rice systems.

4 Estimated as residual.

SOURCE: CIAT, IRTP, Report of the Fifth Conference.

Development of a Rice Improvement Network

Much of the network activities for rice production improvement in Latin America are centered on the International Rice Testing Program for Latin America (IRTP/LA). This project was organized in 1976 as a joint effort between CIAT and the International Rice Research Institute (IRRI).

The primary function of the IRTP/LA is to evaluate and distribute improved germplasm to national programs in Latin America. Germplasm may come from the breeding programs of CIAT, IRRI, or any national program. A number of nurseries are assembled each year and made available for testing under a range of production systems and against several constraints. National programs may also request special nurseries directly from IRRI.

Complementing the actual IRTP evaluations are biannual conferences for reviewing progress and discussing future plans of the project. The conferences are used to offer cooperators the opportunity to hear about CIAT's rice research achievements and plans. The IRTP also sponsors tours to certain areas each year to observe IRTP

Table 2. New rice varieties nominated by national programs in Latin America in 1981 and 1982.

Country	(Institution)	Commercial name[1]	Year
Brazil	(Instituto Agronómico de Campinas)	IAC 1278*	1982
	(Empresa de Investigación Agricola de Minas Gerais)	INCA 4440*	1982
Colombia	(Instituto Colombiano Agropecuario)	ORYZICA 1	1982
El Salvador	(Centro Nacional de Tecnología Agrícola)	CENTA A 2	1982
		CENTA A 3	1982
Guatemala	(Instituto de Ciencia y Tecnología Agrícola)	TEMISQUE	1981
Mexico	(Instituto Nacional de Investigaciones Agrícolas)	CARDENAS A 80*	1981
Panama	(Universidad de Panama)	TOCUMEN 5430	1982
Venezuela	(Fondo Nacional de Investigación Agropecuaria)	ARAURE 2	1982

1 *Selected from nurseries of the International Rice Testing Program for Latin America; all other lines are from materials originating in the CIAT-ICA Rice Program.

nurseries during growth, research being conducted at experimental stations, and commercial rice production.

The IRTP/LA is a very effective project in terms of its regional coverage with 24 countries in Latin America and the Caribbean participating. In 1982 countries selected 140 lines from all IRTP nurseries for use as parental materials in rice breeding, and another 147 lines were selected for yield trials. Table 2 shows the new varieties nominated in various countries in two recent years.

CIAT's training activities help to support the IRTP and individual national programs of the region. A total of 274 persons has been trained by the Rice Program since its inception, with two-thirds of that number trained since 1977.

Solving Major Constraints in Rice Production

The potential of improved varieties like CICA 8 to average 5 t/ha or more under irrigation is considered quite good. Breeders believe it will be difficult to obtain very much more yield using conventional techniques. Their primary objective in breeding for irrigated conditions is to maintain the stability of present yield levels.

Important production constraints found in several areas where irrigated rice is produced include rice blast (*Pyricularia oryzae*), the hoja blanca virus, leaf scald (*Rhynchosporium oryzae*), brown spot (*Helminthosporium oryzae*), and sheath blight (*Thanatephorus cucumeris*). Other constraints include iron toxicity on some acid soils, lodging, low temperatures in several rice-producing countries, and lack of suitable grain quality. The plant hopper (*Sogatodes oryzicola*), also the vector of the hoja blanca disease, is the most important insect pest on rice throughout the region.

Under upland production conditions, many of the above problems occur more frequently and exert more serious pressures on plant growth and yields. Upland rice has an additional group of constraints resulting from environmental stresses: drought, and soil problems resulting from mineral deficiencies or toxicities.

Resistance sources are available for all major production constraints; the task is to select and incorporate them

Iron toxicity is a major problem on acid soils of Latin America Much of the rice is produced on these soils under upland conditions. CIAT has begun intensive breeding and screening work at Villavicencio, Colombia.

in the proper combinations for production systems of a given area. One important example is rice blast which is a problem in many areas of Latin America.

This disease can affect both the foliage and the panicle of the plant, and yield losses are estimated to average 15 to 20 percent. The pathogen is able to develop virulent races and attack resistant genes in new varieties; accordingly, new varieties seldom last more than three or four years before their resistance breaks down. The Program has employed several breeding and evaluation techniques in continuing to produce blast resistant germplasm. All breeding materials generated by the Program from F_3 onwards are planted for evaluation under upland conditions. Blast, and other diseases, are more severe under upland environments and conditions.

Decentralization of Breeding and Evaluation Activities

Disease and insect pressures are relatively low at CIAT-Palmira so the Rice Program has always conducted simultaneous evaluations at other locations within and outside of Colombia. In 1981, the breeding portions of the Program began to move to decentralize from CIAT headquarters into areas more representative of several rice production systems.

Two locations in Panama (Rio Hato and Tocumen) were made available through an agreement with the Instituto de Investigación Agropecuaria de Panamá (IDIAP) as sites for evaluating segregating generations of upland and irrigated materials. Late in 1982 CIAT began working on the Santa Rosa station in eastern Colombia under an agreement with the Colombian Federación Nacional de Arroceros (FEDEARROZ), and shortly afterwards the Instituto Colombiano Agropecuario (ICA) provided the long-term use of an additional 16 hectares of acid savanna land at its La Libertad station, adjacent to Santa Rosa. Rice production ecosystems and probable target areas for which work on these stations will be most useful are shown in Table 3. Selection and evaluation work will continue in Peru (for upland and irrigated systems) and at Nataima, Colombia, for irrigated conditions.

This decentralization has left the CIAT headquarters site as a base for the crossing program and some

Table 3. Target area for decentralized rice testing and selection sites.

Sites	Ecosystem	Target Areas
Santa Rosa (Colombia) and Tocumen (Panama)	Favored upland	Major part of Central America; Colombia, Venezuela, Bolivia, Peru, Brazil (Rondonia, Acre), Ecuador, Chiapas, Tabasco
Rio Hato (Panama)	Less favored	Mexico (Quintana Roo, Uxpanapa), Guatemala, (Cuyuta, Valle del Tempisque), Costa Rica (Liberia, Cañas), Panama (Central Province), and some areas in Nicaragua, Honduras, and El Salvador
La Libertad (Colombia)	Savanna	Plains of Colombia, Venezuela, and Guyana; Brazil (Matto Grosso del Norte and Porto Velho), Peru (Yurimaguas), and Mexico (Balancan area)

evaluation services. Most field research is now done at the other sites.

Impact of Diffusion of Improved Irrigated Rice

Efforts directed to the irrigated rice sector have had a substantial impact on production and availability of rice for consumers. Most countries of the region grow at least some of their rice under irrigated conditions, and so the improved, high-yielding varieties and technology developed by CIAT and national programs have generally helped provide widespread benefits.

The Rice Program has worked first with irrigated rice for three reasons. First, this sector offered the greatest opportunity for rapid results. Second, technology for irrigated rice was more easily generated and transferred than that for other production systems. Finally, the use of limited resources for only one production system was expected to provide the critical mass required for impact.

Germplasm development and distribution have been dual strategies of the Program since its founding in 1968. Cooperative work with ICA led to development of the CIAT/ICA rice varieties CICA 4 (1971), CICA 6 (1974), CICA 7 and CICA 9 (1976), and CICA 8 (1978). These same varieties have been adopted by several other countries of the region in various years or their original lines released under other names. In addition, several other materials from the CIAT/ICA breeding program or the IRTP have been selected and released.

Peruvian scientists crossed parents selected from International Rice Testing Program nurseries to produce Inti, the dwarf variety being selected here.

An important and unexpected spinoff from breeding and selecting materials for irrigated rice systems has been the adoption of certain improved materials for upland rice production; this has occurred primarily in the most favored upland system. Table 4 shows the degrees of adoption of improved, high yielding varieties of rice in various areas of Latin America.

Figure 1 shows the estimated rate of adoption of HYVs over time for Latin America, including and excluding

Table 4. Irrigated and upland rice area (in '000 ha) and the use of high-yielding varieties (HYVs) in Latin America (1981-82).

Country or Region	Irrigated Rice			Upland Rice			Total Area		
	Total	HYVs	HVYs/ % total	Total	HYVs	HVYs/ % total	Total	HYV	HVYs/ % total
Mexico	96.4	86.4	90	110.6	80.0	72	207.0	166.4	80
Central America and the Caribbean[1]	427.3	295.8	69	298.1	164.3	55	725.4	460.1	63
Brazil	740.6	592.5	80	5897.8	163.0	3	6638.4	755.5	11
Andean Countries[2]	636.2	582.2	92	408.7	254.5	62	1044.9	836.7	80
Southern Cone[3]	199.3	48.2	24	11.0	0.0	0	210.3	48.2	23

1 Includes Belize, Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, and Suriname

2 Includes Bolivia, Chile, Colombia, Ecuador, Peru, and Venezuela.

3 Includes Argentina, Paraguay, and Uruguay

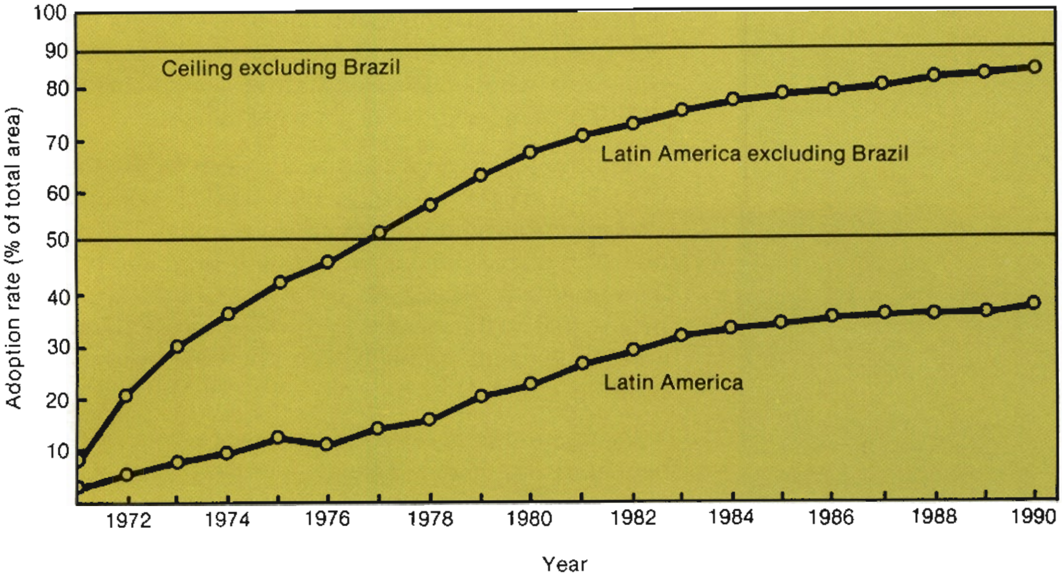


Figure 1. Apparent and estimated adoption of high yielding rice varieties in Latin America.

Brazil. The curves assume a ceiling rate of adoption for each country based on the production system encountered during the 1981-82 season. This feature assumes that adoption of HYVs will not occur under less favored or manual upland conditions.

When yield increases due to the use of HYVs (estimated at 1.2 t/ha) are multiplied by the number of hectares on which HYVs are grown, additional rice production in 1981-82 was about 2.7 million tons for Latin America. On the average across the entire region, the increased production in 1981 from the adoption of HYVs was 20 percent, compared to a no-adoption situation. At 1981 world market prices for rice, this additional production was valued at over $854 million dollars that year.

Economic analyses indicate remarkable benefits from investment in Latin American rice research by CIAT and collaborating national programs. Gross monetary benefits from the additional production from HYVs were estimated from the average Latin American rice export price, the 1.19 t/ha yield advantage of the HYVs, and adoption curves for Latin America. These benefits were then deflated to 25 percent of the total to account for other costs that could not be estimated. Only estimated total costs for irrigated rice research in CIAT and programs with breeding projects and who collaborated either with CIAT or the IRTP/LA were used to calculate net benefits.

Returns to research monies spent from the time the CIAT Rice Program began in 1968, both for periods up to 1981 and projected to 1990, are substantial. The internal rate of return, which measures the profitability of the investment, is almost 90 percent in both cases. This means, that on the average, every dollar invested generates another 90 cents annually from the time of investment until the cutoff date.

Using another measure of research efficiency, a high benefit/cost ratio of 6 calculated for the period from 1968 to 1981 should double by 1990. This will occur as adoption of HYVs continues in the region but as research costs for irrigated rice are reduced and are estimated to average only 60 percent of their 1981 level.

The Bean Program

The Bean Program has developed a vigorous network of bean research in Latin America since 1977. This accomplishment has enabled the Program to decentralize some of its primary activities especially in Central America. Scientists in the network have identified and distributed germplasm which carries resistance or tolerance to most of the bean problems in the region; some materials now show multiple resistance to important production constraints. As a result of the development of the Latin American network and the Program's well-organized system of germplasm evaluation and distribution, over 30 improved lines and existing varieties have been released by national bean programs.

Active collaboration has been initiated with bean research programs in the Middle East and especially Eastern Africa. A CIAT bean breeder was outposted to Rwanda in 1983 to help in developing improved germplasm to overcome production constraints found in the Great Lakes highlands of Eastern Africa; other scientists will be posted there soon. Several CIAT-developed materials have already shown good adaptation to this region, and two varieties have been released for production.

Beans as a Food Staple

Beans are a critically important crop in many countries of the developing world. People in Brazil, Burundi, Rwanda, and Uganda depend on dry beans as their main source of protein. Beans are the main source of non-cereal proteins in Angola, the Dominican Republic, Guatemala, Haiti, Kenya, and Tanzania. Annual per capita consumption in these countries may be as much as 40 kilograms, which provides over 30 percent of one's protein intake and 10 to 15 percent of all calories.

The Latin America and Caribbean region is the leading production area for dry beans in the tropics. Countries of this region harvested some 4.1 million tons annually during 1979-81. Countries in Sub-Saharan Africa are the second largest producers, harvesting about 1.7 million tons annually in that same period.

Yields and production have not, however, kept pace with population growth and demand. Average yields in tropical Latin America and Africa have typically been 500 to 600 kg/ha for the past 20 years. African per capita bean production fell 10.7 percent in the 1970s and the region changed from a net exporter of food legumes to a net importer. Tropical Latin America and Africa imported record quantities of beans in 1980. Their combined total imports, estimated at 700,000 tons, cost these regions nearly half a billion dollars at world market prices.

The Bean Program's mandate is to stabilize dry bean production at high levels, especially in regions where the crop is so important in human diets. Fulfilling this mandate, however, is not simple. Beans are grown under such a wide range of environmental conditions, in several production systems, and in the face of such diverse consumer preferences that a single variety—let alone several varieties—cannot possibly be adapted to local conditions and accepted by consumers over a wide area.

Beans, grown with other crops like maize, are extremely common on small farms because of their protein contribution to the basic diet.

Priorities for Increasing Bean Production

The Bean Program has defined its research priorities to mesh with small farm production systems. Emphasis is on developing technology requiring as few purchased inputs as possible, while relying on the incorporation of desirable characteristics into improved bean genotypes. The main objective of the Program then, is to develop and distribute improved germplasm in target areas. These materials contain, insofar as is practical, multiple disease and insect resistance, tolerance to drought and, in certain cases, tolerance to moderately acidic soils low in phosphorus. Such germplasm should reduce production risks and stimulate farmers to utilize improved management, including increased inputs.

The great diversity of ecological conditions in areas where beans are grown and the need to produce beans of so many sizes and colors, dictates that development and evaluation of improved lines be done at the local level as much as possible. The same is true for the specific agronomic practices developed for new varieties.

Local evaluation and adaptive research can only succeed if well-trained researchers are available within a cooperative network. These scientists must understand the types of materials needed in their specific areas and be able to manage tests, evaluate large numbers of materials, and make intelligent selections of those few lines best adapted to local conditions and needs. Training and network building are, therefore, strong secondary objectives of the Program.

Producing and Distributing Improved Germplasm

The Bean Program uses a two-stage strategy in producing improved germplasm. The first component is character improvement—the development of maximal expression of a character in a diversity of genotypes by accumulating different genes for that character.

CIAT bean team personnel evaluate germplasm from several sources in seeking desired characters. The central source is the richly diverse *Phaseolus* germplasm bank of more than 33,000 accessions.

The quality of the germplasm, with regard to desirable characters, varies from commercial varieties to wild relatives of the common bean. In many instances, desirable traits are expressed too weakly to directly solve a particular production constraint, and recurrent breeding programs are needed to improve them.

The *Phaseolus* Germplasm Bank

The Genetic Resources Unit has played a leading part in supporting the collection, maintenance and distribution of *Phaseolus* germplasm. Since the beginning of 1977, the number of accessions on hand at CIAT has increased from about 13,000 to more than 33,000. About 89 percent of the present collection is cultivated and wild ancestral forms of *P. vulgaris*. The remainder consists of cultivated and wild ancestral species including *P. lunatus*, *P. coccineus*, *P. acutifolius*, and others. Practically all of these related species have been added during collections in recent years to help amass genetic variability for use in bean character improvement breeding.

Acquisitions have come from collections held by other institutions or in specific collecting trips to most countries of tropical Latin America, the center of genetic diversity of *Phaseolus*. More recently, germplasm has flowed into CIAT from expeditions in Africa and Asia funded by the International Board for Plant Genetic Resources (IBPGR).

The collection is now thought to represent a good percentage of the existing genetic diversity of *P. vulgaris*; however, additional collections still need to be made to obtain landraces of this species and germplasm of other wild species.

Materials entering CIAT are grown out for seed increase under quarantine regulations from the Instituto Colombiano Agropecuario (ICA). More than 15,000 accessions of *P. vulgaris* have been evaluated for 12 primary characteristics, in addition to other information on reactions to pest and disease attacks.

The Unit is also working to characterize and evaluate materials of the related species. The aim is to quantify the genetic variability in *P. vulgaris* germplasm, especially, and in the entire genus *Phaseolus*, in general.

In order to maintain the *Phaseolus* collection more efficiently, the Unit has developed short- and long-term storage techniques based on precise temperature control and seed moisture content. The working collection is kept under short-term conditions with the materials being renewed every five years. Under long-term conditions, it is estimated that samples will maintain the original 90 percent germination at least 25 years. This base collection is for the preservation of genetic variability for the future.

The Genetic Resources Unit is also responsible for preparing and distributing bean germplasm both within and outside of CIAT. In five years of this activity, the Unit has shipped almost 100,000 samples, about one quarter of which was to fill requests from workers in 58 countries.

No matter what the source of germplasm, the primary task is to carefully evaluate materials under sufficient pressure from each constraint that is to be overcome. Materials are then selected that have apparently acceptable levels of desired characteristics. These are used in the second stage of germplasm development, breeding to consolidate or recombine multiple factors into commercial cultivars to meet the needs of particular ecological regions.

Uniform Screening of Improved Bean Materials

One of the most important accomplishments during 1977 and 1978 was the installation of a set of uniform screening tests for evaluating bean germplasm in the character and cultivar improvement stages.

Bean team members initially select promising materials from CIAT's character improvement projects, national breeding programs, the CIAT germplasm bank, or multiple factor recombination projects to form the Bean Team Nursery (VEF). The approximately one thousand entries of this annual nursery are screened for resistance to angular leaf spot, anthracnose, bean common mosaic virus, common bacterial blight, rust, and leafhoppers, and for adaptation in two Colombian localities—CIAT-Palmira and CIAT-Popayan, 965 and 1850 meters above sea level, respectively.

Some 300 entries are selected from the VEF for evaluation in the Preliminary Yield Trial (EP). The EP consists of replicated yield trials under low and adequate inputs at two or more sites within Colombia and other locations. Entries in the EP are tested for many other characteristics not considered in the VEF including yield.

The final stage in the evaluation process is the International Bean Yield and Adaptation Nursery (IBYAN). It was established in 1976 to help distribute promising materials from breeding projects of CIAT and other programs in several countries. In breeding terms, entries in the IBYAN were finished or nearly finished varieties.

As breeding and evaluation activities in CIAT's Bean Program and programs of the Latin America countries have matured, important changes have been introduced

CIAT's network for distributing improved lines and varieties of beans has enabled Burundi to evaluate and release the Colombian variety Diacol-Calima, sold here in an open market.

in the evaluation scheme discussed above. These changes represent a continued decentralization of selection. For example, in 1981 the Adaptation Nursery (VA) was added to enable countries to test more materials under their local conditions and involve local scientists in selecting crosses to be made. The VEF is later selected from this nursery. Also, the National Yield Nursery (VINAR) and the Regional Yield Nursery (VICAR), corresponding to the EP and the IBYAN, respectively, were developed especially for Central America.

Evolution of Distribution of Improved Germplasm

CIAT's bean germplasm improvement and distribution activities have contributed to the release by national programs of more than three dozen bean varieties since 1977. Four types of germplasm distribution are represented (Table 1).

In the first case, superior accessions in the CIAT germplasm bank were made available, mostly through the IBYAN. These materials were often varieties or germplasm bank entries already being grown in other areas. This was an effective means of making improved germplasm available before the breeding program had superior material available for evaluation. Outstanding examples were the adoption of the Colombian varieties ICA-Pijao in Bolivia,

Table 1. Methods of distributing germplasm within the bean improvement network.

Identification	Country of origin	Country of new release	Year of release	New varietal identification
		Stage I: CIAT Germplasm Bank Accessions Released as New Varieties		
Diacol Calima	Colombia-ICA	Burundi	1979	Diacol Calima
Redkloud	USA-Cornell University	Chile	1978	Redkloud
E 1056	Ecuador-Univ. Loja	Colombia	1982	ICA-Llano Grande
ICA COL 10103	Colombia-ICA	Costa Rica	1980	Talamanca
ICA-Pijao	Colombia-ICA	Cuba	1978	ICA-Pijao
ICA-Pijao	Colombia-ICA	Guatemala	1978	ICA-Suchitan
ICA-Pijao	Colombia-ICA	Bolivia	1978	ICA-Pijao
Brazil 2	Brazil	Ecuador	1977	INIAP-Bayito
E 1056	Ecuador-Univ. Loja	Ecuador	1983	INIAP-400
G2829	Mexico	Peru	1982	Gloriabamba
ICA L 23	Colombia-ICA	Brazil	1983	EMPASC 201-Chapeco
		Stage II: Superior CIAT Improved Lines Released as New Varieties		
BAT 7, 76, 304, 448	-	Argentina	1981	BAT 7, 76, 304, 448
EMP 84	-	Argentina	1982	EMP 84
BAT 64	-	Brazil, Minas Gerais	1982	Rico 1735
BAT 65	-	Brazil, Minas Gerais	1982	Milhionarios 1732
BAT 179	-	Brazil, Esp. Santo	1983	Vitoria
BAT 304	-	Brazil, Esp. Santo	1983	Capixaba Precoce
BAT 76	-	Bolivia	1978	BAT 76
BAT 304	-	Costa Rica	1981	Brunca
BAT 202	-	Cuba	1982	Hatuey 2
DOR 15	-	Cuba	1982	Tomeguin 1
EMP 84	-	Cuba	1982	Tomeguin 2
BAT 58	-	El Salvador	1981	Tazumal
BAT 41	-	Nicaragua	1979	Revolución 79
BAT 789	-	Nicaragua	1983	Revolución 79A
A 40	-	Nicaragua	1981	Revolución 81
BAT 1215	-	Nicaragua	1983	Revolución 83
BAT 317	-	Rep. South Africa	1982	Cordoba
		Stage III: Local Selections from CIAT-provided Segregating Populations		
-	-	Costa Rica	1982	Huetar
-	-	Costa Rica	1982	Chorotega
-	-	Costa Rica	1982	Corobici
-	-	Guatemala	1980	ICTA-Quetzal
-	-	Guatemala	1980	ICTA-Tamazulapa
-	-	Guatemala	1980	ICTA-Jutiapan
-	-	Honduras	1980	Acacias 4
-	-	Honduras	1982	Copan
		Stage IV: Horizontal Transfers between Countries		
ICTA Quetzal	Guatemala	Argentina	1982	DOR 41
D-145	Guatemala	Mexico	1981	Negro Huasteco 81

Cuba, and Guatemala, and Diacol Calima in Burundi. The United States variety Redkloud was released in Chile.

As promising new lines began to emerge from the various projects, some of these were carried through the germplasm improvement process into finished varieties. The Bean Program does not emphasize the production of finished lines, especially as national programs mature and are able to accept greater responsibility for materials under local conditions. However, CIAT-bred lines that have been adopted include: BAT 76 in Argentina and Bolivia, BAT 304 in Argentina, Brazil and Costa Rica, and EMP 84 in Argentina and Cuba.

The more common route in recent years and for the future is for the CIAT program to make segregating populations available to national programs for evaluation and selection. This represents the third stage of distribution. Examples in this stage include the three selections made in 1980 by Guatemala (ICTA- Quetzal, Tamazulapa, and Jutiapan), three made in Costa Rica in 1982 (Huetar, Chorotega, and Corobici), and the Honduran selections Acacias 4 and Copan made in 1980 and 1982, respectively.

Finally, CIAT will continue to facilitate the horizontal transfer between countries of new varieties developed either by national programs alone or in collaboration with CIAT. For example, the variety ICTA-Quetzal was originally selected and released in Guatemala and is now grown on over 15,000 hectares in Argentina.

The Bean Program's expanding decentralization activities will ensure that improved varieties like this high-yielding climber will continue to reach farmers.

Development of a Bean Improvement Network

Part of the facility with which improved germplasm is transferred between Latin American countries is due to the viable network of cooperators now in place. Training, workshops, conferences, communications materials, and personal visits have all been utilized to build and maintain the network.

The deployment of regional cooperation staff from CIAT has also contributed greatly to building the chain of cooperators and to decentralizing research activities away from CIAT-Palmira. They are expected to assist in training national program staff and help national program

In 1983, CIAT assigned the first of four outreach scientists to work in Francophone Africa. Improved varieties developed from selections made in fields such as this one in Rwanda will continue to provide the main source of protein in these countries.

scientists to better plan and evaluate nurseries and other experiments.

The earliest outposting effort was in Central America where a team composed of a breeder, a pathologist-coordinator, and an agronomist has been working since 1978. These scientists have been able to work within national programs to overcome production constraints that can best be studied in local areas of Central America.

More recently, a scientist has been stationed in Goiania, Goias, Brazil, in cooperation with CNPAF. Emphasis there is on developing both screening methods and germplasm adapted to low pH soils containing low amounts of phosphorus. This researcher is also collaborating with Brazilian scientists to help create a national bean nursery scheme.

A plant breeder was stationed in Peru to work on a bilateral project to breed bean varieties for ecosystems not present at CIAT locations. Finally, in 1983, the first CIAT scientist in Africa assumed his duties in Rwanda. He soon will be followed by a pathologist, an anthropologist, and an agronomist as the first components of the outreach plan in Africa.

Decentralization of Bean Breeding and Evaluations

Between 1977 and 1983, the Bean Program has helped train within CIAT 476 persons at various levels. The Program has also assisted in 25 in-country courses in which more than 700 persons have participated. These latter courses have most frequently been held in conjunction with the release of new varieties and are designed to improve the capacity of national research and extension services to support diffusion of these varieties.

More recently, on-farm research has been initiated with training at CIAT and through in-country and regional courses. The objective is to improve the feedback of information from farms to the experiment station, and to ensure that newly developed germplasm is appropriate for the often rigorous conditions for which it is destined.

With the training of a critical mass of cooperators and continued support from CIAT staff, the Bean Program has been able to decentralize a considerable part of breeding and evaluation activities for some areas. In Central America, for example, testing for resistance to bean golden mosaic virus (BGMV), web blight, *Apion*, and rust and for adaptation to the traditional relay cropping systems is now done largely within the area. Evaluations for resistance to bean common mosaic virus (BCMV), common bacterial blight, and *Empoasca* in materials destined for Central America, are still performed mostly at CIAT.

In implementing a decentralization strategy, the Bean Program and its collaborating national institutions do not seek to have each country work on all problems. Rather, research and evaluation for a particular production problem are concentrated in one country where the national team is trained and equipped to deal with specific problems. Then improved materials or agronomy can be transferred horizontally between countries.

The work to solve BGMV and web blight problems is a good example. Initial crosses and preliminary selections were made in CIAT, then materials were sent for continued selection in countries where disease pressure was heaviest. A great part of the BGMV evaluations was done in Guatemala using a modified recurrent selection program.

Levels of tolerance were raised to where new varieties such as ICTA-Quetzal and others possessing such tolerance have been adopted by farmers first in Guatemala and later in other countries.

Surveys show that almost half of the small bean farmers in Guatemala have adopted the new, BCMV resistant varieties developed by CIAT in coordination with ICTA. These varieties are also being used in areas where bean production previously was abandoned due to the virus. Largely as a result of the introduction of these new materials, Guatemala has now reached self-sufficiency in bean production.

Web blight is a major constraint under the moist-warm environments of the lowland tropics in Mexico, Nicaragua, El Salvador, Costa Rica, Guatemala, Panama, Brazil and Argentina. Much of the screening for resistance was conducted especially by Costa Rican scientists. Lines such as HT 77-16, with intermediate levels of resistance under severe disease pressure, have now been identified. When combined with improved cultural practices, these lines offer an integrated control of the disease. Collaborative economic surveys show that more than 60 percent of the bean farmers are growing these tolerant varieties.

Figure 1 provides some idea of the present state of the Bean Program's decentralization work. In Central America, where national programs are collectively the most advanced, the large number of segregating populations and materials entering the region indicates that much of the evaluating and selecting will occur within countries. Conversely, in Africa, where most materials entering the region are parental lines, the major activities in the new future will consist of selecting the best parents for crossing back in CIAT.

Adoption of New Varieties

In addition to the acceptance of new bean materials documented in the previous section, other cases may be selected to show farmer adoption of improved beans. Argentina introduced new CIAT germplasm in 1979 for testing, and some of these materials are now planted on 30,000 hectares, or 80 percent of the black bean area of that country. Only short seed supplies from the increased production areas prevented complete coverage with

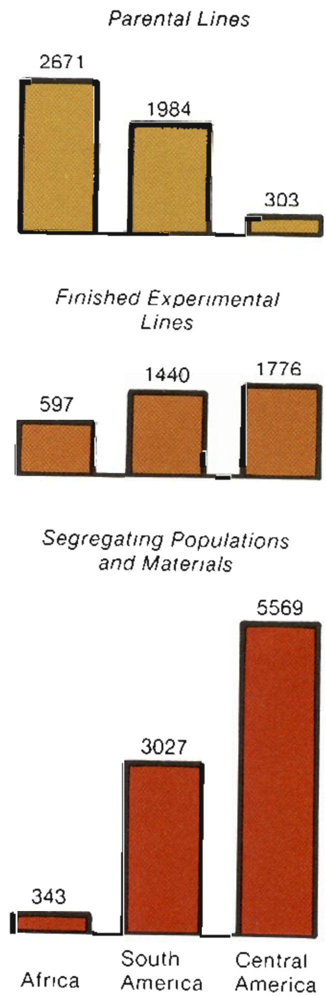


Figure 1. Decentralization of bean germplasm activities, as represented by germplasm shipments during 1983.

improved varieties. The yearly value of the increased production and reduced cost of production in 1984 is estimated at $8.4 million dollars.

The IBYAN trials have furnished several varieties (such as Carioca, ICA-Pijao, and the CIAT-bred line BAT 76) which are being grown in the Santa Cruz area of Bolivia due primarily to their rust resistance and stable yields. A 1978 survey showed 11 hectares of beans in the local area, but in 1983, 4500 hectares around Santa Cruz were planted to beans. Beans have shown up for the first time for sale in supermarkets around the city.

The Cassava Program

The Cassava Program has made significant progress in developing improved production technology for a crop about which relatively little was known only a decade ago. Simple, low-cost cultural practices have been successfully tested and applied in many countries, and breeding efforts to introduce resistance to major biological constraints and to improve yields of hybrid materials are producing exciting new lines for evaluation as potential varieties. The Program's definition of edaphoclimatic zones for cassava production has made it possible to focus breeding and selection activities to meet specific, local needs.

Personnel training and consulting by Program members have helped several countries organize cassava research and development projects where little or no work had been done before and these efforts are beginning to result in increased production and more effective utilization of cassava.

Cassava as a Tropical Crop

Cassava production embodies interesting contrasts in tropical agricultural production. After rice, maize and sugarcane, cassava is the most important carbohydrate source grown in the tropics. In terms of its tropical distribution range, it is probably comparable to maize. Unlike rice and sugarcane, it is hardly ever irrigated.

Until some 10 to 12 years ago, little research had been done to understand how this important crop grew, to what degree yields could be increased by breeding and better management, and how the roots could be utilized more efficiently. Due to the fragmented research and development policies most producing countries assigned to the crop in the past, questions arose about how any increased production would be absorbed and utilized.

Although the product deteriorates very rapidly after harvest, efficient marketing infrastructures can move and sell the fresh roots at reasonable prices. In addition, processing and marketing industries can transform and utilize end products such as flour and animal feeds. These resources and markets are available in numerous countries.

Improved technology that will increase cassava productivity implies then that attention must also be given to overall development of the crop. Benefits from this dual approach can be expected to have impacts on nutrition, small-farm incomes, and balances of payments in tropical Third World countries.

CIAT's Responsibility for Cassava Development

CIAT has the global responsibility among international agricultural research centers of creating improved cassava production technology with special emphasis in Latin America and the Caribbean and in Asia. The International Institute for Tropical Agriculture (IITA) works with the crop in Africa.

Within CIAT's regions, cassava production and utilization take several forms. In Asian countries like India and Indonesia, virtually all production is utilized domestically, whereas, in Thailand about 75 percent of the crop

Cassava is a valuable crop in Indonesia with almost all of that country's production utilized domestically.

produced is exported to Europe. In Asia as a whole, about 60 percent of all cassava is used as food.

People in Latin America still utilize cassava in traditional forms, either for fresh consumption or processed for food uses. It may also be fed fresh to swine in on-farm feeding systems. Little or no processed cassava is exported from the region, but 70 percent of the crop is marketed so that cassava is very much a cash crop.

About 60 percent of the cassava farmers in Latin America have farms of 10 hectares or less, and almost one-half of the cassava area is intercropped, most frequently with maize. The wide use of intercropping adds another important dimension to creating new production technology.

Priorities for Developing Cassava Production Technology

In order to produce new technology for cassava production, Program scientists first had to develop more information about the basic biology of the crop, the pests and diseases that affect it, and its responses to broad environmental factors such as temperature, moisture availability, and soil fertility. At the same time, they had to solve some problems of infrastructure to facilitate future technology transfer.

As national agricultural programs had paid little or no attention to developing the crop, formal, organized groups of specialists were practically nonexistent. The CIAT Program had not only to train personnel to solve general and specific problems, but in many cases it had to help organize national programs.

The problem of prohibited movement of cassava vegetative materials between many countries because of the threat of disease dissemination was another serious constraint. While true sexual seed of the plant could be exchanged more freely, the lack of trained personnel to accept, grow out and evaluate new plants hindered the effective exchange of seed.

Because the major long-term contribution was to be improved germplasm, a breeding program seeking higher yielding hybrids was begun using germplasm accessions which could be collected, assembled and evaluated in CIAT, and other locations in Colombia. At the same time, intensive interdisciplinary research was initiated to study which crop and plant characteristics were associated with high, stable yields. Researchers knew that cassava had high yield potential, but high yields could not be obtained consistently. Unlike many other crops, cassava did not always give high yields with conventional inputs such as increased plant populations, higher fertility levels and irrigation.

Improved Cultural Practices

The CIAT cassava team recognized that better, more stable yields were possible in the short term if farmers used improved cultural practices. Included among these practices were stake selection, weed control, planting density, and intercropping relationships.

Cassava has no organized "seed" industry; instead, farmers plant stem pieces from the previous crop. Two of cassava's most important diseases—cassava bacterial blight and African mosaic disease—are transmitted on infected stem cuttings.

CIAT workers found that planting disease-free cuttings obtained after careful selection and propagation techniques will delay the onset of a severe infection and, in some instances, even eliminate the disease. The procedure has been used in Brazil, Colombia, Cuba, and Malaysia to produce blight-free planting material. Farmers in Costa Rica and the Caicedonia area of Colombia have erradicated the disease by planting only blight-free stakes. Low-cost mixtures of fungicides and insecticides that protect stakes from the superelongation disease, soil

The Cassava Germplasm Bank

The Genetic Resources Unit has provided very significant support to the Cassava Program by developing tissue culture procedures for handling cassava germplasm *in vitro*. These procedures have opened the way for propagating cassava plantlets free of pests and diseases; for moving germplasm with minimum risks of introducing undesirable pests and pathogens; and for conserving germplasm in limited space, protected against disease outbreaks, pest infestation, and climatic and soil problems.

During the past four years, 745 cassava varieties have been cultured free of frog skin disease, and other viral, bacterial and fungal diseases. The new plantlets were produced through *in vitro* culturing of meristem tips excised from sprouts grown under thermotherapy.

The Unit has recently found that plants of traditional cassava cultivars grown from meristem cultures yield more than 50 percent more roots and planting material than plants grown from stakes. This is thought to be due to erradication of certain negative factors such as diseases and viruses which may be present to affect plant vigor and physical characteristics but are not expressed visually.

Meristem culture methods have enabled the flow of germplasm to occur to and from CIAT and between national programs. Over the past five years, 1348 cassava varieties have been transferred to CIAT from several existing national collections and from collection expeditions throughout the major center of variability. This activity has helped increase the total cassava collection at CIAT to more than 3400 accessions.

As national program personnel have been trained in tissue culture techniques, the flow of cassava varieties has accelerated. More than 400 varieties were shipped in this manner during the last five years. Beginning in 1983, a set of 40 to 50 elite varieties selected by the Cassava Program was made available as *in vitro* cultures.

A "minimal growth storage" technique was developed to retard the growth of meristem-derived cultures so they need to be transferred to new media only every 18 to 24 months. Over 2000 cassava varieties (58% of the total CIAT collection) have been placed into *in vitro* storage.

pathogens, and surface pests such as scales, mites and mealybugs have also been defined.

At recommended planting densities, cassava is slow to cover the ground surface with a canopy. Research proved that properly timed weedings during the first three to four months of growth can raise yields. Even when labor was scarce, two properly spaced weedings helped boost yield to 77 percent of that obtained from a cleanly weeded field. Proper planting densities were also determined, based on the variety grown and whether the crop is for fresh consumption or starch production.

Cassava growers in various locations have picked up the package of simple, cheap cultural practices. Cuban scientists modified the practices and adopted this so-called "Colombian System" to increase cassava yields on state farms from 7 to 20 t/ha in four years, while decreasing production costs per hectare and per ton. In Mexico, small farmers are now obtaining yields of over 20 t/ha, using CIAT technology modified by Mexican scientists for local conditions.

Other important cultural practices have been developed during recent years. Forty percent of the cassava produced over the world comes from intercropped systems. Over the past seven years, CIAT has developed the basic management practices for producing cassava in association with grain legumes (common beans, cowpeas, and peanuts) and maize. Findings involve relative plant populations, spatial arrangements, relative planting dates,

Scientists in Mexico have modified CIAT-developed cultural practices and helped farmers increase yields substantially fertilizer practices, and weed control. Land Equivalent Ratios of 1.2 to 1.8 have been obtained in efficient systems, indicating that one unit area can produce almost twice as much in total products in intercropping as in monoculture.

Long-term studies on nutrient needs showed that although cassava is relatively tolerant of low fertility, soil acidity, and high levels of aluminum, it does respond well to fertilization. Table 1 shows the very significant yield advantage of a CIAT hybrid over a local variety grown on an infertile soil. Even without fertilization, yields of the hybrid were twice those of the local cultivar, and the hybrid responded very well to a low level of fertilization.

Cassava has a high requirement for phosphorus and a rather low nitrogen requirement. Potassium fertilization is necessary to maintain soil fertility and produce good yields of high-quality cassava. The major elements generally should be applied annually in continuous cropping. Cassava also responds to lime on acid soils, but overliming can induce minor element deficiencies. The most common minor element problem is zinc deficiency; treating stakes with a zinc solution before planting overcomes the problem.

A Basic Understanding of Cassava

Among the first initiatives undertaken by the Cassava Program were studies on the biology of the plant. Several

Table 1. Root yields of a traditional (Guajiba) and a CIAT hybrid (CM 507-37) cassava line in the Colombian Llanos, under minimum levels of fertilizer

Line/Fallow system	Fertilizer (kg/ha N-P_2O_5-K_2O)	
	0-0-0 (t/ha)	50-100-100 (t/ha)
Guajiba		
3-Year cropping cycle	6.2	7 3
Pasture	16 2	17.3
CM 507-37:		
3-Year cropping cycle	12.0	20 2
Pasture	29 5	32.8

Studies of the cassava plant's physiology have helped CIAT scientists better define their breeding and evaluation strategies.

important findings have shown the way for breeding and evaluation strategies now being used in the Program.

One basic clue to the yielding behavior of the cassava plant concerned how the roots form most efficiently. Aerial parts of the plant and the commercial roots were found to form simultaneously; an optimum balance exists, for maximum yield, between leaf and stem development and root growth. Simulation models suggested that a physical plant type and management practices that gave harvest indices (the ratio of root biomass to total biomass) of about 0.6 and a Leaf Area Index (ratio of leaf area to unit surface area) of 2.5 to 3.5 would provide highest yields. These findings also indicated that maximum root yield occurs well below maximum yields of total biomass. These results were later confirmed in field trials. The physical features of a plant, such as its branching pattern and Leaf Area Index, can be easily selected in field nurseries.

More recently, Program scientists have come to a partial understanding of how cassava plants handle moisture stress. Dry seasons are common features in most ecosystems where cassava is produced.

The plant compensates for a lack of water by reducing its leaf area; fewer new leaves are produced while older leaves continue to be shed. At the same time, the stomata of the remaining leaves partially close, the transpiration rate decreases, and the plant conserves what water is available. If the dry period persists, both root growth and top growth may cease. When rains resume, however, the plant draws from its carbohydrate reserves, producing new leaves and becoming productive again. Thus, while dry periods will reduce cassava yields, only plant death will cause crop failure.

Soil-living mycorrhizal fungi which associate with and aid plant roots in taking up phosphorus were found to be essential for cassava production. This new avenue of research in the Program has shown native mycorrhizal populations to differ greatly in their effectiveness. In one case where an effective strain was inoculated into soil containing an inefficient native strain, cassava yields increased 90 percent. Field trials on a broader scale indicate that inoculation with more effective strains can probably increase cassava yields on the order of one-third.

Work is underway to classify some 400 mycorrhizal strains already collected for their general or specific effectiveness. Researchers also are seeking better understanding of relationships between strains, and between various strains, different soils, and the cassava plant.

Identification of Edaphoclimatic Zones for Cassava

The cassava crop has diverse mechanisms for tolerating many environmental stresses, and it is grown under a wide range of edaphic and climatic conditions. While the rich diversity of ecotypes enables cassava to be grown across many ecological zones, Program scientists found that a given ecotype or variety is only well-adapted to limited conditions.

By the end of the 1970s, the Program had accumulated enough information on varietal adaptation and genotype-by-environment interactions that it could define six edaphoclimatic zones in which cassava is produced. The subdivision is based principally on differences in mean temperature, rainfall distribution, photoperiod, and soil characteristics. Ecosystem conditions also largely determine which pest and disease complexes are present locally and how plants develop.

The definition of six zones implied that the entire germplasm improvement process should be decentralized and so Program breeding objectives have been adjusted to seek materials adapted to conditions within zones. At the same time, clones that perform well in early stages of selection are selectively placed in particular sites. CIAT-managed international trials do not exist. Instead, the Program passes on to collaborating countries that germplasm which is matched to local edaphoclimatic and pest conditions and national programs then continue evaluations.

Over the past few years, the movement of germplasm has evolved to meet the needs of individual countries. In the early 1970s, India was the only country prepared to receive and handle sexual seed. Through intensive training efforts and distribution of publications on breeding and selection methodology, nine more countries are now receiving and exploiting the genetic variability present in

Costa Rican scientists have received training for handling meristem cultures of cassava, enabling them to accelerate evaluations of improved lines.

true cassava seed. These countries are: Brazil, China, Cuba, Indonesia, Malaysia, Mexico, Peru, the Philippines, and Thailand.

On the other hand, the development of tissue and meristem culturing techniques at CIAT, and training of national workers to handle this germplasm source has opened the way for germplasm exchange with 18 countries. These countries include: Costa Rica, the Dominican Republic, Ecuador, Haiti, Nicaragua, Panama, Paraguay, and Venezuela, plus the 10 who also receive sexual seed.

Identifying and Solving Biological Constraints

Before CIAT began studies with cassava, not much was known about pests and diseases which might limit production. Cassava has often been considered a rustic crop, little affected by insects or diseases. Part of the reason for this view was that cassava can frequently survive attacks and recover to give a reasonable yield. Nevertheless, CIAT entomologists and pathologists have identified numerous insects, diseases and viruses that can severely reduce yields.

With its long growing season extending across both wet and dry climatic conditions, cassava cannot usually be protected economically by chemical treatments. The objective of the Program has been to develop integrated control measures. Sources of varietal resistance in the germplasm bank have been identified and utilized for breeding improved lines. Cultural practices have been found to help control some diseases, and natural predators, parasites and biological agents have been effective as components of integrated control strategies against insects.

Insect control. Several alternatives exist for controlling insect and mite pests; the two receiving primary emphasis are host plant resistance and biological control. Pests are classified through studies that determine their potential and actual effects on yield, and bioecological research is conducted to determine relationships between the cassava crop, the pest species and the ecosystem involved.

Damage and bioecological studies, including the identification of natural enemies, have been conducted with 17 cassava pests. In recent years, the Program has directed most emphasis to mites, mealybugs, lace bugs, the hornworm, and stemborers.

A detailed study of natural enemy complexes of mites and mealybugs is underway. Approximately 70 natural enemies of mealybugs and 30 of mites have been recorded. Studies have shown that mealybug parasites and predators help reduce populations and delay pest outbreaks. A detailed survey is being conducted in Colombia to identify major predators of mites, especially those in the Phytoseiid predator group.

Several species of natural enemies have been reared in the laboratory and sent to IITA, in Nigeria, for study and future release in cassava fields against pests such as mites and mealybugs that originated in the neotropics.

The cassava germplasm bank is continually evaluated for resistance to mites and insects. Resistant cultivars have been identified for species of the *Mononychellus*, *Tetranychus*, and *Oligonychus* genera of mites, and for thrips, whiteflies, mealybugs, and lace bugs.

Hybrids have been developed from resistant materials and evaluated for resistance levels and yield; some varieties and hybrids contain multiple resistance qualities against several insect or mite pests. Hybrid lines are now available with resistance to mites, whiteflies, and thrips.

Disease Control. Several important diseases have been studied from the time the Cassava Program was formed and since 1978, seven viral, one mycoplasmal, two bacterial and three new fungal pathogens have been identified on cassava. Identities of most of the pathogens and symptoms of the diseases they cause are also now known.

Program scientists had identified resistance in existing germplasm to all major known diseases. With the defining of the six cassava growing zones, more emphasis has been directed to zone-specific screening. This involves developing systems to screen for multiple resistance (to several constraints) in each edaphoclimatic zone where the Program is working. Clones in which multiple resistance is available have proved to be very stable (for both yield and resistance) during more than seven years of continuous evaluation, under field conditions of natural epidemics.

Development and Distribution of Improved Germplasm

Progress in breeding and selection of improved materials has been continual. Varieties selected by CIAT in regional trials and sent out to countries have been officially released in Cuba, Haiti, and Mexico. Many other clones developed at CIAT are known to be grown commercially in Colombia, Ecuador, the Philippines, and Venezuela, although none has been released officially.

The selection process for cassava clones produced from sexual seed normally involves seedling selection, single plant trials, replicated yield trials, advanced yield trials, regional trials, and on-farm testing before a material is released as a variety. This means hybrids made at CIAT between 1973 and 1976 are only now reaching final stages of evaluation for release. Table 2 shows the stages which selections from CIAT hybrids have reached in various countries.

Thailand released the new variety Rayong 3 in 1983; this line had been introduced as a CIAT hybrid in 1975. Thailand has adopted a seven-stage evaluation procedure

Table 2. Movement of CIAT-produced cassava hybrids through selection process in national programs.

	Stage of development			
	Seedling selection	Single row trial	Advanced yield trial	Released
AMERICA				
Brazil	X	X	X	-
Cuba	X	X	-	-
Peru	-	-	X	-
Mexico	X	-	-	-
ASIA				
Thailand	X	X	X	Rayong 3
Philippines	X	X	X	-
Malaysia	X	X	X	-
Indonesia	X	X	X	-
China	X	-	-	-

and has several other lines under testing; some of these will probably be released in the future. Other countries, including Brazil, China, Cuba, Indonesia, Malaysia, Mexico, and the Philippines have adopted similar selection techniques and program structures and have materials in evaluation stages for release within the next few years.

Post-Harvest Utilization

Fresh Root Preservation. The very rapid physiological and microbial deterioration of fresh cassava roots has been a major constraint in marketing this product efficiently. Results from a project jointly financed with the Tropical Development Research Institute showed that two simple treatments can help growers store roots for up to two weeks without adverse quality changes.

Root treatment immediately after harvest with low concentrations of thiabendazole, a low toxicity fungicide, prevents the onset of microbial rotting. Roots are then packed in plastic bags where the buildup of humidity encourages natural wound healing and retards physical deterioration. Adoption of this method would greatly decrease marketing margins, increase urban consumption (through price decreases), and increase the farm gate price of cassava. Not only are losses very low over two weeks of storage, but cooking times, starch content, and taste and texture considerations are not significantly affected.

The Utilization Challenge. With the arrival of cassava technology that enables small farmers to boost production substantially, some type of market development is needed to protect them from price uncertainties. Processed dried cassava is one utilization outlet that not only could offer the farmer an additional outlet, but the product could also be substituted for milled grain flours or expensive feed grains for animals. These uses would help lower balance of payments deficits in many developing countries, while providing additional income at the local farm level.

An integrated development project has been initiated on the North Coast of Colombia as a pilot project for this strategy. The project is designed to show how commercially viable small-scale units can be developed and move increased cassava production into non-traditional uses. Cassava processing/drying plants are being operated to produce cassava chips for animal feed concentrates.

A major benefit of the project is the establishment of market stability. The largest feed mill in the area has guaranteed a minimum price for chips. Thus, farmers are able to move their product between the fresh and processed outlets knowing what range of price they can expect.

After three years, seven plants have been established across four states in northern Colombia with 20 more plants planned. Farmers have increased their production area, intensified their management practices, and are evaluating improved varieties. CIAT's Cassava Program assisted the Colombian Integrated Rural Development (DRI) program which set up and now supervises the project. Similar drying facilities have now been established in northeast Brazil, Mexico, and Panama.

Regional Assistance

CIAT has played a fundamental role in helping establish cassava programs in many countries. Table 3 shows how the Cassava Program has been involved in assisting or setting up national programs through training, germplasm distribution, and consulting.

Table 3. Status of various national cassava programs and their relation with CIAT.

	National program established[1]	CIAT trainees[1]	Participation in conferences	Leader visited CIAT	Receiving genetic material from CIAT[2]	CIAT lines released or grown	Visits by CIAT staff since 1977
Thailand	Yes	24	Yes	Yes	S	Yes	(18)
Indonesia	Yes	12	Yes	Yes	S	No	(8)
Philippines	Yes	11	Yes	Yes	S	Yes	(18)
Malaysia	Yes	14	Yes	Yes	S	No	(10)
China	Yes	No	No	Yes	S	No	(2)
India	Yes	5	Yes	Yes	S	No	(11)
Brazil	Yes	94	Yes	Yes	S	Unknown	(34)
Paraguay	Yes	3	Yes	Yes	S	No	(6)
Bolivia	No	5	No	--	No	No	(6)
Peru	No	10	Yes	--	S	No	(7)
Ecuador	No	12	Yes	--	No	Yes	(18)
Colombia	Yes	86	Yes	Yes	E	Yes	NA
Venezuela	No	14	Yes	--	--	Yes	(2)
Panamá	Yes	7	No	Yes	M	No	(6)
Costa Rica	No	9	No	--	No	Yes	(12)
Mexico	Yes	31	Yes	Yes	SM	Yes	(27)
Haiti	Yes	4	Yes	Yes	No	Yes	(6)
Dominican R.	Yes	20	Yes	Yes	No	Unknown	(17)
Cuba	Yes	12	Yes	Yes	S	Yes	(14)
Guyana	No	4	No	--	No	No	(1)

1 Most of these programs were established in the mid- to late- 1970s.
2 M = Meristems, S = Seeds, E = Stakes.

In 1983, the Cassava Program stationed a breeder in Thailand. Up until a few years ago, the germplasm base in the Asian region was extremely narrow. With the accelerated movement of germplasm into and between countries, this scientist is helping national programs to evaluate new materials and to train personnel, especially in skills relating to cassava breeding.

Training Activities

Training conducted in the Cassava Program has evolved as needs of client national programs have changed. During the past eight years the Program has helped train 365 professionals from 37 countries. In the early years of the Program, disciplinary training for long periods (up to a year or more) was common. The objective at this stage was to provide a sound overall knowledge of cassava. Many of the trainees returning to their countries became the core personnel of new programs.

Emphasis was gradually shifted to shorter term training covering all aspects of cassava production; this was often followed by some disciplinary training with the idea of trainees returning to join a multidisciplinary team in their home country.

As programs grew stronger, more personnel were trained at advanced degree levels in order to assume research roles. More recently, training of technicians to do specialized tasks has increased in frequency. Such special topics can include rapid propagation techniques, meristem culture handling, and biological control procedures for rearing and release of natural enemies of cassava pests.

Since 1980, the Cassava Program has also assisted in 10 training courses conducted in six countries.

The Tropical Pastures Program

The Tropical Pastures Program has made significant progress during the past seven years in meeting its international objectives. The Program has moved through a functional reorganization to become a multidisciplinary group based on germplasm development for the acid, infertile soil areas of Latin America. Its long-range objective is to increase beef and milk production in Latin America by providing new options of adapted, persistent, and nutritious pastures for a variety of ecosystems and farming systems. Studies to define these systems, the wide-ranging expansion of the available forage germplasm base, the high levels of animal productivity potential of the new pastures, and the establishment of an international network for multi-level evaluations in each ecosystem are among the major research accomplishments of the Program. Based on these achievements, improved grass and legume germplasm selections are being evaluated and released for commercial production in two target ecosystems.

Beef and Milk in Latin America

Accomplishments of the Tropical Pastures Program over the past seven years reflect this group's major refocusing of efforts away from cattle production systems towards germplasm and pasture development and evaluation in ecosystems containing acid, infertile soils. The Program has designed its present strategy on previous work, mainly in the Colombian Eastern plains (the Llanos), which showed the main limiting factor in animal production to be poor nutrition. Native grass savannas lack the nutrients to provide satisfactory animal growth and performance.

Demand for beef and milk has increased faster than supply and both products have remained important ingredients of the typical food basket in Latin America. Peoples in all economic strata of the region spend rather high proportions of their incomes on beef and milk products. Income elasticities of demand are high, indicating people would spend more for beef and milk as their incomes rise.

Milk production in Latin America is presently concentrated on better lands with high cropping potentials, frequently at altitudes higher than 1500 meters above sea level. High population densities and more profitable alternative uses of land are reducing milk production and raising market prices.

Beef production is being frequently shifted to the extensive native grasslands which at best are of only marginal quality for other agricultural production. While cattle can be raised on the extensive systems under low economic risk, output is also very low. Average annual production of beef per head of cattle inventory in tropical Latin America is about 24 kilograms, while in more temperate zones like Argentina, production is at least twice this amount.

Identification of the Area of Interest

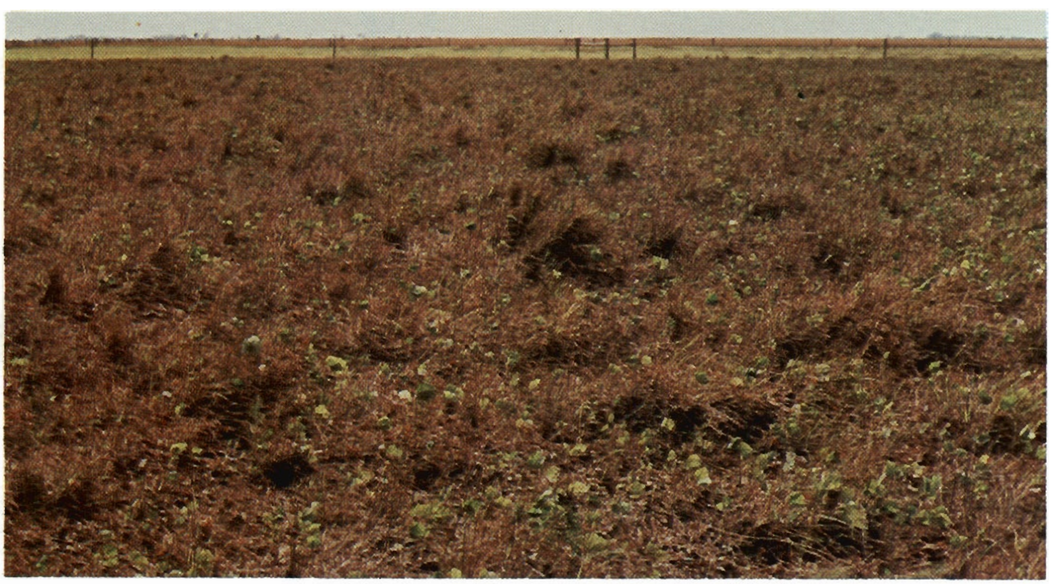
About one-half of the land area in Latin America has been classified as of low fertility with acid soil conditions and varying rainfall intensity and distribution. Some 300 million of that 850 million hectares are savanna areas with the remainder forests. Surveys to more precisely classify these areas showed that acid, infertile Oxisol and Ultisol lands extend from southern Mexico to northern Paraguay. Countries including Brazil, Colombia, Peru, Venezuela, Bolivia, Guyana, Surinam, French Guyana, Panama, Jamaica, Trinidad, Guadalupe, and Martinique have more than 40 percent of their territories with these conditions.

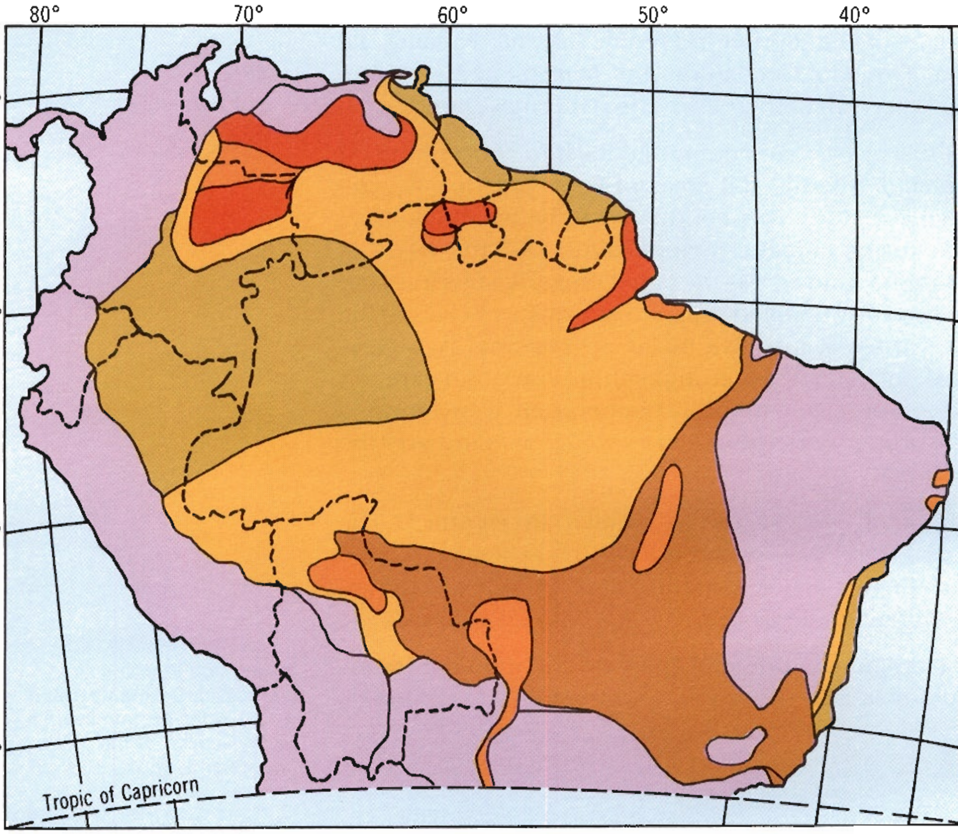
By 1976, CIAT had committed itself to concentrate on these acid, infertile soil areas of Latin America. A comprehensive study was conducted to better understand which major climatic factors influenced the types of vegetation found across the target range. Results from the climatic study enabled Program scientists to classify the area of interest into five major ecosystems. Two parameters, the total wet season potential evapotranspiration and the wet season monthly temperature, were found to be the primary determinants of vegetation found over the target area.

Limits of ecosystems are shown in Figure 1. The Tropical Pastures Program utilizes this system as a basis for locating its major screening sites, and for germplasm differentiation and testing.

The Program conducted a second survey in the Llanos of Colombia and Venezuela, and the Cerrados of Brazil,

The legume *Pueraria phaseoloides* remains green and provides protein even in the dry season of the Colombian Llanos.





Well-drained isohyperthermic savannas (mainly the Llanos); TWPE between 901-1060 mm; 6-8 wet-season months, WSMT ⩾ 23.5°C.

Tropical rainforest; TWPE>1300 mm; more than 9 months wet season; WSMT ⩾ 23.5°C.

Well-drained isothermic savannas (mainly the Cerrados); TWPE between 901-1060 mm; 6-8 wet season months; WSMT ⩾ 23.5°C.

Poorly drained savanna; various sets of landscapes and edaphic conditions across lowlands of tropical America.

Tropical semi-evergreen seasonal forests; TWPE between 1061-1300 mm; 8-9 wet-season months; WSMT ⩾23.5°C.

Figure 1. Boundaries of ecosystems defined for the target area of the CIAT Tropical Pastures Program.

concurrently with the land systems studies. This work was done to understand better the types of farming operations prevalent in the target area and the types of pasture systems needed to increase animal productivity most efficiently.

In line with generally better rural infrastructures in Brazil and Venezuela, many ranches in these countries had up to 30 percent of their area in seeded pastures and some cropping was common. A large percentage of the cattle in Venezuela were milked at some time. Herds in all three countries contained high number of replacement heifers, indicating that the productive life of cows was short and that new technology was needed critically.

Research Focus within Ecosystems

The Tropical Pastures Program has concentrated its efforts in two ecosystems, represented by the Llanos of Colombia and Venezuela (the well-drained, isohyperthermic savannas) and the Cerrados of Brazil (the well-drained isothermic savannas). Scientists from CIAT and respective national programs work together at one major location in each ecosystem with activities organized among three functional groups—germplasm development and evaluation; pasture development and evaluation; and evaluation of pastures in farming systems. In addition, an international pasture evaluation network operates across all target area ecosystems.

Llanos. The primary research site for the ecosystem of the Llanos is at Carimagua, Colombia, at the National Center for Agricultural Research (CNIA). Experiments are done here by personnel from both CIAT and the Instituto Colombiano Agropecuario (ICA).

Cerrados. CIAT entered into a cooperative pasture research program with the Agricultural Research Center for the Cerrados (CPAC) of the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), in 1977. Three CIAT scientists were outposted in this center at Planaltina, to work with Brazilian counterparts. In 1983, the CIAT staff was reduced to an agronomist and a soil scientist, the latter working under funding from EMBRAPA and administered by the Instituto Interamericano de Cooperación para la Agricultura (IICA).

Many regional pasture network trials, like this RT-A in Calabacito, Panama, are managed by former CIAT trainees.

Pasture Evaluation Network. Representatives of national pasture programs meeting in a workshop at CIAT in 1979 agreed to form the International Tropical Pastures Evaluation Network (RIEPT) as a mechanism to utilize germplasm bank resources of CIAT and national programs in the region as efficiently as possible. Another important objective is to assist in studying the adaptational range of grass and legume germplasm across the lowlands of tropical America.

The evaluation network consists of four levels of trials (RT-A through RT-D), with each series tested in each of the five target ecosystems. Network activities are shared equally between national programs and CIAT, with all network members receiving data and information on test results or other information. CIAT acts as sponsor in consultation with the network advisory committee of pasture research leaders from national programs.

RT-A trials are designed to evaluate adaptation of approximately 100 to 150 entries in a few, highly representative sites of each ecosystem. RT-Bs measure seasonal dry matter productivity of some 20 to 30 promising entries selected from A trials. B trials are conducted in sub-ecosystems of the major ecosystems. Both A and B trials employ uniform testing methodologies.

RT-Cs are designed to evaluate a reduced number (10) of accessions of grass/legume mixtures in small plots under grazing. Objectives are to measure the productivity and persistence of the components in the pasture under different grazing management schemes and intensities. These trials are under different designs and established in only a few locations, since most of the information developed can be extrapolated to rapidly assemble the design of the more advanced, larger trials in level D.

RT-Ds assess pasture productivity in terms of animal gains and pasture persistence. They are conducted in as many locations as possible, but each is designed independently to test the new pastures within prevailing utilization systems.

Pasture programs in 17 countries of Latin America and the Caribbean have participated by establishing trials. At the end of 1983, trials in operation included 25 RT-As, 65 RT-Bs, 8 RT-Cs, and 9 RT-Ds, located across the five ecosystems.

Germplasm Evaluation and Development

The Tropical Pastures Program has made very significant progress in collecting and evaluating germplasm, especially legumes, native to the acid, infertile savannas of Latin America. Between 1977 and the end of 1983, the Program had almost quadrupled its collection of germplasm, from 3037 to 11,291 accessions. Almost 90 percent of the collection is legumes, mostly from tropical America. The doubling in percentage of collaborative germplasm collections compared to CIAT-only collections also indicates increasing integration with and interest by national programs in forage germplasm activities.

Table 1 shows how the Tropical Pastures Program germplasm base has evolved between 1977 and 1983. This list—with the exceptions of *Pueraria phaseoloides*, and in the *Brachiaria* complex, *B. decumbens*—does not contain any traditional, agronomically well-known tropical forage species, but rather, consists of new, undomesticated materials. This is one of the fundamental achievements of the Program, and illustrates its pioneer role in developing a germplasm based, low-input technology.

Evaluation in Ecosystems. New forage accessions entering the Program's collection undergo a series of in-

Table 1. Evolution of the Tropical Pastures Program germplasm base between 1977 and 1983, according to inventories of key species in the collection.

Species	No. of Accessions 1977	No. of Accessions 1983
LEGUMES:		
Stylosanthes capitata	45	266
Stylosanthes guianensis "tardio"*[1]	33	194
*Stylosanthes macrocephala**	4	159
*Centrosema brasilianum**	4	129
*Centrosema macrocarpum**	3	102
Centrosema sp.n.*	2	11
Desmodium ovalifolium	1	84
Pueraria phaseoloides	11	76
Zornia sp. (type CIAT 7847)*	-	21
Total legume accessions	103	1021
GRASSES:		
Andropogon gayanus	5	66
Brachiaria spp *	24	197
Total grass accessions	29	263

1* Indicates no accessions of these species had advanced to Category III or higher in 1977.

creasingly stringent evaluations to measure their adaptation to edaphic and biotic conditions in the Llanos and Cerrados ecosystems. This scheme for evaluating germplasm within categories is summarized in Figure 2.

In addition to evaluations at sites within ecosystems, new accessions are grown in the field at the Santander de Quilichao substation, an acid soil site located south of Cali, Colombia. The Program utilizes this location for identification, maintenance, early seed multiplication, and initial characterization of materials. Evaluations of materials in Category III are also conducted here as well as in the main ecosystems locations.

Adaptation to Soils. One of the primary determinants of how well new forage accesions perform agronomically is their adaptation to the poor soils found in the target ecosystems. Among the important chemical characteristics of the soils of the Llanos and the Cerrados are their

Category I

Germplasm bank maintained at CIAT-Palmira and CIAT-Quilichao, and evaluated for adaptation to edaphic conditions at ecosystems sites.

Category II

Agronomic evaluation in small plots, in each ecosystem.

Category III

Grazing trials in grass/legume associations to assess resistance to trampling, competitive ability, dry matter productivity, nutritional quality, and relative grazing preferences, in each ecosystem.

Category IV

Pastures evaluated for potential animal productivity, in each ecosystem.

Category V

Best pasture options evaluated under experimental and commercial farm conditions of each ecosystem.

Figure 2. Methods of evaluating germplasm in the Tropical Pastures Program.

high acidity, high levels of aluminum, and low levels of available plant nutrients, especially phosphorus.

Nutrient requirements had not been determined for germplasm materials available when the Program began extensive decentralization in 1977. Studies since then have caused several species to be discarded from lists of promising materials, due to their lack of adaptation to edaphic conditions.

During this same time, new materials have been collected, especially from acid, infertile soils, so that newer and promising accessions generally are well-adapted to soil conditions in at least one of the two main ecosystems. This adaptation includes low external requirements for nutrients, and as a consequence, only low amounts of fertilizers are needed to establish the more promising legumes and grasses.

Soil Microbiology. The legume in the improved legume/grass pasture is expected to utilize *Rhizobia* to fix nitrogen and supply the grass with this nutrient. Studies in the Llanos have shown that it is possible to identify superior strains of *Rhizobia* from soil cores for inoculating certain legumes. The same studies have also shown that some promising legume species apparently nodulate effectively with native strains and, therefore, do not respond to additional soil inoculations.

Disease and Pest Problems. Diseases and pests are the main limiting factors to forage adaptation in each ecosystem. Continuous and systematic monitoring of pest and disease prevalences in the major screening and regional trial sites across all ecosystems has enabled Program personnel to detect several previously unrecorded biotic problems and to assess their relative importance. Germplasm materials entering advanced testing stages have demonstrated their adaptation to disease and insect conditions prevailing in a given ecosystem.

Legume Breeding. The Program is using breeding techniques to a limited degree to develop improved forage species. One important project, however, is that of seeking to combine the traits of anthracnose tolerance and high seed yield which occur separately in "tardío" and common types of *Stylosanthes guianensis*. The first series of F_2 crosses have been established for field evaluation in both Carimagua and Brasilia.

Disease pressure is severe across the tropical pasture ecosystems. This screening trial for resistance to anthracnose by *Stylosanthes guianensis* clearly shows that few materials can survive.

Table 2 shows the materials the Tropical Pastures Program and national programs now consider to be most promising in each of the two main ecosystems. Accessions in this list have successfully passed agronomic evaluations in one or both ecosystems and are now undergoing grazing trials.

Pasture Development

As new, promising forage germplasm moves through early evaluations, questions of compatibility in grass/legume mixtures must be answered. The pasture development group conducts agronomic compatibility and animal selectivity studies which seek to provide these answers. Results enable scientists to design the grazing manage-

Table 2. Promising forage species of the Tropical Pastures Program germplasm collection nominated for (Category III) or under (Category IV/V) grazing trials in two ecosystems (1983).

	Llanos		Cerrados	
	Category		Category	
	III	IV/V	III	IV/V
LEGUMES:				
Arachis pintoi	1	-	-	-
Centrosema brasilianum	-	1	1	-
Centrosema macrocarpum	1	1	5	-
Centrosema sp.n.	3	-	1	-
Desmodium canum	1	-	-	-
Desmodium heterocarpum	1	-	-	-
Desmodium ovalifolium	3	-	-	-
Pueraria phaseoloides	-	1	-	-
Stylosanthes guianensis "tardio"	7	-	7	1
Stylosanthes capitata	5	5	2	2
Stylosanthes leiocarpa	1	-	-	-
Stylosanthes macrocephala	4	1	5	1
Zornia brasiliensis	1	-	5	-
Zornia sp. (type CIAT 7847)	1	-	1	-
Total legume accessions	29	9	27	4
GRASSES:				
Andropogon gayanus	3	1	-	1
Brachiaria brizantha	4	-	3	-
Brachiaria dictyoneura	1	1	-	-
Brachiaria humidicola	-	1	-	-
Brachiaria ruziziensis	1	-	-	-
Panicum maximum	-	-	3	-
Total grass accessions	9	3	6	1

ment strategies to maintain balanced forage mixtures for given pasture objectives in each ecosystem.

As examples, the legume *Desmodium ovalifolium* has potentially good compatibility with more aggressive grasses like *Brachiaria humidicola*. *Stylosanthes capitata* is well accepted in association with the grass *Andropogon gayanus*, but *D. ovalifolium* and *S. guianensis* "tardío" have low acceptabilities, relative to the grass, and *Zornia brasiliensis* is completely rejected. The fact that some legumes are not consumed readily makes them valuable candidates for pasture systems under strong drought stress.

Carimagua. The pasture development group has also looked closely at satisfactory and economical means of establishing improved pastures on native savanna of this ecosystem. At Carimagua, *A. gayanus*, *B. humidicola*, *D. ovalifolium* and *P. phaseoloides* have all been established successfully using minimum tillage practices. Alternative planting methods such as row seeding or strip planting have proven effective in reducing seed requirements, improving fertilizer efficiency, and in allowing rapid initial establishment of grasses and legumes.

Also in Carimagua, large portions of the existing savanna are being successfully replaced with improved legume/grass mixtures.

Twenty percent of a pasture is tilled in either 0.5-, 2.5-, or 5.0-meter strips, fertilized and planted with the grass/legume mixture, which is expected to invade the adjoining strips of savanna. Each year, another 20 percent of the savanna is fertilized to encourage spreading of the improved species. After three years, all treatments except the 5.0-meter strips of *D. ovalifolium* have covered at least 60 percent of the total area. Stocking rates have been from 1.0 to 1.5 an/ha, and liveweight gains have been good. Animals are also consuming larger amounts of unburnt native savanna due to the legume in their diets.

Data from four years of grazing trials in Carimagua indicated that improved pasture species and associated improved management plans offer a choice of methods for increasing animal productivity (Table 3).

Improved pastures of grass/legume mixtures have consistently produced about 30 percent higher gains per

Table 3. Average productivity over four years of improved pastures in terms of weight gains of young steers (Carimagua).

Treatment	Liveweight gains per year (kg)	
	Per animal	Per hectare
Native pasture:		
- Savanna + burning	75	15
Supplementary legume grazing:		
- Savanna + bank of *Pueraria phaseoloides*	101	51
Improved grass pastures:		
- *Brachiaria decumbens*	145	250
- *Andropogon gayanus*	120	268
Legume grass associations:		
- *B. decumbens* + strips of *P. phaseoloides*	183	294
- *A. gayanus* + *P phaseoloides*	182	308
- *A. gayanus* + *Stylosanthes capitata*	193	320

animal and 15 percent higher gains per hectare than grasses alone, with the major benefit occurring during the dry season.

Management plans developed by Program scientists include maintenance fertilization and some combinations of adjusted stocking rates and grazing systems to help assure persistence of the pasture species chosen. The very productive associations of *B. decumbens* and *P. phaseoloides* indicates how good persistence can maintain liveweight gains over time (Figure 3).

One of the objectives of creating legume-based pasture systems is to provide a more nutritious diet for grazing cattle. The success of this strategy is shown in Table 4, where the quality and quantity of a mixed pasture has been sufficient to sustain liveweight gains during the dry season. This has been impossible with pure grass pastures, at usual stocking rates. Nitrogen recycling by the legume has also been documented through higher protein content of the grass and the total diet, especially in the wet season.

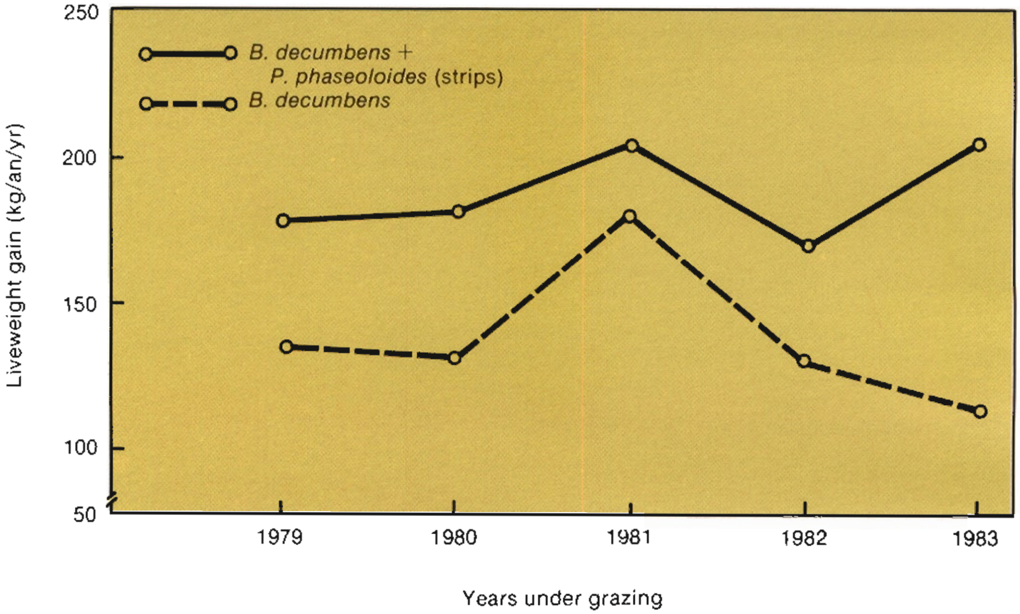


Figure 3. Productivity over time of *Brachiaria decumbens* alone and with a legume (Carimagua).

Cerrados. The Cerrados region of Brazil contains extensive areas of degraded pastures based on *Brachiaria* species. The lack of available nitrogen is one significant factor contributing to the decline of grass species so methods have been developed to seed promising legumes within degraded pastures. Total forage production more than doubles while available crude protein also increases, especially during the dry season. This technology will have an increasing impact as improved legumes continue to be selected.

Two years of agronomic evaluations were completed in 1983 with eight promising forage legumes grazed in small plots. All the legumes are associated with *A. gayanus* cv. Planaltina. Those showing most promise as measured by animal selection and grass/legume balances in paddocks during the wet and dry seasons include *S. macrocephala* CIAT 2039 and 2053, *Z. latifolia* CIAT 728, and the two controls *S. macrocephala* cv. Pioneiro and CIAT 10138.

Large-scale grazing trials in pasture systems were initiated in mid-1983 with four legumes. These highly promising selections for the Cerrados ecosystem include

Table 4. Relationship between quality of the grass on offer and selected diet with changes in liveweight of animals grazing *Andropogon gayanus* alone and in association with *Stylosanthes capitata* (Carimagua).

Pasture	Season	Protein content Grass (leaf) (%)	Diet (%)	Legume in diet (%)	Changes in liveweight (g/an/day)
A. gayanus	Dry	4.7	4.9	-	- 36
	Wet	6.4	8.5	-	+454
A. gayanus + *S. capitata*	Dry	5.1	6.3	17.1	+147
	Wet	8.2	10 1	4.3	+666

S. guianensis cv. Bandeirante, *S. capitata* CIAT 1019 and 1097, and *S. macrocephala* cv. Pioneiro; all are being evaluated in association with *A. gayanus* cv. Planaltina to measure animal productivity and pasture persistence.

Pasture and Animal Production Sytems

Several experiments have been designed and carried out to help define present and future technologies for animal production. Of special interest is the understanding of how improved pasture species will fit into production systems in terms of animal productivity and economic returns.

Carimagua. A herd systems experiment conducted at Carimagua in the early 1970s highlighted the need for better nutrition in cattle being raised on the acid, infertile Colombian savannas. This project showed nutrition to be the main limiting factor in cattle productivity and reproductive efficiency.

A second herd system project was initiated at Carimagua in the late 1970s, after the Program began to select improved pasture species. A major finding highlighted the importance of strategic use of the pastures (10% of the entire pasture planted to available improved grasses and legumes) for cows in late pregnancy, and for lactating cows during the mating season. Cows had significantly higher reconception rates and decreased overall intercalving intervals, regardless of the cows' post-calving weight. Calf mortality rate was also lower on improved pastures, compared to native savanna. A third systems

The herd systems project at Carimagua provides valuable data on many measures of animal productivity on improved pastures.

project has begun at Carimagua in 1982. This trial utilizes small areas of improved pastures made up of associations of *A. gayanus/P. phaseoloides* and *B. humidicola/D. ovalifolium* as a strategic supplement to native savanna. Animals and pastures are under two levels of management and data are being collected on agronomic behavior of the pasture as well as animal productivity and animal nutritional status.

A set of commercial on-farm trials is also being conducted on seven farms in the Colombian Llanos. The objective is to determine what influences improved pastures and associated management have on herd productivity and on specific categories of animals.

Figures from one of the farms, which has 5.5 percent of its total area sown to *A. gayanus/S. capitata* and *B. decumbens/D. ovalifolium* associations, indicate that internal rates of return range from 19 to 35 percent, depending on assumptions made about pasture persistence. The new pasture areas of this farm are used by nursing cows to improve their reconception rates and increase calf weaning weights.

Production figures after four years are considered very preliminary as herd composition and quality continues to improve due to culling and entry of better animals into the breeding herd. Selected figures show increases of 29 percent in cow weights, 14 percent in weaning rate, 49 percent in weaner weights, and 85 percent in animal unit stocking rate per hectare.

Program economists have performed ex-post analyses to obtain some idea of the profitability of new pasture systems under Llanos conditions. Using an estimated pasture persistence of six years, costs of maintenance fertilization every two years, and experimental weight gain results obtained in Carimagua, rates of return to total capital (excluding land) are calculated to range between 17 and 24 percent, depending on the species seeded.

Newer data indicate less fertilizer may be required for the system, due to improved establishment techniques and soil mineralization. Little data is available on persistence, although *B. decumbens* is known to do well for at least 10 years, under farmer management in the area. If a four- to five-year persistence is used for the legume and an indefinite period for the grass, it is possible that farmers will prefer to continue converting additional savanna into legume/grass pastures. As low percentages of farms are under improved pastures, establishment will possibly be more profitable than re-establishing the legume in grass pastures.

Cerrados. A herd systems project was conducted at CPAC at the same time as the second one in Carimagua. It demonstrated that early weaning management used with improved pastures can significantly increase cow reproductive performance. Cows grazed an improved pasture during breeding seasons of either 90 days or two 45-day periods. Those weaning calves at three months and rebred over 90 days produced an average annual calf crop of 83 percent, compared to a 66 percent crop for cows nursing for five months. Rebreeding ability of first-calf heifers is severely affected by lactational stress. Rebreeding efficiency increased from 36 to 78 percent or more when calves were weaned at three months, compared to five months, when the young cows grazed improved pastures.

The early-weaned calves were shown to perform satisfactorily on high-quality, legume-based pastures. A temporary advantage in gain by calves supplemented with ground corn for the first 90 days after weaning disappeared when calves became about a year old.

Release of New Pasture Species

Several forage species new to the Latin American tropics are in the process of being released and offered to farmers.

Andropogon gayanus (CIAT 621) was introduced into the CIAT germplasm collection from Africa in 1973. This bunch-type grass proved to be very productive, highly adapted to high-aluminum, low-fertility, acid soils. It also possesses other important characteristics, including tolerance to pests and diseases, high tolerance to drought and fire, high seed yielding ability, and good compatibility with legumes.

In 1980 this grass was released in Colombia by ICA as Carimagua I, and in Brazil by CPAC/EMBRAPA as Planaltina. Two years later INIPA, in Peru, released it as San

Successful research on seed production of forage species not widely grown previously has contributed greatly to the evaluation and dissemination of improved pasture materials.

Martin, and in Venezuela, FONAIAP released it as Sabanero. Three Panamanian institutions, IDIAP, BNP and the University of Panama, released the grass as Veranero in 1983.

A survey of farmers adopting the new grass in the Colombian Llanos showed rapid expansion of the area planted. Major reasons given for using it have been its dry season performance, good growth on very poor soils, and resistance to the spittlebug. This latter characteristic is very important in the Cerrado where the best-known sown grass, *B. decumbens*, is highly susceptible.

In 1983 ICA in Colombia released a blend of five entries of the legume *S. capitata* (CIAT 10280) under the name of Capica. The materials were collected between 1975 and 1977 in the Brazilian Cerrados by the Program.

Another material from the Cerrados, *S. guianensis* CIAT 2243, is being released in Brazil under the name of Bandeirante. *S. macrocephala* CIAT 1281 is also in the process of release in Brazil with the name Pioneiro. Both lines show resistance to anthracnose, are good dry matter yielders, and are compatible with bunch-type grasses.

Training

The Tropical Pastures Program has trained 255 professionals since 1977, and many of these have become collaborators in the international pasture network. Sixty-eight percent (173 persons) have participated in annual 10-week intensive courses which are typically followed by a three- to four-month specialization phase in which individuals work closely with Program senior staff.

Some emphasis has also been placed in promoting higher degree studies to train pasture researchers. The Program has assisted in training 13 Ph.D. and 19 M.S. candidates since 1977.

Other Activities Contributing Directly to CIAT's International Mandate

The Seed Unit

Communication and Information Support Unit

Training and Conference Activities

The Seed Unit

Since its formation in 1979, the Seed Unit has employed an intensive training program supported by workshops and technical collaboration to lay the foundations for seed technology networks in Latin America. These networks are now becoming evident and will support CIAT's commodity programs and the work of other international centers in helping to make improved varieties of crops available more readily within the region.

The Seed Unit was formally organized in early 1979 as a CIAT special project funded by the Swiss Development Cooperation.The Unit was formed to fill a critical need in the chain for moving newly developed, improved germplasm to the ultimate user on the farm. A majority of the countries in Latin America lacked clear consistent policies for seed program development, and so the Unit's objectives were directed to activities that would contribute to building strong seed programs.

Training and Conferences

Training. Training has been the first priority of the Seed Unit. Training has been provided in several channels although almost all of the 571 persons trained between 1979 and 1983 from both public and private sectors were

Training in many phases of seed technology is helping public and private organizations move improved germplasm to farmers.

in either intensive short courses or in in-country and sub-regional courses.

The Unit has offered 11 short courses at CIAT for 312 persons. One course was taught in English to meet the needs of participants from the Caribbean area. All but six attendees of these courses have come from 25 countries in Latin America and the Caribbean with 111 public and private organizations represented.

The Seed Unit also assisted in various ways with 12 in-country and sub-regional courses involving 267 persons. Most of these courses have been held in Central America. Staff from the Unit also presented a one-week seed technology module within two wheat and maize production courses at CIMMYT, in Mexico. Similar seed production and technology sections are now incorporated in the bean and rice short courses at CIAT.

Fifteen persons received individualized in-service training within the Unit and another four have completed Master of Science theses research projects within the Unit.

Conferences. Five workshops have been held in CIAT with total participation of 319 persons representing 157 organizations. The Seed Unit also has co-sponsored two regional workshops in Central America and assisted with another one at CIAT for Andean Zone countries. Participation by and with this diversity of organizations of the region has forged links between CIAT and seed programs and industries that didn't exist previously.

Technical Collaboration

Training and conference activities combined with technical collaboration by Seed Unit staff are helping to form seed technology networks. Collaboration exists through visits that have been made to almost all countries in Latin America and the Caribbean region, as well as through assistance being given to national programs, associations, and institutions.

Activities in Central America have led to a seed section being added to the annual meetings of the Central American Cooperative Program for Improvement of Food Crops (PCCMCA). Participation in the section has been excellent, and in 1983, the Regional Association of Seed Technologists for Central America, Panama, and the Caribbean (ARTES) was formed to provide a vehicle for continuing activity. Cooperative efforts between the Seed Unit and the Interamerican Institute for Agricultural Cooperation (IICA) have also resulted in the creation of a Seed Advisory Council and a Technical Committee of representatives from throughout the region.

Work in the Andean Zone and especially with the Board of the Cartagena Accord (JUNAC) has resulted in an agreement between that group and CIAT. Specifically, JUNAC will provide support for seed training at CIAT during two years and the Seed Unit will organize two courses especially for the sub-region.

In 1983, CIAT signed collaborative agreements between the Centro de Estudos e Treinamento en Tecnologia de Sementes e Mudas (CETREISEM), in Brazil, and the University of Cordoba, Argentina, for mutual assistance in training activities. The Seed Unit is also working with other universities in the region to support training and research.

The Unit has been asked to assist the recently activated Latin American Association of Seed Experts (ALES), an affiliation of several seed associations. The Unit formed the Seed Liaison Committee to help strengthen collaborative seed activities in the region. This group includes

The Seed Unit cooperates with other CIAT groups to produce and distribute basic seed of selected crops being released to growers by national programs.

representatives from seed programs in Latin America and from the four international agricultural research centers providing services in the region (CIAT, CIMMYT, CIP and ICRISAT).

Seed Production and Supply

Creation of the Seed Unit and development of its physical facilities have given CIAT's commodity programs and national programs in the region extra capability for providing basic seed of promising materials and varieties under release. These facilities include laboratories and equipment for quality control testing, drying, conditioning, and seed storage. Since 1981, the Unit has cooperated with CIAT's Farm Operations Unit and the commodity programs to produce and ship 152 tons of basic seed of beans, rice, and selected tropical pasture species to 16 countries in the region.

Research and Development

While the Seed Unit has not given major attention to research, results from thesis projects have provided valuable findings on seed quality in selected pasture species and on environmental-varietal interactions of characters used in describing bean and rice varieties. A fourth project explored the economics of seed conditioning and developed important information useful for seed enterprises.

Major cooperation has existed with Mississippi State University, under a bilateral contract with USAID. The Seed Unit has also drawn on public and private seed specialists from the region for assistance in training and collaborative activities. Visiting scientists and consultants have also assisted the Seed Unit by adapting existing technology from temperate areas to fit conditions and problems of the region.

Impact on Public and Private Seed Sectors

The major impact of the Seed Unit's activities has been in its work to help develop networks of related entities in Latin America. These different networks now involve national seed programs, seed associations, universities with seed technology courses, and sub-regional organizations.

National program goals and strategies are more clearly defined in several countries. Among 21 national seed program leaders interviewed during one workshop, 15 of 17 who indicated progress in their programs said the Seed Unit had contributed to that progress. Individually, many seed technologists have advanced professionally because of their direct involvement in Seed Unit activities.

Across the region the Unit's work to help programs and enterprises achieve improved quality control systems and greater uniformity in seed quality standards will have an increasingly positive impact on movement and adoption of new varieties originating in national programs or international centers. Greater attention is also now given by some countries and organizations to improving seed for small farmers. The ultimate impact of the Seed Unit will be seen as the use of improved seed of better varieties accelerates.

Communication and Information Support Unit

The Communication and Information Support Unit produces a wide range of informational materials. The variety and numbers of publications and instructional slide sets have increased steadily since 1977, as more support is directed to the growing commodity networks of the Center. The Unit also has continued to produce high-quality materials for audiences outside the networks and to support CIAT research and training activities with development of communication strategies and with library and production services.

Support to Commodity Networks

Commodity Information Centers. The commodity information centers offer a specialized service to scientists and other users within each of three commodity networks—cassava, beans, and tropical pastures. The centers basically attempt to make existing information more easily available to those needing it. Each commodity center contains a database of thousands of documents carefully screened from the world's literature to be most useful to tropical country scientists working within the commodity. Published compilations of abstracts on subject matter literature and retrospective literature searches for specific areas of the database are offered in each commodity. Each database includes or is expected to include all pertinent published information for that commodity.

Additionally, information specialists offer other services, such as searching out and providing answers to questions sent in by subscribers or referral services to those who might have answers—other information centers or scientists working in similar areas.

Two commodity information centers were established before the period covered by this CIAT Report (Cassava in 1972 and Beans in 1975); the Tropical Pastures Information Center began operating in 1978. By the end of 1983, the three information centers had 1295 subscribers. The number of documents processed and offered to subscribers total more than 16,000.

Network Newsletters. Newsletters written and distributed periodically to subscribers within the commodity programs and the Seed Unit networks are important vehicles for synthesizing and providing quick dissemination of the latest research information and network news. Most of these newsletters have been developed and standardized since 1977, and a total of 55 issues have now been distributed.

Other Network Publications. The Unit also edits, publishes, and distributes research data and similar information for commodity networks. Examples include annual reports of the International Bean Yield and Adaptation Nursery and the International Rice Testing Program, as well as reports of the International Tropical Pasture Evaluation Network. Seventeen of these network reports have now been published.

Training Materials. The Communication and Information Support Unit assists CIAT training activities in various ways. Some 15 manuals and 89 other publications have been produced since 1977 for use in training courses, either in CIAT or in other institutions.

Audiovisual instructional units represent another important communication product. These self-teaching units consist of a set of slides, a cassette tape, and a printed study guide including evaluation sheets. The units are used in conjunction with training courses in CIAT as well as in national research programs, agricultural universities, and even in some commercial enterprises. Eighty-one units are in distribution and 19 more in production. More than 2600 sets have been sold to 353 institutions and individuals in 38 countries.

During 1982 and 1983, CIAT cooperated in a special project to help train staff in nine new centers set up to produce and utilize audiovisual instructional units. These centers for Production and Utilization of Audiovisual Materials (PUMA) each have a complete set of the CIAT-produced units along with equipment to produce their own new materials. One of the PUMAs is already involved in production and has completed an audiovisual instructional unit of very high quality.

Support to Other Clients

Table of Contents Service. The Communication and Information Support Unit prepares and communicates information to a number of other publics. One of the most popular outlets is the Pages of Contents service which currently has 1559 subscribers. Each month a subscriber receives a collection of contents pages from 800 key agricultural journals. The subscriber can select and order the full article or articles as photocopies.

This service fills a great need in many developing countries where scientists do not have access to current published information. In the first eight months of 1983, 6301 articles were ordered through the service. Eight other agricultural libraries and one national agricultural information service in Latin America have developed similar systems based on the CIAT model.

Publications. In addition to the specific network publications already mentioned, the Unit writes, edits and publishes a variety of other information pieces. These range from popular-style newsletters and reports like CIAT International and the CIAT Report, to proceedings of meetings and conferences, and to more technical materials such as program annual reports, monographs and technical bulletins. Users of these publications include CIAT donors, scientists and institutions around the world, and the general public.

Training and Conference Activities

Activities in Scientific Training and Conferences at CIAT have helped many countries develop critical masses of researchers within the target areas of CIAT's commodities thereby strengthening the research capabilities of national programs. These newly qualified professionals have, in turn, helped set up the international networks which are evaluating and selecting genetic material to develop numerous new releases of improved germplasm.

More than 2300 persons have received training at CIAT since 1969, with 75 percent of these professionals completing training within the past seven years.

The Scientific Training and Conferences Office directly supports the research and evaluation networks and decentralization activities of CIAT's commodity programs. The primary purpose of Scientific Training and Conference Activities is to help personnel in national programs acquire leadership capabilities for collaborative research with other programs and with CIAT. This objective is accomplished through a dynamic training program tailored to meet the joint needs of individual programs and CIAT's own commodity programs. Through its conference functions the Office helps CIAT programs strengthen and maintain their ties with collaborators in their respective networks.

Evolution of Training Decentralization

Training activities have become progressively decentralized since 1976. The commodity programs and other units have assumed greater responsibility for conducting their own training with the Office of Scientific Training providing centralized support and coordination, leadership, and complementary relations with national programs and funding donors.

CIAT training emphasized a "short-course" strategy for four years through 1980. This strategy was designed to help commodity programs rapidly develop a critical mass of professionals in national programs. Specific training objectives included making these future collaborators aware of the respective program's research plan, the germplasm it offered, and the prospects available for cooperative efforts.

About 676 professionals from 22 countries and 36 national institutions were trained in intensive courses in beans, rice, cassava, and tropical pastures during that period. Attention continued to be given also to training researchers through discipline-specific internships, and 404 persons received this type of training.

After peaking at 336 in 1979, the total number of trainees at CIAT began to decline as offerings of intensive courses were reduced (Figure 1). Increased emphasis was directed to medium-duration (3 to 12 months) internships as a means of consolidating teams of cooperating researchers in each national program.

An increasing number of professionals are now being trained through short *in-country* and *regional courses*. These courses are generally directed to training extension personnel who have major roles in diffusing new germplasm varieties and other technology. Most of the courses are organized and taught by CIAT-trained local researchers; CIAT outposted and headquarters staff assist as necessary. Numbers of courses and total professionals trained have been closely related to accomplishments in germplasm development and distribution (Figure 2). Since 1977, CIAT has assisted in 49 such courses involving more than 1600 professionals. About 80 percent of the participants have been in courses offered during the past three years.

While large numbers can be impressive, the most important factor concerns what the large body of newly skilled professionals are accomplishing as they reenter their programs. CIAT's training activities support the objectives of commodity programs and other units in four ways. Two of these ways—the collaborative work of CIAT-trained workers in the selection/release process for new

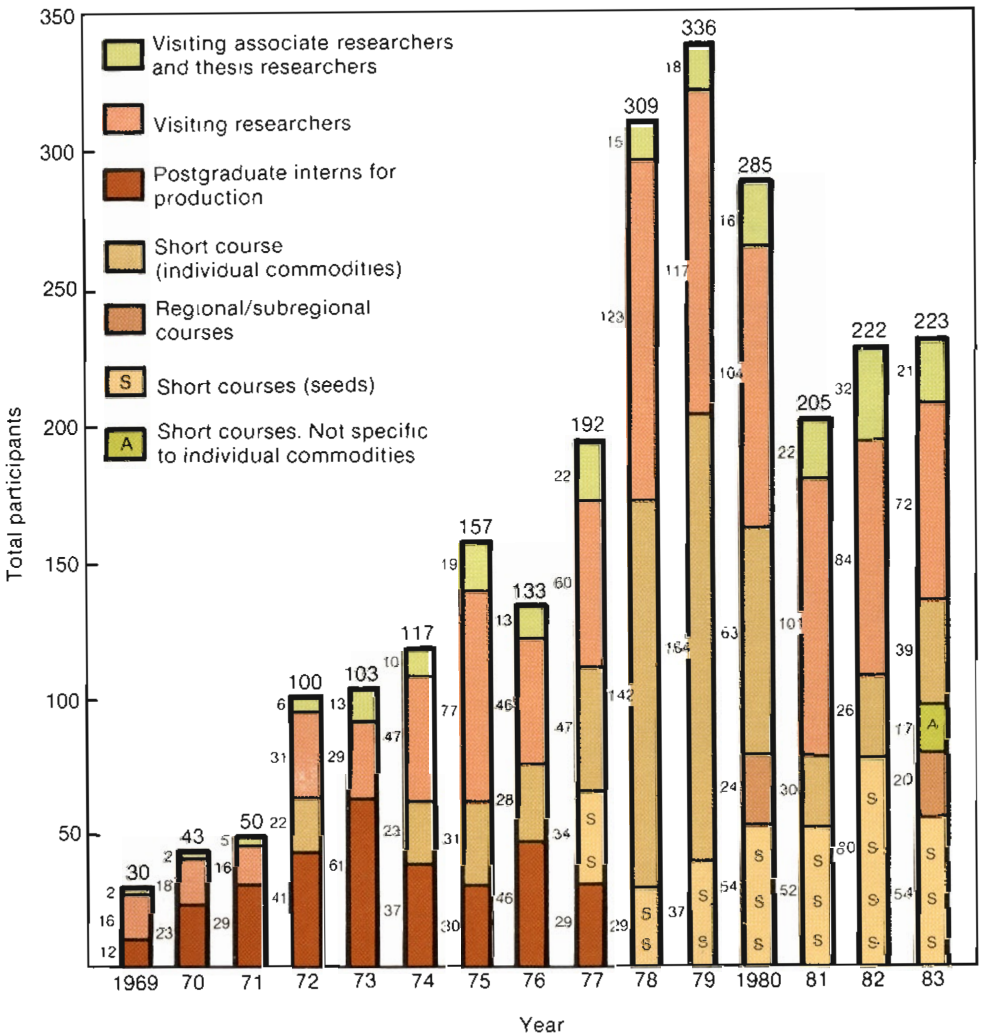


Figure 1. Numbers of persons who have completed training at CIAT (1969-1983).

varieties and technologies, and the contributions of CIAT alumni to the growth and operation of research networks—have been documented in the reports of the respective programs.

CIAT-trained personnel also frequently serve as new trainers. This has rapidly accelerated the training process, especially through in-country courses where a large percentage of the instruction is done by staff of national programs who were trained at CIAT.

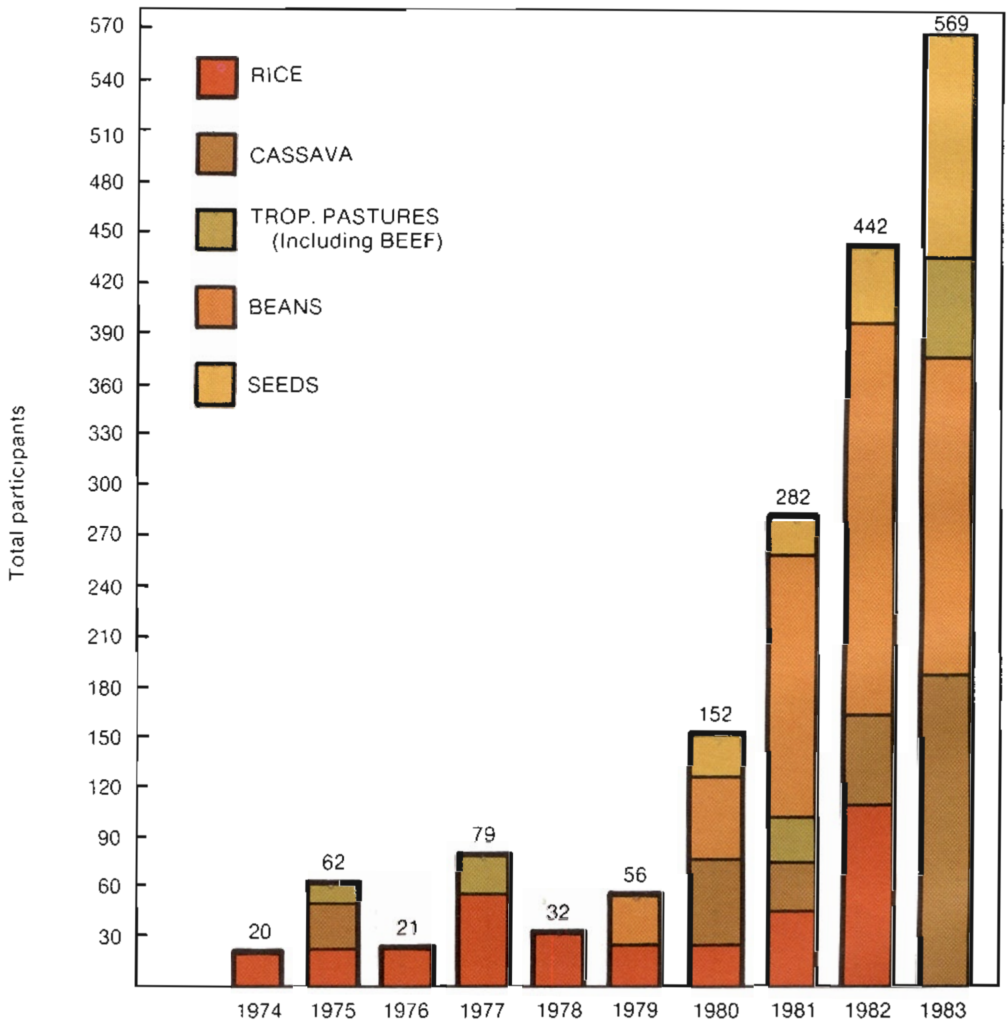


Figure 2. Number of persons participating in CIAT-assisted in-country training courses (1974-1983).

Finally, CIAT training is helping to strengthen national programs. This long-term process is critical if CIAT is to continue to accomplish its strategy of decentralized research. The increasing capabilities of several national programs to accept greater responsibilities in conducting applied research indicates this objective is being met.

Impact of CIAT-Training Activities

The true impact of CIAT's training accomplishments is difficult to quantify for a number of reasons. All training courses contain an evaluation to measure participants' knowledge of a subject before and after courses. These evaluations consistently indicate gains in knowledge of about 40 to 60 percent. Participants also consistently rate their levels of satisfaction with courses as high to very high. In the field, post-training performance in research is generally rated high by supervisors and by CIAT's staff who visit in countries.

Additional evidence of the success of CIAT training is the critical mass of key researchers and extensionists forming the nuclei of many national commodity programs in Latin America, Southeast Asia, and East and Central Africa. Although turnover is active in many national programs, remaining key professionals are able to provide continuity in programming in most countries.

Support to Research Networks

Professionals trained at CIAT are primarily responsible for the successful operation of commodity research networks. Network activities are discussed in detail in the reports for each program. To support and strengthen these important activities in technology development and diffusion, CIAT sponsors conferences designed to exchange information on trials and to plan cooperative research strategy. These meetings are usually biennial workshops. Other scientific meetings on various topics are held during the year as needed.

At a higher level, CIAT also hosts a biennial "consultation workshop" with directors of national research institutions with which the Center works. These workshops are for mutual consultation for fixing future cooperative activities and setting research priorities.

Supplementary Information

Financial Information

Board of Trustees

Senior and Professional Staff

The CGIAR System

Financial Information

Price Waterhouse

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February 20, 1984

REPORT OF INDEPENDENT ACCOUNTANTS

To the Board of Trustees of

Centro Internacional de Agricultura
Tropical (CIAT)

In our opinion, the accompanying balance sheets and the related statements of revenue and expenditures and unexpended funds present fairly the financial position of Centro Internacional de Agricultura Tropical (CIAT) at December 31, 1983, 1982 and 1981 and the results of its operations for the years then ended, in conformity with generally accepted accounting principles consistently applied. Our examinations of these statements were made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

Our examination for the year ended December 31, 1983 also encompassed the schedules of analysis of grants and related expenditures, earned income, comparison of approved budget and actual expenditures and dates of receipt of grants for that year, which are presented as supplementary information, and, in our opinion, these schedules present fairly the information shown therein.

Price Waterhouse

BALANCE SHEET

(Expressed in thousands of U.S. dollars)

ASSETS	December 31 1983	1982	1981
CURRENT ASSETS			
Cash	3,698	2,698	1,484
Accounts receivable			
Donors	1,177	316	273
Employees	952	447	275
Others	1,357	1,594	1,268
	3,486	2,357	1,816
Inventories	1,550	947	1,335
Prepaid expenses	47	52	69
Total current assets	8,781	6,054	4,704
FIXED ASSETS			
Equipment	5,300	4,441	3,682
Aeroplane	1,271	676	676
Vehicles	2,655	2,557	1,993
Vehicles (replacements) in transit	15	75	523
Furnishings and office equipment	1,458	1,364	1,286
Buildings	7,175	7,116	6,929
Others	78	201	201
Total fixed assets	17,952	16,430	15,290
Total assets	26,733	22,484	19,994

LIABILITIES AND FUND BALANCES	December 31 1983	1982	1981
CURRENT LIABILITIES			
Bank overdrafts	52	40	44
Accounts payable	5,227	3,982	2,371
Total current liabilities	5,279	4,022	2,415
GRANTS RECEIVED IN ADVANCE	1,052	70	407
FUND BALANCES			
Invested in fixed assets	17,952	16,430	15,290
Unexpended funds (deficit)			
Core			
Unrestricted	(15)	165	(100)
Working fund	1,562	1,099	603
Capital grants			265
Special Core projects	519	372*	699*
Other special projects			
Donors	638	448*	518*
Others	(254)	(122)	(103)
	2,450	1,962	1,882
Total fund balances	20,402	18,392	17,172
Total liabilities and fund balances	26,733	22,484	19,994

*Reclassified for comparative purposes.

The notes on page 82 are an integral part of the financial statements.

STATEMENT OF REVENUE AND EXPENDITURES AND UNEXPENDED FUNDS

(Expressed in thousands of U.S. dollars)

	For the year ended December 31		
	1983	1982	1981
Revenue			
Core programs			
Operating grants			
Unrestricted	10,689	10,447	9,283
Restricted	8,293	7,653	6,358
Capital grants	605	470	678
Total Core	19,587	18,570	16,319
Special Core projects	1,723	1,105*	1,692*
Other special projects	1,226	792*	1,040*
Total special projects	2,949	1,897	2,732
Earned income	1,189	926	540
Total revenue	23,725	21,393	19,591
Expenditures			
Core programs			
Research programs	7,768	7,985*	6,617*
Research support	2,869	2,641*	2,662*
International cooperation	2,140	2,117*	1,965*
Administration	2,506	2,159*	1,767*
General operating expenses	3,948	2,985	3,200
Total Core programs	19,231	17,887	16,211

	For the year ended December 31		
	1983	1982	1981
Special Core projects	1,476	1,432	1,416
Other special projects	1,008	854	518
Fixed assets	1,522	1,140	1,096
Total expenditures	23,237	21,313	19,241
Excess (deficit) of revenue over expenditures			
Operating grants	(180)	265	(100)
Working fund	350	244	70
Capital grants	(147)	(40)	(418)
Special Core projects	247	(327)	276
Other special projects	218	(62)	522
	488	80	350
Transfers between funds			
To (from) working fund	113	252	(327)
From special projects	(260)	(27)	(158)
To (from) capital grants	147	(225)	485
	488	80	350
Unexpended funds at beginning of year	1,962	1,882	1,532
Unexpended funds at end of year (see balance sheet)	2,450	1,962	1,882

*Reclassified for comparative purposes.

The notes on page 82 are an integral part of the financial statements.

NOTES TO FINANCIAL STATEMENTS

NOTE 1 — ACCOUNTING POLICIES

The following significant accounting policies and practices of CIAT are set forth to facilitate the understanding of data presented in the financial statements.

Inventories
Inventories are stated at the lower of cost or market value, cost being determined on an average basis.

Fixed assets
Fixed assets are recorded at cost.

Depreciation
In conformity with generally accepted accounting principles applicable to nonprofit organizations, CIAT does not record depreciation of its property and equipment.

NOTE 2 — FOREIGN EXCHANGE

All foreign exchange transactions are controlled by the Colombian government and, accordingly, all foreign exchange received in Colombia must be sold through official channels. The following exchange rates were used to translate Colombian pesos (P) to U.S. dollars ($) for the year 1983:

	P/$1	
Peso balances included in current assets and current liabilities	88.77	Year-end exchange rate
Peso income and peso disbursements for fixed assets and expenses	78.10	Average monthly rate of exchange applicable to sales of dollars

NOTE 3 — OPERATIONS

The land on which CIAT carries out its operations was ceded to CIAT under an agreement with the Colombian government which expires on July 15, 2000. The agreement may be extended thereafter by mutual consent, but if it is not, then CIAT will be obligated to relinquish its immovable assets on the land to the Colombian government.

NOTE 4 — CONTINGENCIES

A former employee has filed a labor claim of P30,000,000 (US$338,000) against the Center based on local labor legislation related to indemnities.

Directors and the legal advisor are of the opinion that the final outcome of this claim will be in favor of the Center and accordingly no provision has been recorded.

SUPPLEMENTARY INFORMATION
COMPARISON OF APPROVED BUDGET AND ACTUAL EXPENDITURES FOR THE YEAR ENDED DECEMBER 31, 1983

(Expressed in thousands of U.S. dollars)

	Unrestricted Core		Restricted Core		Capital	
	Approved budget	Actual	Approved budget	Actual	Budget	Actual
Research programs						
Beans	853	816	1,303	1,338		
Cassava	696	638	1,284	1,259		
Rice	194	223	637	637		
Tropical pastures	2,208	2,032	825	825		
	3,951	3,709	4,049	4,059		
Research support						
Visiting Scientists and Post-doctorals	139	104	160	149		
Genetic resources	163	162	191	194		
Research services	157	101	183	168		
Station operations	440	343	508	485		
Carimagua station	256	205	295	283		
Data services	412	250	476	425		
	1,567	1,165	1,813	1,704		
Total research	5,518	4,874	5,862	5,763		
International cooperation						
Training and conferences	529	403	549	519		
Communication and information support	648	430	788	788		
	1,177	833	1,337	1,307		
Administration						
Board of Trustees	77	84	18	20		
Director General	407	365	95	85		
Directors	408	337	98	79		
Administrative support	1,064	1,246	250	290		
	1,956	2,032	461	474		

(Continued on page 84)

SUPPLEMENTARY INFORMATION
COMPARISON OF APPROVED BUDGET AND ACTUAL EXPENDITURES FOR THE YEAR ENDED DECEMBER 31, 1983
(Expressed in thousands of U.S. dollars)

(Continued from page 83)

	Unrestricted Core		Restricted Core		Capital	
	Approved budget	Actual	Approved budget	Actual	Budget	Actual
General operating expenses						
Physical plant	1,228	1,212	289	284		
Motor pool	808	472	191	111		
General expenses	910	1,515	215	354		
	2,946	3,199	695	749		
Contingency	117		27			
Total Core	11,714	10,938	8,382	8,293		
Capital						
Fixed assets					1,038	1,522
Analysis of variances						
Underfunding		308		89		
Under (over) expenditures		483				(484)
Deficit transferred to fund balances		(15)				
		776		89		(484)

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(1983-1984)

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(as of December 1983)

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Carlos Meneses, Ing. Elect., Analysis
Rubén D. Osorio, Analysis
Rodrigo de los Ríos, Ing. Sist., Analysis

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Ricardo Castañeda, Administrative Associate, Government Relations (stationed in Bogotá)

Assistant
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Food and Housing

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Human Resources

General Administrative Services staff
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Associate
Germán Arias, Abog., Personnel Officer

Maintenance Services

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Jorge Uribe, Head, Electricity
Oscar Sánchez, Head, Air Conditioning and Refrigeration

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Jaime E. Cumba, Budget Assistant
César Moreno, C.P.T., Accountant
Mario Rengifo, Cashier

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Diego Mejia, Head, Purchasing

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Stephen Beebe, Ph.D., Plant Breeder, Central America Bean Project (stationed in Asunción Mita, Guatemala)
Jeremy H. Davis, Ph D., Plant Breeder, Plant Breeding
Michael Dessert, Ph.D., Central Africa Bean Project (stationed in Rubona, Rwanda)
Guillermo E. Gálvez, Ph.D., Plant Pathologist, Regional Coordinator, Central America Bean Project (stationed in San José, Costa Rica)
Guillermo Hernández Bravo, Ph.D., Plant Breeder, Co-leader, World Bank/INIPA (Peru)/CIAT Collaborative Bean Project (stationed in Chiclayo, Peru)
Francisco J. Morales, Ph.D., Virologist, Virology
Silvio H. Orozco, M S., Agronomist, Central America Bean Project (stationed in Guatemala City, Guatemala)
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Marcial Pastor-Corrales, Ph.D., Plant Pathologist, Plant Pathology
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Steven R. Temple, Ph.D., Plant Breeder, Plant Breeding
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Jonathan Woolley, Ph.D., Agronomist, Cropping Systems

Visiting scientists
David Allen, Ph.D., Plant Pathology
Jairo Castaño, Ph.D., Plant Pathology
N. Ruaraidh Sackville Hamilton, Ph.D., Data Management Systems
Jeffrey White, Ph.D., Physiology

Postdoctoral fellows
Guy Hallman, Ph.D., Entomology
* James Nienhuis, Ph.D., Plant Breeding

* Left during 1983

Joachim Voss, Ph.D., Central Africa Bean Project (assigned by the Rockefeller Foundation, stationed in Rubona, Rwanda)

Visiting research associates
* Krista C. Dessert, M.S., Nutrition
Elizabeth Lewinson, M.S., Agronomy (Gembloux Project)
Jeffrey MacElroy, M.S., Plant Breeding

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Jorge E. García, Ing. Agr., Entomology
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Jorge Ortega, M.S., Agronomy

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Gloria Isabel Ocampo, Bact., Microbiology
Darío Ramírez, Ing. Agr., Plant Breeding
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Gerardo Tejada, Ing. Agr., Agronomy

CASSAVA PROGRAM

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Anthony C. Bellotti, Ph.D., Entomologist, Entomology
* Guillermo G. Gómez, Ph.D., Nutritionist/Biochemist, Utilization
Clair Hershey, Ph.D., Plant Breeder, Plant Breeding
Reinhardt Howeler, Ph.D., Soil Scientist, Plant Nutrition and Soils
Kazuo Kawano, Ph.D., Plant Breeder, Plant Breeding (stationed in Rayong, Thailand)
Dietrich Leihner, Dr.agr., Agronomist, Cultural Practices
J. Carlos Lozano, Ph.D., Pathologist, Plant Pathology
John K. Lynam, Ph.D., Agricultural Economist, Economics
* Julio César Toro, Ph.D., Agronomist, Agronomy

Visiting scientists
Rupert Best, Ph.D., Utilization
Mabrouk El-Sharkawy, Ph.D., Physiology
* Marta Rojas de Hernández, Ph.D., Entomology

Postdoctoral fellows
* Upali Jayasinghe, Ph.D., Virology
Ewald Sieverding, Dr.agr., Soil and Plant Nutrition
Christopher Wheatley, Ph.D., Utilization

Research associates
Rafael Orlando Díaz, M.S., Economics
Rafael Alberto Laberry, M.S., Plant Pathology
Bernardo Ospina, Ing. Agric., Utilization (stationed in Sincelejo, Colombia)
Benjamín Pineda, M.S., Plant Pathology
Octavio Vargas, M.S., Entomology

Research assistants
Lisímaco Alonso, Ing. Agric., Utilization
Bernardo Arias, Ing. Agr., Entomology
Darío Ballesteros, Ing. Agr., Soils (stationed in Carimagua)
Eitel Adolfo Burckhardt, Lic. Biol., Soils
Luis Fernando Cadavid, Ing. Agr., Soils
Fernando Calle, Ing. Agr., Germplasm
José Aquileo Castillo, Biol., Entomology
Carolina Correa, Econ., Economics
Miguel A. Chaux, Tec. Ing. Ind., Office of the Coordinator
Diego Izquierdo, Econ., Economics
Gustavo Jaramillo, Ing. Agr., Agronomy
Javier López, Ing. Agr., Cultural Practices
Jorge Orrego, Ing. Agr., Utilization
Germán E. Parra, Ing. Agr., Physiology
José Antonio Puente, Ing. Agr., Cultural Practices
Edgar Salazar, Ing. Agr., Cultural Practices
* Mauricio Valdivieso, Zoot., Utilization
Ana Cecilia Velasco, Lab. Clin., Plant Pathology

RICE PROGRAM

Senior staff
Joaquín González, M.S., Agronomist, Coordinator

Sang-Won Ahn, Ph.D., Plant Pathologist, Plant Pathology

* Left during 1983

Peter R. Jennings, Ph.D., Plant Breeder, Plant Breeding (assigned by the Rockefeller Foundation)
César Martínez, Ph.D., Plant Breeder, Plant Breeding
Edward Pulver, Ph.D., Plant Breeder, Co-leader, World Bank/INIPA(Peru)/CIAT Collaborative Rice Project (stationed in Tarapoto, Peru)
Manuel Rosero, Ph.D., Plant Breeder, IRRI Liaison Scientist
Hector Weeraratne, Ph.D., Plant Breeder, Plant Breeding

Visiting scientist
Surapong Sarkarung, Ph.D., Plant Breeding (stationed in Villavicencio, Colombia)

Postdoctoral fellows
* Jairo Castaño, Ph.D., Plant Pathology
* Rafael Posada, Ph.D., Economics

Research associate
Marco Perdomo, Ing. Agr., Agronomy (stationed in Villavicencio, Colombia)

Research assistants
Luis Eduardo Berrío, Ing. Agr., International Trials
Luis Eduardo Dussán, Ing. Agr., Plant Breeding (stationed in Villavicencio, Colombia)
Yolanda Cadavid de Galvis, Ing. Agr., Agronomy
Jenny Gaona, Ing. Agr., International Trials
Luis Eduardo García, Ing. Agr., Plant Breeding (stationed in Villavicencio, Colombia)
Julio Eduardo Holguín, Ing. Agr., Plant Breeding
* Luis Octavio Molina, Ing. Agr., Plant Breeding
Eliseo Nossa, Ing. Agr., Plant Breeding (stationed in Villavicencio, Colombia)
Miguel Eduardo Rubiano, Ing. Agr., Plant Pathology (stationed in Villavicencio, Colombia)
Edgar Tulande, Ing. Agr., Plant Pathology

SEED UNIT

Senior staff
Johnson E. Douglas, M.S., Seed Specialist, Head

* Federico Poey, Ph.D., Seed Specialist, Seed Production

Visiting scientists
Juan Carlos García, M.S., Training and Seed Production
* Don F. Grabe, Ph.D., Seed Production

Research associates
Edgar Burbano, M.S., Laboratory and Seed Production
Joseph E. Cortés, Ing. Agric., Training

Research assistants
* José F. Aristizábal, Ing. Agric., Seed Quality Control
José Fernández de Soto, Ing. Agric., Communication
Guillermo Giraldo, Ing. Agr., Seed Production
Napoleón Viveros, Ing. Agric., Seed Processing

GENETIC RESOURCES

Senior staff
William M. Roca, Ph.D., Physiologist, Acting Head

Research associates
* Germán Alvarez, M.S., Germplasm (Forages)
Rigoberto Hidalgo, M.S., Germplasm (Beans)

Research assistants
Javier Beltrán, Biol., Physiology
Graciela Mafla, Biol., Physiology
Javier Narváez, Ing. Agr., Physiology
Jorge Alberto Rodríguez, Ing. Agr., Physiology
Hember Rubiano, Ing. Agr., Germplasm (Beans)
Isabel Salas, Biol., Seed Quality

LABORATORY SERVICES

Research associate
Octavio Mosquera, M.S., Analytical Services

Research assistants
Charles McBrown, Tec. Elec., Instruments Maintenance
Roberto Segovia, Ing. Agr., Greenhouses/Landscaping

EXPERIMENTAL STATIONS OPERATIONS

Senior staff
Alfonso Díaz-Durán, Ing. Agric., P.E., Superintendent

Research associate
Javier Carbonell, M.S., Palmira Station

Research assistants
* Javier Castillo, Ing. Agric., Head, Popayán Substation
Ramiro Narváez, Ing. Agric., Head, Quilichao Substation
Edgar Quintero C., Ing. Agr., Palmira Station
Raimundo Realpe, Ing. Agr., Head, Popayán Substation
Gonzalo Rodríguez, Ing. Agric., Head, Santa Rosa Substation

* Left during 1983

Senior staff
Gustavo A. Nores, Ph.D., Director

Associate
Uriel Gutiérrez, M.S., Administrative Associate

TROPICAL PASTURES PROGRAM

Senior staff
José M. Toledo, Ph.D., Pasture Agronomist, Coordinator

Rosemary S. Bradley, Ph.D., Soil Microbiologist, Microbiology
Mario Calderón, Ph.D., Entomologist, Entomology
***Walter Couto, Ph.D., Agronomist, Soil and Plant Nutrition/Pasture Development
John E. Ferguson, Ph.D., Agronomist, Seed Production
Bela Grof, Ph.D., Agrostologist, Legume Agronomy (stationed in Carimagua)
Carlos Lascano, Ph.D., Animal Scientist, Pasture Quality and Animal Nutrition
Jillian M. Lenné, Ph.D., Plant Pathologist, Plant Pathology
John W. Miles, Ph.D., Plant Breeder, Agronomy/Forage Breeding
* C. Patrick Moore, Ph.D., Animal Scientist, Cattle Production Systems (stationed at CPAC, Brasilia, Brazil)
Esteban A. Pizarro, Ph.D., Agronomist, Regional Trials
José G. Salinas, Ph.D., Soil Scientist/Plant Nutritionist, Soil and Plant Nutrition
Rainer Schultze-Kraft, Dr.agr., Agronomist, Germplasm
Carlos Seré, Dr.agr., Agricultural Economist, Economics
James M. Spain, Ph.D., Soil Scientist, Pasture Development (on sabbatical leave, stationed at CEPLAC, Bahia, Brazil)
Luis E. Tergas, Ph.D., Agronomist, Pasture Productivity and Management
Derrick Thomas, Ph.D., Forage Agronomist, Agronomy (stationed at CPAC, Brasilia, Brazil)
Raúl R. Vera, Ph.D., Animal Scientist, Cattle Production Systems

Visiting scientists
Pedro J. Argel, Ph.D., Pasture Evaluation Program in Panama, INIAP/AID/Rutgers University/CIAT Bilateral Project (stationed in David, Panama)

* Left during 1983
** Deceased
*** Leave of absence

* Bruce Davidson, Ph.D., Economics
Haruo Hayashi, B.S., Pasture Productivity and Management

Postdoctoral fellows
Saif ur Rehman Saif, Dr.agr., Soil Microbiology
Julie M. Stanton, Ph.D., Plant Pathology

Visiting research associate
Martin Schneichel, Dipl.agr., ETES Project (stationed in Carimagua)

Research associates
* Edgar Burbano, M.S., Soil Microbiology
Rubén Darío Estrada, M.S., Economics
Silvio Guzmán, D.V.M.Z., Cattle Production Systems
Libardo Rivas, M.S., Economics

Research assistants
Amparo de Alvarez, Ing. Agr., Plant Pathology
Guillermo Arango, Lic. Biol., Entomology
* Alvaro Arias, Ing. Agr., Agronomy (stationed in Carimagua)
Hernando Ayala, D.V.M.Z., Cattle Production Systems (stationed in Carimagua)
Javier Belalcázar, Ing. Agr., Germplasm
Gustavo Benavides, Ing. Agr., Germplasm
* Raúl Botero, D.V.M.Z., Cattle Production Systems
Javier Asdrúbal Cano, Lic. Econ., Office of the Coordinator
Carlos Iván Cardozo, Ing. Agr., Seed Production
** Gustavo Cuenca, Zoot., Pasture Quality and Nutrition (stationed in Carimagua)
Fernando Diaz, Ing. Agr., Agronomy (stationed in Carimagua)
Martha Lucia Escandón, Ing. Agr., Forage Breeding/Agronomy
* Carlos Escobar, Ing. Agr., Soil and Plant Nutrition
Julián Estrada, D.V.M.Z., Pasture Quality and Nutrition (stationed in Carimagua)
Luis H. Franco, Ing. Agr., Regional Trials
Manuel Arturo Franco, Ing. Mec., Office of the Coordinator
César Augusto Garcia, Ing. Agr., Entomology (stationed in Carimagua)
* Duván Garcia, Ing. Agr., Seed Production
Obed Garcia, D.V.M.Z., Cattle Production Systems (stationed in Carimagua)
Hernán Giraldo, Ing. Agr., Pasture Agronomy
Arnulfo Gómez Carabaly, Ing. Agr., Regional Trials
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Phanor Hoyos, Zoot., Pasture Quality and Nutrition
Jesús A. Méndez, Ing. Agr., Microbiology
Carlos Humberto Molano, Ing. Agr., Forage Breeding/Agronomy
Dazier Mosquera, Ing. Agr., Soil Microbiology (stationed in Carimagua)
Gloria Navas, Ing. Agr., Pasture Development (stationed in Carimagua)
Carlos E. Perdomo, Ing. Agr., Soil and Plant Nutrition (stationed in Carimagua)
Fabiola de Ramírez, Lic. Bact., Microbiology
Hernando Ramírez, Biol., Germplasm
* Raimundo Realpe, Ing. Agr., Agronomy (stationed in Carimagua)
* Bernardo Rivera, D.V.M.Z., Animal Health (stationed in Carimagua)
José Ignacio Roa, Ing. Agr., Forage Breeding/Agronomy/Seed Production (stationed in Carimagua)
Edgar Salazar, Ing. Agr., Legume Agronomy (stationed in Carimagua)
Manuel Sánchez, Ing. Agr., Seed Production
Celina Torres, Ing. Agr., Plant Pathology
*Fernán A. Varela, Ing. Agr., Entomology

IFDC/CIAT PHOSPHORUS PROJECT

Senior staff
Luis Alfredo León, Ph.D., Soil Scientist, Head

Jacqueline A. Ashby, Ph.D., Rural Sociologist, Sociology

Postdoctoral fellow
* Elizabeth Hansen, Ph.D., Anthropology

Visiting research associate
* David J Harris, M.S., Soils, IFDC/Benchmark Soils Project

Research assistants
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Luis Guillermo Restrepo, Ing. Agr., Agronomy

DATA SERVICES

Senior staff
Leslie C. Chapas, Dipl. Math. Stat., Biometrician, Head

Peter Jones, Ph.D., Agrometeorologist, Agroecological Studies

General Administrative Services staff
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José Eduardo Granados, M.S., Biometrics
Hugo Macías, Ing. Civil, System Programmer

Research assistants
Miriam Cristina Duque, Mat., Biometrics
María del Rosario Henao, Ing. Sist., Computing
* Oscar L. Quevedo, Ing. Sist., Computing
Julián E. Rengifo, Ing. Sist., Computing
* Alfredo Rojas, Biometrics

COMMUNICATION/INFORMATION SUPPORT UNIT

Senior staff
Susan C. Harris, M.L.S., Informationist, Head

Training Materials

Visiting scientist
Jairo Cano, Ph.D., Communication Specialist, Head

Associates
* Cornelio Trujillo, M.S., Supervisor
Oscar Arregocés, Ing. Agr., Production

Assistants
Fernando Fernández O., Ing. Agr., Production
Héctor Fabio Ospina, Ing. Agr., Production
Carlos Alberto Valencia, Ing. Agr., Production

Communication

Senior staff
Susana Amaya, Ph.D., Editor/Communication Specialist, Research Network Communication
Cynthia L. Garver, M.A., Editor/Communication Specialist, Scientific/Technical Communication

Associates
Francisco Motta, M.S., Research Network Communication
Ana Lucía de Román, Ing. Agr., Research Network Communication

Assistants
* Maria Lida Cabal, Internal Communication
Rodrigo Ferrerosa, Lic. Econ., Scientific/Technical Communication
María Cristina Henao, Com. Soc., Scientific/Technical Communication
Nelly M. de Nivia, Com. Soc., Internal Communication
Alexandra Walter, Scientific/Technical Communication

Graphic Arts/Production

General Administrative Services staff
Walter Correa, Ph.D., Head

Associates
Alvaro Cuéllar, Supervisor, Photography
Carlos Rojas, Supervisor, Graphic Design

* Left during 1983

Assistants
Didier González, Graphic Design
Carlos Vargas, Graphic Design

Library and Documentation Services

Associate
Jorge López S., Supervisor, Specialized Information Centers

Assistants
Fabiola Amariles, Lic. Educ., Reference Services
Stella Gómez, Lic. Bibl., Supervisor, Bibliographic Services
Francy González, Ing. Agr., Specialized Information Center, Beans
Mariano Mejía, Lic. Educ., Specialized Information Center, Tropical Pastures
Lynn Menéndez, Editing and Translations
Piedad Montaño, Supervisor, Acquisitions
Hernán Poveda, Lic. Bibl., Supervisor, Technical Processes

TRAINING AND CONFERENCES

Senior staff
Fernando Fernández, Ph.D., Soil Scientist, Coordinator

General Administrative Services staff
Alfredo Caldas, M.S., Admissions Administrator

Associates
Carlos Dominguez, M.S., Cassava
Carlos Flor, M.S., Beans
Elias García, Ing. Agr., Rice
Marceliano López, M.S., Beans
Alberto Ramirez, M.S., Tropical Pastures
Jesús Reyes, M.S., Cassava
Eugenio Tascón, Ing. Agr., Rice/In-country Training

Assistants
María Eugenia Cobo, Conferences
Carlos Suárez, B.S., Orientation

REPRESENTATION OF COLLABORATING INSTITUTIONS IN CIAT

CIMMYT/CIAT ANDEAN REGION MAIZE PROJECT

Senior staff
Gonzalo Granados, Ph.D., Entomologist, Head

James Barnett, Ph.D., Plant Breeder, Andean Regional Services

INTSOY/ICA/CIAT

Senior staff
Luis H. Camacho, Ph.D., Plant Breeder, Head

INTSORMIL/CIAT REGIONAL SORGHUM PROJECT

Senior staff
Lynn Gourley, Ph.D., Plant Breeder, Head

Research assistant
Manuel Coronado, Ing. Agr., Plant Breeding

CIP REGIONAL REPRESENTATION

Senior staff
Oscar Malamud, Ph.D., Liaison Officer, Head (stationed in Bogotá, Colombia)
Jan Henfling, Ph.D., Liaison Officer (stationed in Medellín, Colombia)

IBPGR REGIONAL REPRESENTATION

Miguel Holle, Ph.D., IBPGR Regional Representative for Latin America

GTZ REGIONAL REPRESENTATION

* Gunther John, Dr.agr., Liaison Officer

* Left during 1983

The CGIAR System

THE CONSULTATIVE Group for International Agricultural Research (CGIAR) was formed in 1971 to provide a mechanism for mobilizing broadbased financial support for the global system of 13 international agricultural research centers and organizations. The creation of CGIAR indicated the desire of donor agencies to provide long-term support for agricultural development in the developing world. In addition, in consultation with the Technical Advisory Committee—a panel of top-level scientists who oversee the research programs of the centers — CGIAR is able to assure financial donors that their resources are being used to achieve maximum benefits.

The soundness of this system is evidenced by the fact that donor membership in CGIAR has grown from 15 in 1972, who contributed about US$20 million, to 37 in 1983, with a total contribution of about US$148 million.

Each center or organization in the CGIAR system is autonomous, with its own Board of Trustees or other governing body. Each develops its own budget for funds provided by CGIAR, consistent with the total money pledged to be available for the coming year and the center's program in relation to the goals of the system. Each center budget is submitted annually during the center's review week, when a short overview of its programs and accomplishments is presented before the body of CGIAR donors and other representatives.

CGIAR operates informally and by consensus and provides an outstanding example of effective, flexible, and successful cooperation between the industrialized and developing worlds. Headquarter offices are furnished by the World Bank in Washington, D.C. The Bank also provides the services of a Chairman and an Executive Secretariat. The Secretariat of the Technical Advisory Committee is provided by the Food and Agriculture Organization of the United Nations in Rome.

The nine international agricultural research centers and four associated organizations have the following headquarters and research responsibilities:

Latin America

- Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia: cassava, field beans, rice, and tropical pastures.

- International Center for Maize and Wheat Improvement (CIMMYT), El Batan, Mexico: maize and wheat
- International Potato Center (CIP), Lima, Peru: potatoes

Asia

- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India: chickpea, pigeonpea, pearl millet, sorghum, groundnut, and farming systems.
- International Rice Research Institute (IRRI), Los Baños, Philippines: rice

Middle East

- International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria: farming systems, cereals, food legumes (broad bean, lentil, chickpea), and forage crops

Africa

- International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria: farming systems, maize, rice, roots and tubers (sweet potatoes, cassava, yams), and food legumes (cowpea, lima bean, soybean)
- International Laboratory for Research on Animal Diseases (ILRAD), Nairobi, Kenya: trypanosomiasis and theileriosis of cattle.
- International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia: livestock production systems.
- West Africa Rice Development Association (WARDA), Monrovia, Liberia: rice

Europe and the United States

- International Board for Plant Genetic Resources (IBPGR), Rome, Italy: plant varieties collection and information.
- International Service for National Agricultural Research (ISNAR), The Hague, the Netherlands: research support.
- International Food Policy Research Institute (IFPRI), Washington, D.C., USA: analysis of world food problems