CIAT 1988
PROGRAM AND BUDGET

CIAT

Centro Internacional de Agricultura Tropical

Centro Internacional de Agricultura Tropical (CIAT)
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CONTENTS

MANDATE AND OBJECTIVES OF CIAT

The purpose and approach of CIAT—one of several agricultural research centers under the aegis of the CGIAR—is given in the following statement of objectives:

> To generate and deliver, in collaboration with national and regional institutions, improved technology which will contribute to increased production, productivity, and quality of specific food commodities in the tropics—principally countries in Latin America and the Caribbean—thereby enabling producers and consumers, especially those with limited resources, to increase their purchasing power and improve their nutrition.[1]

The CIAT strategy to accomplish these objectives is summarized by the following statements regarding resource emphasis, commodity choice, institutional role, and scope of activities.

Resource Emphasis

CIAT's strategy emphasizes enhanced production through increased resource productivity on farms with limited resources and on underutilized land. By contributing to the improvement of productivity on small- and medium-scale farms, the Center seeks to provide for increased rural income and employment, moderate and stable food prices, and improved diets, especially of the low-income population in rural and urban areas. Technology which contributes to the expansion of agricultural production of suitable commodities on the less fertile frontier lands makes possible the release of the more fertile lands for maximum crop cultivation. Hence more efficient food and animal production is achieved by using both poor and fertile land resources.

Commodity Choice

Commodities included under CIAT's mandate are predominantly food staples. Each commodity has one or more of the following attributes: it is a relatively inexpensive source of calories; it is a relatively inexpensive source of protein; and it is an important component in the food budget of low-income consumers in the geographic region of emphasis. Commodities are selected for their potential to augment the productivity and incomes of small farmers and/or to contribute to increasing agricultural production on existing cultivated lands or in the agricultural frontier.

Institutional Role

A basic premise of CIAT's strategy is that it represents only one small segment of the agricultural research and development matrix. All the Center's activities, therefore, are viewed as complementary to those of other organizations. Linkage to other closely related activities is essential in developing effective research networks that *capture economies of scale* in research on the chosen commodities. Such activities involve such groups as national research and extension systems, advanced scientific institutions, and related international programs.

The most important interface is that with national research systems. In partnership with these programs,

1. Statement of objectives and strategies as approved by the CIAT Board of Trustees at its annual meeting in 1983.

CIAT concentrates on activities in which it has a clear comparative advantage and in which the results have international transferability. Such activities include the assembly of germplasm banks; large-scale screening, crossing, and selection; methodology development; and information services. CIAT attempts to strengthen collaboration and to encourage horizontal technology transfer among national programs by helping to develop and strengthen research networks. Active training and conference programs serve to fortify national research systems, as well as the network activities.

Basic research institutions in both developed and developing countries are linked with CIAT activities to provide basic research inputs and specialized research services that complement and support CIAT's more problem-solving research.

The principle of complementarity also applies to other international institutions, especially sister centers within the CGIAR system. Through informal discussions and formal agreements cooperation and division of labor is defined to maximize the benefits of comparative advantage and minimize duplication.

Scope of Activities

CIAT's efforts are predominantly focused on the American tropics. Its commodities are selected for their importance in this region. Yet, within the CGIAR system the Center has been assigned broader responsibilities for given commodities. CIAT is differentiating functional responsibilities on the basis of their being either principal mandates or regional responsibilities.

Principal Mandates

For commodities for which CIAT is assigned a principal mandate, CIAT assumes the following responsibilities.

1. Assemble, maintain, and make available the world germplasm collection.
2. Conduct specialized strategic research.
3. Generate improved production technology components for, and develop cooperative activities with, national research systems in all regions in the developing world where the commodity is important and where no sister CGIAR center is assuming regional responsibilities.
4. Provide, on a global basis, inservice training for professionals in the specialized strategic areas of research.
5. Provide specialized inservice and production-oriented training for professionals from countries where no other CGIAR center has regional responsibilities.
6. Collect, process, and disseminate information on the commodity on a global basis.
7. Support the activities of another institution or institutions, if any, which has regional responsibilities for that commodity.

Regional Responsibilities

This category applies when a sister CGIAR center has global responsibilities for a commodity and, in close cooperation with that center, CIAT takes on the mandates 3 and 5. Together with national research systems, it identifies principal production constraints. In close collaboration with the center having principal responsibility, CIAT seeks to facilitate such activities as are required to overcome such constraints.

Current Mandate

In order to achieve the objectives and apply the strategy described above, and taking into account the results of socioeconomic studies and the mandates of other centers, the CIAT programs have evolved to currently encompass the following responsibilities:

1. Principal responsibilities for beans (*Phaseolus vulgaris* and related species) and cassava (*Manihot esculenta*).
2. Principal responsibilities for tropical pastures with specific responsibilities for the acid infertile soils of the American tropics.
3. Regional responsibilities for rice with specific responsibilities for the American tropics.

GOVERNANCE, ORGANIZATION, AND RESEARCH SITES

The Board of Trustees

CIAT is governed by an independent Board of Trustees. The membership of the 1987-1988 Board is as follows:

Name	Country of origin
William E. Tossell (Chairman)	Canada
Nohra de Junguito (Vice-Chairwoman)	Colombia
William A. Carlson	USA
Eduardo Casas Díaz	Mexico
Dely P. Gapasin	Philippines
Ken-ichi Hayashi	Japan
Frederick E. Hutchinson	USA
Gabriel Montes Llamas	Colombia
John L. Nickel (Director General)	USA
Josef Noesberger	Switzerland
Marco Palacios Rozo	Colombia
Luis Guillermo Parra	Colombia
Michel Petit	France
Rodrigo Tarté	Panama
Helio Tollini	Brazil
Fredrick Wang'ati	Kenya
Armando Samper Gnecco (Chairman Emeritus)	Colombia

The full Board meets at least once during each calendar year. It has four standing committees: Executive Committee, Program Committee, Audit Committee, and Nominations Committee.

Organizational Structure

Organizationally, CIAT is comprised of three divisions. **Research Division I** consists of the commodity research programs for beans and cassava, as well as the Biotechnology Research Unit, the Genetic Resources Unit, Station Operations, and Research Services (except Data Services). **Research Division II** comprises the Tropical Pastures Program, the Rice Program, the Data Services Unit, the Seed Unit, and the Coordinating Office for Training and Conferences. The third division, **Finance and Administration,** is responsible for the general services and financial administration.

Research Sites

CIAT's research activities are concentrated at five locations in Colombia: the headquarters at Palmira, near Cali; Santander de Quilichao, 60 kilometers south of Cali, and characterized by acid, infertile soils; an intermediate altitude station at Popayán, 180 kilometers south of Cali; a substation for upland rice research in Santa Rosa, near Villavicencio (Meta); and Carimagua in the Eastern Plains of Colombia which is comanaged with ICA. In addition, pasture research is also carried out in Brazil at CPAC of the Brazilian agricultural research system (EMBRAPA). CIAT also maintains cooperative agreements with other national and regional institutions to help carry out regional and international testing activities at many locations. In some cases, these agreements help support outposted staff members who conduct research or support commodity networks.

SUMMARY OF ACHIEVEMENTS

Despite a levelling off of core funding in recent years, the Center has systematically sought to fulfill its role as projected in its "Medium-term Plan for 1986 to 1990." This has been made possible through a series of interlinked developments, including:

1. Obtaining sizeable special project funds, a large portion of which are used to expand and intensify CIAT's international commodity networks, especially in relation to beans in Africa.
2. Systematically building up collaborative research projects with advanced research institutions around the world, which greatly contributes to the effectiveness of the Center's research efforts.
3. Strategic use of the contributions of visiting scientists and postdoctoral fellows, both for carrying out well-defined, one-time research projects and to begin work that may ultimately need attention by core-funded senior staff.
4. Noticeable progress on the part of many collaborating national programs, and of the commodity networks in general, in assuming an increased degree of responsibility for research and development tasks that formerly were conducted by CIAT.

Impact of CIAT's Work

The impact of CIAT's work is increasingly evident. In **beans,** farmers in many areas that have been assigned high priority by the Bean Program and its national collaborators have shown their acceptance of improved varieties. In selected countries, where, in spite of limited resources, CIAT was able to conduct systematic adoption studies, conservative estimates of the additional wealth generated by the new bean technology was close to US$25 million per year. Moreover, the potential benefits of the production technology now under development in eastern and southern Africa promise to be immense.

In **tropical pastures** many years of highly innovative and systematic germplasm development work have led to a wide range of highly productive grass/legume combinations which are stable over time and economically viable. Farmers are beginning to experiment with this new technology on a large scale.

In **cassava** the recent breakthrough in terms of a low-cost, safe preservation technology for the fresh root promises to make fresh cassava available to the urban and rural population at reasonable, stable prices. This will benefit both producers and consumers in cassava-producing countries. The integration of production, processing, and marketing of dried cassava—successfully demonstrated in pilot projects in which CIAT played a central role—holds great promise for many cassava-producing countries, especially in Latin America.

In **rice,** the Program's efforts to help rice-growing countries expand their rice production around well-defined national plans, and the Program's work on reducing production costs (primarily through a fully integrated approach to pest and disease control) are showing signs of having major impact on national production statistics.

Organizationally, the trend toward decentralization has continued: the Bean Program is building up its efforts on behalf of Africa, the Tropical Pastures Program is increasingly seeking to have an impact in tropical America outside the highly acid savanna regions, and the Cassava Program is in a position to materially contribute to cassava production outside Latin America. The number of outposted staff is increasing. Some of this increase is counterbalanced by a corresponding decrease at headquarters, although CIAT is making every effort to ensure that its outposted staff can count on a stable source of backup support from headquarters.

Selected major achievements of the four commodity research programs during the reporting period, 1986-1987, are described, together with achievements in the areas of Training, Genetic Resources, Biotechnology Research, Seed Technology, and Communication and Information.

Tropical Pastures Program

A. A germplasm pool of more than 18,000 accessions, complemented by a parallel collection of *Rhizobium,* provides the Program with the basic resources to attack the need for improved grasses and legumes for the Brazilian, Venezuelan, and Colombian savannas. Several genera and species have already been identified as being well adapted to the conditions of one or more of the ecosystems in which the Program works: the grasses *Andropogon gayanus, Brachiaria* spp., *Panicum maximum;* and the legumes *Arachis* spp., *Centrosema* spp., *Desmodium* spp., *Stylosanthes* spp., and *Pueraria phaseoloides.*

   To support the germplasm collection, an inventory of land resources with edaphic, topographic, and climatic characterizations of the region has been developed. The information is organized in a systematic manner and is easily retrievable. The Program has assessed the biological and economic parameters of the extensive cattle-production systems that are predominant in the savannas, and this data is also in constant use in the evaluation of germplasm and technologies.

B. The productivity of a "first-generation technology" for savanna ecosystems, based on environmentally adapted, grass-legume pastures for example, *A. gayanus* + *S. capitata*, has been tested in farmers' fields and under farmer management, with encouraging results— similar to those obtained at Carimagua. There it was found that the combination produced 150 kg of liveweight gains per animal per year, and 230 kg per ha per year. This represented a two-fold increase in individual liveweight gains and more than a ten-fold increase in the productivity per area for savanna grasslands.

   These varieties have been released by national programs. *Andropogon gayanus* CIAT 621 has been released by Colombia, Brazil, Venezuela, Peru, and Panama. *Stylosanthes capitata* CIAT 10280, which was released by ICA in Colombia, is being adopted in the savannas of Colombia in association with *A. gayanus,* and this will increase once seed becomes commercially available. Similarly, the legume *Stylosanthes guianensis* CIAT 184 was released in Peru for the humid tropics. Initial commercial seed multiplication is underway.

C. A "second-generation technology" is proving to be even more productive than those that have already been released, in the case of associations of *A. gayanus* and *Brachiaria dictyoneura* CIAT 6133 with *Centrosema acutifolium* CIAT 5277. The productivity of these associations is 20-30 kg higher in individual animal gains than those obtained with *A. gayanus* and *S. capitata.* It is highly encouraging to see that these associations are performing well under a wide range of management regimes, which is an important characteristic for future adoption. This second-generation technology is also being exposed to farmers. ICA in Colombia will release *Brachiaria dictyoneura* CIAT 6133 and *Centrosema acutifolium* CIAT 5277 during 1987.

D. Through the formation of the International Tropical Pastures Evaluation Network (RIEPT) in 1979, an effective mechanism was established for collaboration with and among the national research programs working on pastures. Through RIEPT, pasture research programs, large and small, are working together toward the development of new pasture technology that will allow the expansion of the cattle industry into marginal and frontier lands. At present, RIEPT is conducting more than 200 trials in tropical America, and more than 120 scientists from institutions in 18 countries are taking part in systematic screening of germplasm and pasture evaluation. To support the collaborative efforts of RIEPT, the network has produced five man-

uals dealing with the shared methodologies used in research, from agronomic research to the evaluation of pastures under grazing. RIEPT is catalyzing a massive continental effort in pasture research that will not only contribute to increasing the productivity of beef and milk production systems in marginal and frontier areas, but will also help to free prime, fertile lands that are now used for cattle production, so that the countries of Latin America can increase expansion of crop production to feed their populations.

Bean Program

A. The Bean Program's breeding strategy, based on stress tolerance, saw a "fine tuning" of research efforts, directed toward incorporating those types of resistance that were lacking in superior lines. For example, the high susceptibility of landraces (especially red-seeded, early, Central American criollos) to BCMV has prevented their wide use in genetic improvement and production. Now that the linkage is broken between the I-gene and the unstable, "off-color" reds, the I-gene is being incorporated into a wide range of landraces through backcrossing or a modified backcrossing scheme. The true-red, BCMV-resistant landraces will be available for wide testing, as well as for use in breeding programs, in early 1987.

B. Sometimes deficiencies are encountered, even in highly successful varieties, when the variety is put into routine agricultural production. Another aspect of "fine tuning" in our genetic improvement program is, therefore, that of improving newly released and successful varieties. Examples include the incorporation of anthracnose resistance in "Talamanca," and of CBB resistance in "EMGOPA Ouro." Seed size has been increased, and CBB resistance incorporated, in excellent small-seeded lines such as BAT 1297.

C. The major part of the collection of *Phaseolus coccineus* has been evaluated and multiplied, and an international *P. coccineus* trial was distributed to several countries. This germplasm may be used directly or as a donor parent to the common bean, for breeding resistance. The multiplication of the collection has also been initiated.

The previously identified, new sources of resistance to BGMV in grain types other than black, have been further exploited. Lines resulting from crosses involving these resistance sources (for example, Pinto, Garapato, A 429, DOR 303, and others) show high levels of resistances to BGMV and good performance under stress in both Central and South America.

The race variability and racial geographic distribution of halo blight has been clarified through collaborative research with NVRS, in England. Four races have been found, and parents have been identified to breed for resistance to this important African disease.

D. In mutated populations, plants were selected that lacked the ability to fix nitrogen in N-free medium with high *Rhizobium populations.* These non-nodulating plants can serve as a zero-level check for nitrogen fixation, thereby eliminating the need to use nonfixing species as a check in bean breeding trials.

The presence of even moderate levels of soil nitrogen inhibits nodulation, although the nitrogen level in the soil may be inadequate to permit normal plant development. Plants were selected from mutated populations because they were able to develop effective nodules under high nitrogen levels--these plants will be used to develop varieties that are able to fix nitrogen, even in the presence of soil nitrogen.

E. High resistance to the bruchid, *Zabrotes subfasciatus,* in wild accessions of the common bean is due to the substitition of a part of the phaseolin protein by a new protein called arcelin. The presence of this protein is now being used by the Program (after research was completed in a collaborative project with the University of Wisconsin) as a rapid screening technique for *Zabrotes subfasciatus* resistance. Other compounds that may be associated with resistance to *Acanthoscelides obtectus* were found by the TDRI, in England.

F. National programs have released over 100 improved bean varieties obtained through the CIAT network and, in several countries, new bean varieties have been widely adopted. Surveys of bean farmers have been conducted to measu the adoption and impact of new varieties in Argentina, Costa Rica, Guatemala, and Nicaragua. These results are summarized in Table 1. In 1986 an estimated 154,000 hectares were sown to new bean varieties derived from CIAT germplasm.

Table 1. Impact of improved bean varieties, 1986.

Country	Area in improved varieties (ha)	Area in improved varieties (%)	Production of improved varieties (t)	Production increase due to improved varieties (t)
Costa Rica	21,700	62	18,900	5,300
Guatemala	12,300	13	11,700	4,100
Nicaragua	14,000	17	11,200	2,800
Cuba	16,000	80	25,000	11,200
Argentina	90,000	40	120,000	26,000
Total	154,000		186,800	49,400

SOURCE: Farm surveys in Argentina, Costa Rica, Guatemala, Nicaragua; National Program estimates in Cuba and Nicaragua.

The gross value of production of the improved varieties was US$93,400,000 (1985), while the value of the additional output from new varieties, over what could have been produced with the traditional varieties during 1986, was US$24,700,000. This sum is nearly four times the 1986 CIAT expenditures on bean research, including both direct program costs and a prorated share of nonprogram costs .

Of course, national program efforts have played a vital role in the success achieved with the new bean varieties. Arbitrarily assigning to CIAT and national programs an equal share of the gross benefits due to the improved bean varieties, the net benefits (gross benefits minus investment costs) of CIAT bean research are presented in Figure 1. This shows a period of increasing real net investment from 1973 to 1979. From 1979 onwards the benefits of the new varieties began to accrue, and from 1983 onwards the program entered a period of substantial and increasing positive net benefits, reaching US$5.9 million in 1986.

G. New varieties were released by national programs during 1986. "ICTA Ostua (JU 81-53)" was released as a BGMV-tolerant and earlier maturing line in Guatemala. Costa Rica released the locally developed line, HT 77-19, as "Canário" for its tolerance to web blight. Brazil released BAT 48 as "Sobradinho." Peru released "Panamito Molinero" (line W 126 from MITA, Puerto Rico). Rwanda released A 197 as "Ikinyange."

H. Lack of seed for new varieties has too often been shown as a major bottleneck to increased adoption of new varieties. Onfarm seed production methods are being promoted, in collaboration with the Seed Unit. Some promising developments are taking place in Colombia, where small local cooperatives are involved in seed production for members. One such cooperative in San Gil, Santander, produced over 20 tons of seed. A similar program is being initiated in Guatemala.

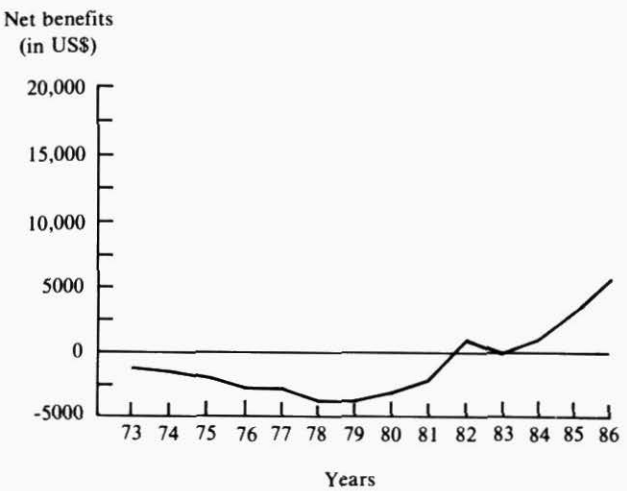

Figure 1. Net benefits of CIAT Bean Program, 1973-1986 (1985 US$ in thousands.)

Rice Program

A. The Rice Program continued to reorient its activities toward a more holistic approach to crop improvement in Latin America. While varietal improvement will continue to play a key role in the overall Program strategy, it is becoming increasingly clear that varietal improvement in itself is not sufficient to sustain continued growth within the Latin American rice sector. Factors that combine to limit production increases fall within the realms of crop mangement and policy environment as well as biological yield potential. The Program is therefore expanding and reorienting its activities to respond to the changing world of rice production in Latin America.

B. While modern varieties are grown on almost 70% of irrigated and favored upland rice-growing areas, surveys of national rice programs in the region have shown that the production costs are typically high, primarily because of high crop-protection costs. In Colombia, where the problem is acute, the Rice Program has launched a pilot study to develop an integrated crop management (ICM) program designed to bring down costs. This program included agronomy components such as timely and adequate weed control, appropriate seeding rates, and land preparation, and a pest-management component. The latter centered on the development of an integrated pest management (IPM) research program for rice. The entire program was conducted in close cooperation with the Federation of Colombian Rice Growers (FEDEARROZ) and the Colombian Institute of Agriculture (ICA), bringing these institutions together with CIAT to work on a well-focused, collaborative project.

   From the technical side, the project results clearly indicate that modifying current practices, by incorporating the research results developed during the study, can result in reduction of per-hectare production costs by the equivalent of 1 metric ton of paddy, with no yield sacrifice. The experience gained in inter-institutional cooperation; the development of ICM and IPM research programs; and the incorporation of a research strategy into a production-oriented methodology will permit the Rice Program to assist other national rice programs in developing a similar approach to solving their particular problems.

C. The training activities of the Program are evolving, reflecting the evolution of the program as well. Although there will always be the need for the general introductory course for young agronomists just beginning in rice research, as the national programs mature there is the need for more specialized programs that focus on the changing limitations to production. For example, the agronomists who participated in the ICM program in Colombia received specific training on weed control and IPM as part of the overall project. Similarly, in most areas of the region, red rice is a severe problem. However, no progress will be made if the seed sector is not brought into an integrated red-rice-control project. Therefore, as part of a collaborative red-rice project with EMPASC (Santa Catarina, Brazil), members of farmers' cooperatives involved in seed production and certification were brought to CIAT for a specific course on rice production.

D. In the Program's traditional area of crop improvement, the hoja blanca-resistant lines, developed by using a new, large-scale field-screening methodology, were tested in Ecuador under natural and heavy virus epidemic conditions. As expected, they proved to be highly resistant. An exhaustive characterization of the components of the resistance being used indicates that it is true resistance to the virus (as opposed to simply differential feeding behavior of the insect vector on differential genotypes), and that it is not likely to break down quickly, if ever. Resistant lines are being advanced rapidly in Ecuador and Colombia and should be released in approximately two years.

   In Panama and Guatemala, two new varieties—one for irrigated rice and the other for favored upland and irrigated rice—are scheduled for release this year. The principal site in Panama is also used as a prescreening site for material destined for testing by Central America programs. An analysis of the disease pressure at this site demonstrated that the disease complex and pressure are representative of the region, and more uniform from year to year than at other available sites.

   The breeding program for upland rice for the acid-soil savannas, after evaluating parental material under various management packages, has found that the production goal of 3 t/ha with low inputs is easily obtainable. The material has very high tolerance to the severe soil and biotic stresses encountered in this ecosystem. The

current improvement cycle is concentrating on ensuring that the high grain quality demanded by Latin American consumers is incorporated into all breeding lines.

An unexpected spinoff from the savanna project may be the diversification of the irrigated/favored-upland germplasm. Many of the lines that are emerging combine dwarf plant type, typical of irrigated material, with deep, thick roots and diverse, high-level, disease resistance, typical of traditional African upland material. The incorporation of superior lines from the savanna program into the irrigated/favored-upland program is underway.

E. Rice anther culture has, until recently, been viewed more as a laboratory curiosity than as a tool available to a large-scale breeding program. Typically, its proposed uses were limited to in vitro screening for tolerance to such stresses as toxins and herbicides. The Program has taken a different approach and examined its potential role in permitting the rapid advance of a large number of breeding lines. A principal application would be to permit rapid progress in breeding for environments that are typically limited to one cycle per year, such as the temperate regions of South America and the Caribbean.

The incorporation of superior grain quality and high-yield potential into cold-tolerant Chilean varieties is being used to test the application of the method. The results clearly indicate that anther culture, with the substantial modifications developed by Program scientists, is adaptable to a large-scale breeding effort.

Field evaluations of these lines in Chile, and seedling evaluation under laboratory conditions, show that some of the lines have high levels of cold tolerance combined with excellent grain quality. The high-yielding, high-quality, cold-tolerant lines developed from this project will have direct application to Chile, and they should also prove to be excellent parents for a wide variety of breeding objectives. Anther culture is now being evaluated for its applications to tropical breeding as well.

F. The pathogenic, fluorescent *Pseudomonas* spp. that cause sheath rot and grain discoloration of rice were recently discovered by the Program to be present in rice in Latin America. These have now been studied in considerable detail. A survey of discolored rice samples received from countries throughout Latin America indicated that these pathogens account for a substantial portion of discolored grain that was previously of unknown origin. Three closely related bacterial pathogens have been identified and means have been developed to eradicate them from seed. All seed dispatched from CIAT is treated to ensure that it is free from these seed-borne pathogens. However, it has been found that clean seed is not sufficient in itself to ensure disease-free fields. A program is therefore underway to identify and exploit varietal tolerance.

Cassava Program

A. The demand studies have continued as an area of emphasis—the studies for Southeast Asia and Latin America are now completed. In Asia the demand for cassava is strong—production has been increasing at five percent per annum for the last two decades. In most of this region the demand is for local use—either as food, for animal feed, or as the basis for the local starch industry. Most of the starch produced by local industry is eventually used for food products. Thailand differs from other producers in the region in that its production is almost entirely for export as pellets or as starch. The introduction of quotas by the European Economic Community cast doubts on the future of these exports. However, Thailand has responded by moving into the rapidly expanding Southeast Asian market for energy sources for feed concentrates and starch.

In Latin America, production outside Brazil has been keeping up with population growth. In Brazil, production has declined slightly, principally due to the negative effects of the massive wheat subsidies.

The demand situation in Latin America, which was greatly influenced by policies that favored the cereal grains, was also affected by the urbanization process which tended to reduce the aggregate demand for fresh cassava. Rural consumption levels are generally two to three times those in urban areas, due to the large marketing margins and the resulting high prices. The pace of urbanization in Latin America is slowing, however, as 70% of the population is now in urban sector. Moreover, the demand for fresh cassava is now increasing rapidly in many of the

major urban centers. New technology developed by the Cassava Program to conserve cassava and make it a more convenient and lower priced food should accelerate this increase in the demand.

As Latin America has urbanized and developed, there has been an extremely rapid increase in the demand for intensively produced poultry products. Producers of cereals have not been able to satisfy the demand for energy sources for feed rations, and the debt crisis has made ever-increasing grain imports impossible. This situation creates a large demand for cassava for animal feed: the studies indicate that cassava is highly competitive with locally produced grain.

B. The development of a cassava-drying industry, based on pilot projects designed to establish the viability and *modus operandi* of integrated production, processing, and marketing systems, has proceeded rapidly. In Colombia there are now forty plants functioning and bringing benefits to more than 2000 farmers. This experience is being used to extend the technology to other regions of Latin America. In Mexico, Panama, and Ecuador, drying plants have now been established and are functioning.

C. Over the years, the Program has emphasized the development of technology to increase the shelf-life of fresh cassava. In 1986-87, this technology was tested for the first time, on a commercial basis, in a pilot project in Colombia. The technology was shown to be highly effective. It allowed the farmers to receive a higher price for their fresh cassava, and at the same time the purchase price for the consumer was reduced. The consumer evaluation of the conserved cassava was excellent. This new technology offers the opportunity to provide the small farmer producer with increased income while at the same time providing the urban consumer with a lower cost, higher quality product.

Also in the area of postharvest handling of the crop, a major problem has been that cassava must be peeled before processing to produce a high quality flour. This process is not only complicated and expensive but also wasteful. The Program discovered that, by drying the unpeeled cassava and then passing it through a standard wheat mill, the peel could easily be separated out and high quality flour could be produced. This process is not only low in cost, but it also greatly increases the yield of flour produced per ton of fresh roots.

D. Breeding in cassava is a slow process: it takes 10 years to produce and test a new variety, and a further five years is needed for that variety to be grown in a wide area. The early crosses and the selections made from local varieties in the mid-seventies are now beginning to be released and grown by farmers. In Thailand, a CIAT hybrid has now been released as "Rayong 3" and is commanding a high price, due to its high dry-matter content. Another CIAT hybrid has been released in the Philippines as PM-1. In Indonesia, an ex-IITA trainee who has worked closely with CIAT has now developed a new hybrid, M-31, and this is being adopted rapidly by farmers due to its high-yield potential.

In Latin America, new varieties are being released and adopted. A CIAT germplasm selection introduced to Mexico is now released as "Sabanera" and is the dominant variety in that country. In Colombia, germplasm accessions and one hybrid made by the local research program collaboratively were tested in regional trials, and these have now been released as "Manihoica P11, P12 and P13." One of these, "Manihoica P12," is now widely grown in the major cassava-growing area on the north coast. In Cuba, a Brazilian line, "Mantigeira," introduced by CIAT, is now being grown widely as an early clone that extends the market season for fresh cassava. In addition, Cuban breeders trained at CIAT and using breeding and selection methodologies similar to those developed by CIAT have released a new high-yielding hybrid.

E. The development of new varieties that will be well adapted to different growing conditions is dependent on having a profound knowledge of the major ecosystems where cassava is grown. By observing the performance of cassava under a wide range of conditions, the major ecosystems in which cassava is grown and the major constraints of each of these ecosystems have been identified. As a result, elite gene pools can be developed for each ecosystem and distributed to national programs for the final selection and release of new varieties.

F. In the development of resistant varieties, it is necessary to possess adequate screening methods. Cassava planting material coexists with beneficial bacteria that protect it against attack by certain fungal pathogens. These bacteria complicate the process of screening for resis-

tance. Through research on these bacteria the Program has now developed effective screening techniques.

G. Cassava is grown in conditions where rainfall is often limited and sporadic. The mechanisms of cassava's tolerance to these conditions have been elucidated. In addition, Program scientists have recently shown that cassava is intermediate in its photosynthetic pathway between the highly productive and water-efficient "C4 pathway" and the less-efficient "C3 pathway." This opens up the possibility of selecting even more efficient and water-use-efficient types in the future.

H. In the area of management practices, the control of erosion and maintenance of soil fertility is critical as cassava is grown on the most marginal lands. Effective packages for erosion control and fertility maintenance have been developed.

The adoption of new management practices and their impact on production are notoriously difficult to measure. In various regions of Colombia, in Cuba, and in Mexico, packages of improved management practices are being used with the new varieties, and good yields are being obtained. In one area of southern Colombia, where production had declined drastically due to the presence of the frogskin disease, the use of clean seed has brought yields up to previous levels and total production is increasing rapidly.

I. Biological control of pests can be used, even by farmers, to reduce losses. In Brazil, the hornworm is a serious pest. A Brazilian scientist working in CIAT studied the use of *Baculovirus* as biocontrol agent. On her return to Brazil, she developed a practical scheme for use of this virus that is now being extensively used by farmers.

In Africa the cassava mealybug has devastated cassava plantations. Initial efforts to search for biocontrol agents were hampered by the fact that it was not known where in Latin America the cassava mealybug originated. CIAT scientists identified the cassava mealybug in southern Latin America, and scientists from the CIBC and IITA collaborated on the collection of parasites. *Epidinocarsis lopezi* was sent to IITA, and it has now been released in various African countries where it is reducing the populations of the mealybug.

J. Cassava will grow in areas where the dry season is longer than the wet season. Under conditions where the dry season is prolonged, storage of planting material is a serious problem. Virus problems are, at any rate, severe in vegetatively propagated crops. However, no cassava viruses are known to be seed transmitted—thus, using sexual seed of cassava appears as an attractive proposition. CIAT has recently shown for the first time that yields of a crop planted from sexual seed can equal or exceed that of the traditional planting method which uses cuttings.

THE 1988 BUDGET REQUEST

CIAT is presenting a total 1988 budget of US$29.1 million (see Annex, Table Ia). Of this amount, US$24.1 million are to be used for core activities, and the remainder, US$4.4 million, for special projects. The majority of the special project funds will be directed to the relatively large bean networking projects in eastern and southern Africa.

Discounting the estimated inflation costs between 1987 and 1988 the additional core resources requested by CIAT amount to US$0.69 million (see Annex, Table IIa). As mentioned below, this increase is for: (a) hiring two senior scientists who will represent an initial step to expand the resource base of the Cassava Program in order to ensure that the Program can operate at a level commensurate with the world mandate that CGIAR has assigned it, and (b) augmenting resources for the organization and execution of commodity network events.

The core budget as presented in this document fully corresponds to the TAC recommendations regarding the CIAT program and budget for 1988.

Summary of Table IIa (See Annex): *proposed program* additions for 1988.

Item	Cost (US$ in thousands)
Technical adjustments	
1988 price requirements	998
Reduction in projected exchange rate gains	150
Reduced capital requirements	(240)
Addition of senior staff positions	
Position for CIAT cassava scientist at IITA	227
Position for virologist	231
Addition in funds for network conferences	162
Total	(1528)

Discussion of 1988 Additions

Table IIa (see Annex) presents the proposed 1988 additions to the CIAT core budget, a summary of which is presented below:

1988 price requirements. These reflect the expected price increase of 4% between 1987 and 1988.

Reduction in projected exchange rate gains. With the anticipated approximate parity between inflation in the Colombian peso and devaluation in CIAT's host country, CIAT does not expect to realize further reductions in obligations—in dollar terms—on long-term peso obligations (as was the case in previous years when the rate of devaluation was ahead of inflation).

Reduced capital requirements. CIAT's requirements for capital in 1988 are lower than in the preceding year.

CIAT cassava specialist at IITA. The nonlocation specific research done by the CIAT core effort can bring great benefits to African cassava producers. CIAT does not, however, apply this technology directly to African conditions—the information, germplasm, and biocontrol agents are transferred directly and expediently to IITA which incorporates these

elements into its regional efforts in Africa. To establish effective collaboration between the two Centers, IITA and CIAT have agreed that a CIAT cassava specialist be posted at IITA who will be responsible for ensuring that African needs and requests that can make use of CIAT-based resources are rapidly met. Both Centers agree that in the light of the scarce resources available for cassava research the liaison officer will form an integral part of the IITA cassava effort and carry out an active research program. At the present time IITA is developing a new strategic plan which will define the priority area of research by the cassava specialist.

Position for virologist. As a vegetatively reproduced crop cassava is prone to virus problems transmitted by the planting material. This not only affects production on farmers' fields but also inhibits the free exchange of germplasm. It is essential to accurately characterize the cassava viruses, develop techniques for their detection and elimination, and to devise control methods. In order to do this the Biotechnology Research Unit, which provides an administrative and resources umbrella for all virology work at CIAT, proposes to increase its staff by one senior member. While the proposed position for a virologist is to work primarily on cassava viruses, he or she will also dedicate selected resources to specific virus problems in CIAT's Tropical Pastures and Rice Programs.

Additional resources for network conference events. In the course of several years of systematic work toward the building up of international networks in support of the various commodities in the mandate of CIAT, relatively large and highly active networks have developed and are fully functional. The getting together at regular intervals of members of the respective networks to discuss research methodologies and review and modify the process by which ideas and materials are interchanged, has proved to be an essential ingredient in maintaining the dynamics of these networks.

In order for CIAT to be able to fully implement its goal of organizing one network event per commodity network every year (or the equivalent of one network event in the sense that often network events are organized on a regional or subregional basis), the Center urgently needs to add some US$150,000 to its conferences budget. Network conferences referred to here are exclusive of bean networking activities in Africa where adequate resources for conference events are incorporated in the special-project funded projects that support CIAT's bean work in Africa.

It should be pointed out here that prior to the budget difficulties in the early 1980s, CIAT did maintain a conferences budget which included the amount requested here. With the reduction in funding, the conferences budget was reduced but with the understanding that the reduction would only be temporary. In the meantime, the stage of development of the commodity networks is such that a restoration of these funds is essential.

Discussion of "Change List"

As in past years, CIAT is highly attentive to the need of reducing activities that have reached their stated objectives, or that are assuming relatively low priorities vis-a-vis new challenges or opportunities. The "Change List" proposed by CIAT for 1988 involves the following:

Change list 1988.

To be added	To be deleted
Beans: Regional Coordinator for Brazil and Southern Cone	Beans: Coordinator, Regional Bean Project in Central America

Position to be added: Beans: Regional Coordinator for Brazil and Southern Cone. CIAT proposes to attach a scientist to the Brazilian national bean research team because more than half of all bean production in Latin America takes place in Brazil and the Southern Cone. The scientist's responsibilities will be to serve bean research and production in Brazil, as well as in Paraguay, northern Argentina, and Uruguay. This scientist is to provide liaison between CIAT and the respective national bean programs, and is to promote horizontal integration of the respective national program efforts. The incumbent of this position is to place special emphasis on the screening of germplasm for low fertility conditions, and on facilitating the transfer of materials selected for low soil fertility conditions to the bean projects in Africa.

Position to be deleted: Beans: Coordinator position in Central America. CIAT currently maintains a three-man regional team for beans in Central America. From the inception of this involvement in Central America, CIAT has made clear its intended strategy to gradually reduce its commitment there as the subregional bean research network gains strength, and as the national programs assume increasing responsibilities. A recent indepth review of the regional activities in Central America has shown that, at this stage,

project management can and should increasingly pass to the national programs in the region. Consequently, CIAT proposes to delete the position of regional coordinator and, in its stead, one of the two remaining staff members will be assigned, on a part-time basis, the coordinating function. A steering committee is being formed, consisting of national coordinators and the two remaining CIAT staff members to further enhance the regional coordination of bean research and development activities.

THE RESEARCH PROGRAMS

BEAN PROGRAM

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Program leader	1	1	1	1	1	2	2	2	2	2	3	2	2	2	2
Soil microbiology	1	1	1	1	1	2	2	2	2	2	7	7	7	7	7
Soil/plant nutrition	-	1	1	1	1	-	1	1	1	1	-	1	1	1	1
Physiology	1	1	1	1	1	2	3	3	3	3	13	12	12	12	12
Breeding I	1	1	1	1	1	3	4	4	4	4	13	15	15	15	15
Breeding II	1	1	1	1	1	3	3	3	3	3	16	16	16	16	16
Breeding III	1	1	1	1	1	2	2	2	2	2	14	14	14	14	14
Entomology	1	1	1	1	1	3	2	2	2	2	11	10	10	10	10
Pathology I	1	1	1	1	1	3	4	4	4	4	12	17	17	17	17
Agronomy (prelim. trials)	1	-	-	-	-	2	-	-	-	-	10	-	-	-	-
Agronomy (cropping systems)	1	1	1	1	1	1	2	2	2	2	7	8	8	8	8
Agronomy (inter. trials)	1	1	1	1	1	2	2	2	2	2	17	17	17	17	17
Virology	1	-	-	-	-	2	-	-	-	-	7	-	-	-	-
Economics	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3
Total	13	12	12	12	12	30	30	30	30	30	133	122	122	122	122
Decentralized regional programs															
Central America and Caribbean															
Regional Coordinator	1	1	-	-	-	3	3	-	-	-	2	2	1	1	1
Agronomy	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1
Breeding	1	1	1	1	1	1	1	4	4	4	-	-	1	1	1
Brazil and Southern Cone															
Reg. Liaison/Agronomy	-	-	1	1	1	-	-	-	-	-	-	-	3	3	3
Africa (Great Lakes Region)															
Breeding/Coordinator	-	1	1	1	1	-	-	-	-	-	-	1	1	1	1
Pathology	-	1	1	1	1	-	-	-	-	-	-	1	1	1	1
Systems Specialist	-	1	1	1	1	-	-	-	-	-	-	1	1	1	1
Total	3	6	6	6	6	6	6	6	6	6	3	6	9	9	9

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	2067	2448	2448
Honoraria, stipends, and allowances	-	-	-
Supplies and services	416	487	487
Travel	181	303	303
Equipment replacement	16	51	51
Contingency	-	-	58
Subtotal	2680	3289	3347
Support units[a]	-	-	979
Price provision	-	-	132
Total	2680	3289	4458

a. Resource allocation from support units to the Bean Program.

Program Commentary

Importance of beans

Beans *(Phaseolus vulgaris* L.) are grown on approximately 12 million hectares in the tropics, and are a principal food crop for small farmers in many countries in tropical America, Africa, and the Middle East. Beans constitute a major source of protein in these countries, especially for the low-income segments of their populations. Bean production is also the main activity supporting an estimated five million people living on small farms in Latin America and Africa. For a far greater number of such farmers, beans are an important part of their cropping systems and of their diet.

Beans provide 11% of total protein consumption in tropical Latin America and in many countries THEY ARE the cheapest form of high quality protein. In eastern and central Africa per capita bean consumption reaches 50 kg per person per year—the highest in the world. Here, people derive more protein from beans than from all animal products combined.

Because of their low price, beans play an especially critical role in the nutrition of the poor. For example, in urban Colombia, the share of beans in total protein intake of the poor is twice that of high income people. Beans are of greatest importance in diets in rural areas. In rural Brazil, beans provide from one-quarter to one-third of the total protein consumption, as well as 10% to 15% of total calories.

1988 Budget request for Bean Program.

Activity	Amount (1988 US$ in thousands)
Water management	24.9
Soil management and conservation research	30.8
Agroclimatology research	8.8
Germplasm	
Conservation, characterization, and documentation	95.2
Enhancement	246.8
Plant breeding and improvement	828.5
International trials (distribution and exchange)	324.2
Seed production	0.1
Crop systems research	431.4
Plant protection research	381.1
Plant nutrition research	255.2
Human resource enhancement	
Specialized courses (short term)	174.4
Individualized internships	297.7
Conferences and seminars	29.0
Documentation and dissemination	126.1
Research on approaches, concepts, methodologies, and procedures	146.8
Counselling and advising NARS	126.4
Technical assistance	97.3
Coordination of networks	476.8
Economic and social analysis at microlevel	72.8
Market analysis	40.4
Policy analysis	40.4
Nutrition and consumption analysis	29.7
Research on research	8.3
Exploratory research	119.6
Conversarion and utilization research	45.1
Total	4457.8

Bean production in the tropics is principally concentrated in Latin America (the center of the crop's origin) where 4.1 million tons are produced annually. In eastern Africa nearly 2 million tons are produced annually. In Latin America, Brazil is the largest producer, followed by Mexico. In Africa, Burundi, Kenya, Rwanda, Tanzania, and Uganda are the leading producers. Because small farmers in Africa and Latin America produce beans with low levels of inputs, on poor hillside soils, subjected to considerable disease and drought stress, and in low plant populations, yields average little more than 500 kg/ha in tropical Latin America and Africa. However, this low yield is partly due to competition from other crops, such as maize, which are grown in association with beans.

Because of the high stress conditions under which they are produced, beans are a risky crop with highly variable output. For example, in Latin America production fluctuates by as much as one million tons from year to year. Moreover, in most bean-producing countries there has been no productivity growth in the period 1966-1981, and in many instances yields have been falling during this period. Due primarily to area expansion, production increases have been lagging behind population growth in most countries. As a result, for the first time in history, Latin America and Africa have become net importers of beans. For some countries, however, this picture has started to change. (See "Summary of Achievements", p. 6-7).

Problems of the crop

Potential yields of currently grown varieties in Latin America range from 2-3 t/ha. One of the principal reasons why actual yields are low is the heavy disease pressure on the crop. Disease incidence varies from region to region. Nevertheless, some diseases are prevalent in virtually all production regions, for example, 60% of bean production in Latin America is subjected to the risk of anthracnose attack. Disease transmission via the seed has undoubtedly contributed to the wide distribution of many bean diseases. Disease pressure is further increased by the poor plant type of bush beans. Plants commonly lodge at maturity and, with pods in contact with the soil, disease accumulation in seed occurs. Farmers traditionally save their seed for subsequent plantings, a practice which further contributes to disease incidence. Climbing beans that are excessively vigorous have pod loads well above the ground, but are subject to seed loss when the maize lodges. Farmers have reacted to the strong disease pressure by planting toward the end of the wet season, which increases drought stress.

In addition to diseases, insects can cause severe reductions in bean production, particularly under the drier conditions referred to above. With beans increasingly being displaced to marginal lands, soil acidity and phosphorus fixation are becoming important. A further important problem is that beans do not fix much nitrogen under most production conditions.

Program Objective

The Bean Program's objective is to support national programs in the development and promotion of improved technology that permits increased bean production and yields. The following primary activities support this objective:

Genetic improvement of bean germplasm to meet the agronomic requirements of farmers as well as consumer preferences.

Development of agronomic practices compatible with improved genotypes.

Training to strengthen the research and technology transfer and validation activities of collaborating national programs.

International cooperation at all levels for the further development of an active bean research network throughout the action area of the Program.

Program Strategies

Genetic improvement to overcome production problems—rather than the use of purchased inputs—is the principal strategy of the Bean Program to increase yields. Genetic improvement activities are based on the large genetic variability encountered in beans and are facilitated by the availability of more than 35,000 bean accessions (including their wild ancestors and related species) in the bean germplasm bank housed in the Genetic Resources Unit of CIAT. This collection is periodically evaluated for desirable traits. The Bean Program performs several thousand hybridizations per year involving superior accessions. The resulting progenies pass through uniform successive nurseries. The best selections are tested in international uniform nurseries from which the national programs select

materials for direct use in regional or onfarm testing or, alternatively, for use in their own breeding programs.

At the beginning of this decade, and following several years of systematic training of national program personnel, the Program started an intensive effort to decentralize selection. Today, national program scientists are increasingly selecting locally adapted materials mostly from CIAT-generated populations. National programs often request CIAT to make specific crosses for them. CIAT does not release or name varieties as this is entirely a national responsibility. CIAT only provides genetic variability according to expressed needs. Seed shipments pass through the seed health laboratory of the GRU to ensure that the exported seed is free of virus and disease contamination.

The bean breeding activities seek to combine the following desired variability:

Resistance to priority diseases and insects. These are BCMV, rust, anthracnose, angular leaf spot, common bacterial blight, and leafhoppers. In addition, the Bean Program, through its decentralized breeding strategy, attempts to incorporate into improved varieties resistance to important location-specific diseases (such as bean golden mosaic virus in Central America, or the bean fly in Africa). Of major importance in selecting improved varieties is the need to meet local color and seed-size requirements, besides specific agronomic requirements. These requirements vary from country to country and from region to region.

Yield potential. Increasing yield potential of a legume crop such as beans is a long-term objective. In order to be able to increase yields of beans when disease resistances have been incorporated, the Program is placing increasing emphasis on genetic improvement for higher yield potential, first under no-stress conditions and, later, under diverse stress conditions.

Improvement of drought resistance. Over large areas in Africa and Latin America beans suffer from irregular drought stress. The germplasm collection and breeding will provide lines better able to withstand drought stress.

Decreased dependence on fertilizer requirements. While all lines are being developed and evaluated under low fertilizer (and plant protection) regimes, a genetically improved bean/*Rhizobium* interaction is sought to increase the nitrogen-fixation ability of beans. The Bean Program also strives to enhance the genetic variability for adaptation to low soil phosphorus conditions which is of principal importance in Brazil and large areas in Africa.

Nutritional quality. While genetic improvement for protein content, cooking time, or digestibility is not actively pursued, the Program does monitor these factors in newly developed materials to ensure that no deterioration occurs.

Since agronomic practices are largely site-specific, the Bean Program conducts little research in this area. Often, however, improved varieties perform differently on the experiment station than on farmers' fields. Given that onfarm research and regional variety trials are still inadequately developed in most countries, the Program has found it necessary to devote considerable resources to diagnosis and validation trials. The Bean Program has therefore developed an active onfarm research and training program with national programs to provide feedback to research and link research and extension. This program is being developed in close collaboration with other international centers, especially with CIMMYT as beans are mostly grown in association with maize.

Achievements of the Program

(See Bean Program section under "Summary of Achievements", p. 6-7).

Special Projects

Bean improvement for eastern Africa

The objective of this project is to increase bean production in Ethiopia, Uganda, and Somalia, thereby increasing protein intake, and so improving the nutritional status of local populations who are mainly small farmers. Production is to be increased by the propagation of improved varieties and the adoption of improved production technologies. Major activities are: (a) developing national program research capacity by training bean breeders and agronomists; (b) introducing new germplasm and, through national breeding programs, developing highly productive varieties

adapted to local conditions and consumer preferences; and (c) improving cropping systems. Germplasm improvement emphasizes the development and distribution of multiple disease- and pest-resistant lines. Emphasis is on regional collaboration on research and networking activities to improve communication among national programs. This special project is supported by CIDA and USAID.

	Budget (1987 US$ in thousands)	
	1987	1978
Personnel (4 senior scientists)	282	464
Honoraria, stipends, and allowances	122	237
Supplies and services	91	150
Travel	41	50
Equipment replacement and capital	67	57
Indirect costs	76	127
Contingencies	63	101
Subtotal	742	1186

Bean improvement for southern Africa (SADCC countries)

This project is designed to increase bean productivity, production, and consumption, and to strengthen national agricultural research in *Phaseolus* beans in the nine SADCC countries of Africa. This regional networking project will develop, in collaboration with national programs in the region, new bean-production technology for both traditional and innovative cropping systems. It will also strengthen national research capacity so that national bean production can be increased to keep pace with expected demands from the rapidly growing populations of the region. This special project is supported by CIDA.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel (5 senior scientists)	356	504
Honoraria, stipends, and allowances	50	273
Supplies and services	74	132
Travel	68	60
Equipment replacement and capital	316	166
Indirect costs	110	155
Contingencies	46	68
Subtotal	1020	1358

Research on *Phaseolus* germplasm

This project includes collaborative research with Italian institutions on: (a) virus diseases of *Phaseolus*, primarily bean yellow mosaic virus; (b) creation of new variability through mutagenesis in *Phaseolus* germplasm; (c) seed protein quality; and (d) regeneration of *Phaseolus* from unorganized cell preparations. This special project is financed by the Italian government.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	23	30
Honoraria, stipends, and allowances	45	30
Supplies and services	40	22
Travel	26	19
Equipment replacement and capital	16	14
Indirect costs	-	-
Contingencies	-	-
Subtotal	150	115

Beans and rice research in Peru

This project involves collaboration with INIPA on bean and rice research through two advisors who provide technical backup and assist national program coordinators. The advisors also play an active role in varietal selection trials, inservice training, and the selection of candidates for training at CIAT. They also assist in the formulation of medium- and long-term research plans. This bilateral project is financed through a World Bank loan to Peru.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel (2 senior scientists)	140	140
Honoraria, stipends, and allowances	-	-
Supplies and services	53	53
Travel	9	9
Equipment replacement and capital	-	-
Indirect costs	14	14
Contingencies	-	-
Subtotal	216	216

Farmer participation in technology design and transfer

In close collaboration with the Instituto Colombiano Agropecuario (ICA), this project is to: (a) implement, on a pilot scale, new methodology for small-farmer participation in the design and evaluation of agricultural technology; (b) demonstrate the effectiveness of the methodology in achieving accelerated generation and transfer of new technology; and (c) develop training materials on the techniques and management requirements of this methodology for worldwide dissemination. Initially, there will be intensive, practical training in the methodology for ICA staff from the Integrated Rural Development Area in Cauca. This project is supported by the W. K. Kellogg Foundation.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	77	82
Honoraria, stipends, and allowances	15	17
Supplies and services	3	5
Travel	6	8
Equipment replacement and capital	23	15
Indirect costs	20	22
Contingencies	-	-
Subtotal	144	149

Economic study on snap beans in the tropics

This economic study addresses four major areas: (a) compilation of information on developing country production, marketing, and consumption in order to identify the most important production areas; (b) assessment of trends in production, consumption, prices and productivity, and investigation of the causes of such trends; (c) analysis of major production/marketing/consumption systems to determine constraints to increased production and consumption, as well as to generate baseline data on current technology and critical quality characteristics; and (d) evaluation *ex ante* of the socioeconomic and nutritional impact of improved snap bean technology, focusing on the distribution of benefits among consumer and producer groups. This project is financed by the government of the Netherlands.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	32	40
Honoraria, stipends, and allowances	-	-
Supplies and services	3	4
Travel	7	8
Equipment replacement and capital	-	-
Indirect costs	6	8
Contingencies	2	3
Subtotal	50	63

Germplasm collection for beans, cassava, and tropical pastures

(See under "Special Projects" in Genetic Resources Unit section, p. 53).

Legume germplasm

(See under "Special Projects" in Genetic Resources Unit section, p. 53-54).

Specialized information centers

(See under "Special Projects" in Communication and Information Support Unit section, p. 77-78).

CASSAVA PROGRAM

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Program leader	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1
Utilization	1	1	1	2	2	5	4	4	5	5	10	7	7	14	14
Physiology	1	1	1	1	1	1	3	3	3	3	11	11	11	11	11
Germplasm development	1	1	1	1	1	2	2	2	2	2	27	27	27	27	27
Pathology	1	1	1	1	1	2	2	2	2	2	13	11	11	11	11
Entomology	1	1	1	1	1	3	4	4	4	4	12	12	12	12	12
Soil/plant nutrition	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-
Cultural practices (Agronomy)	1	1	1	1	1	1	2	2	2	2	9	11	11	11	11
Economics	1	1	1	1	1	3	3	3	3	3	4	4	4	4	4
Media Luna	-	-	-	-	-	1	1	1	1	1	2	2	2	2	2
Carimagua	-	-	-	-	-	-	-	-	-	-	10	10	10	10	10
Virology	-	-	-	-	-	1	2	-	-	-	6	4	-	-	-
Breeding	-	-	-	1	1	-	-	-	2	2	-	-	-	9	9
Total	8	8	8	10	10	21	24	22	25	25	108	100	96	112	112
Decentralized regional programs															
Asia															
Breeding	1	1	1	1	1	-	-	-	-	-	3	3	3	3	3
Agronomy	-	-	-	1	1	-	-	-	-	-	-	-	-	2	2
Economics	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1
Sub-Saharan Africa															
Liaison scientist (IITA)	-	-	1	1	1	-	-	-	-	-	-	-	2	2	2
Brazil															
Agronomy/Breeding	-	-	-	1	1	-	-	-	2	2	-	-	-	10	10
Total	1	1	2	5	5	-	-	-	2	2	3	3	5	18	18

Program Commentary

As a crop grown exclusively in the tropics of the Third World, adapted to marginal conditions, grown chiefly by small farmers, provider of an important source of inexpensive calories to 500 million of the poorest consumers, grossly underresearched in developing countries, and lacking a research knowledge base from developed countries, cassava would appear to be the ideal candidate to be assigned highest priority for maximum allocation of funds in the CGIAR system. Yet the CIAT Cassava Program, despite having been assigned global responsibilities for this crop, has been perennially plagued by questions as to its future role, and indeed, its very existence.

Many of these doubts originated within the Center itself as the Board and management repeatedly questioned the future of the Cassava Program and constrained its growth, making it the first target for reductions in times of budget constraints. These doubts about a crop of such obvious importance to the poorest farmers and consumers were the result of skepticism about the future demand for cassava and the subsequent misgivings about the need for improved production technology. Consequently, the Cassava Program embarked upon a series of studies to

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	1579	1567	1701
Honoraria, stipends, and allowances	-	-	-
Supplies and services	222	203	220
Travel	213	225	244
Equipment replacement	46	30	33
Contingencies	-	-	39
Subtotal	2060	2025	2237
Support units[a]	-	-	897
Price provision	-	-	128
Total	2060	2025	3262

a. Resource allocation from support units to the Cassava Program.

ascertain the future role of this crop in the agricultural economies of developing nations. This effort was accelerated and expanded in response to the recommendation of the 1984 EPR of CIAT that studies be undertaken to assess the future demand for cassava and cassava products; that the future direction and scope of the Cassava Program should be reviewed after the completion of such studies; and that in the meantime, the program should be held at its current level. The CIAT midterm plan for 1985-1989 (a revision of the long-range plan "CIAT in the 1980's", *taking into account the recommendations* of the EPR) also reserved judgment on the Cassava Program, pending the outcome of the studies. In the interim, the TAC, in its "Review of CGIAR Priorities and Future Strategies" (p. 3-11 and 3-12), gave strong support to cassava as an important small-farmer crop of special importance to and with high potential payoff for research for Africa and stated that demand was "buoyant" in Asia, but they considered the situation in Latin America to be more complex, with future demands for cassava unclear. The TAC stated: "Firm recommendations for the longer term must await the outcome of the market study."

These studies have now been completed for Latin America and Asia. The results of the studies, as well as the empirical observations of what is happening to cassava in the rapidly changing economic conditions of the Third World, convince us that cassava is indeed *a crop whose time has come!*

The description below describes what CIAT now considers to be the present and future role of cassava;

1988 Budget request for Cassava Program.

Activity	Amount (1988 US$ in thousands)
Soil management and conservation research	58.0
Germplasm	
Collection	52.0
Conservation, characterization, and documentation	299.6
Enhancement	300.9
Plant breeding and improvement	640.0
International trials (distribution and exchange)	242.7
Crop systems research	295.7
Plant protection research	335.3
Plant nutrition research	23.7
Human resource enhancement	
Specialized courses (short term)	89.0
Individualized internships	172.0
Conferences and seminars	35.6
Documentation and dissemination	55.6
Research on approaches, concepts, methodologies, and procedures	2.8
Counselling and advising NARS	76.1
Technical assistance	97.3
Coordination of networks	84.5
Economic and social analysis at microlevel	96.6
Market analysis	61.4
Policy analysis	64.2
Nutrition and consumption analysis	49.8
Exploratory research	67.0
Conversion and utilization research	62.2
Total	3262.0

the objectives and strategies of a program with the global mandate to conduct research to enhance that role; and the minimum size and deployment of a research team to carry out such a strategy. It should be seen as an update and addendum to the other documents referred to above. In the interest of brevity, much of what should be said about cassava cannot be included here. For a more complete picture, the reader should also read the CIAT long- and midterm plans and the TAC priorities paper.

Present Status of the Crop

Nature of the crop

The cassava plant, which originated in Latin America, was probably first cultivated by Amerindian tribes about 4000 years ago. The fact that it spread so rapidly and became an important component of small farmers' cropping systems and of the diet of hundreds of millions of the people in Africa and Asia so quickly after its introduction to these continents by Spanish and Portuguese traders less than 400 years ago, attests to its unique nature. It is one of the world's most efficient converters of solar energy to carbohydrates. The crop's special stomatal response to low relative humidity allows it to survive and produce a reasonable harvest under conditions of drought and sporadic rainfall that frequently cause other crops to fail. Because of its drought tolerance and the fact that its roots can be left in the ground for long periods as a food reserve, it represents excellent insurance against famine. The plant's inherent characteristics and association with mycorrhizae make it especially well adapted to acid, infertile soils. As the plant does not have a critical growth stage during which a severe insect or disease attack can cause complete crop failure, it is particularly suited to biological control measures. These characteristics have made cassava an attractive option for farmers with limited resources in marginal agricultural areas of the tropics. It ideally meets the equity criteria of the CGIAR. As cassava production and processing are highly labor intensive, it responds to CGIAR concerns for employment generation.

Distribution

Cassava is grown throughout the lowland tropics. Total world production is about 130 millions tons (52 million tons cereal equivalent), with about 40% of production in each of Africa and Asia, and 20% in Latin America. Brazil is the world's largest producer and consumer of cassava. In terms of total calories produced in the tropics, cassava ranks fourth, following rice, sugarcane, and maize.

End uses

Cassava is a multipurpose crop as shown in the following table. These global statistics mask large inter- and intraregional, and even intracountry, differences. In Latin America, use of cassava for consumption by humans is about the same as the global figures, while in Africa a larger portion is utilized as food. In several African countries cassava provides 40% to 50% of the total calorie intake and is the single most important source of calories. In the economically depressed northeast region of Brazil, it is the dominant food staple.

World utilization of cassava, 1975-77.

End use	Contribution (%)
Human food	64.6
Fresh	30.8
Processed	33.8
Animal feed	11.5
Starch	5.5
Export	7.0

SOURCE: FAO.

Future Prospects

Demand studies

Defining the problem. Much of the basis for skepticism about the future demand of cassava relates to the observed decline in per capita consumption of this crop in Latin America. This was perceived as being due to rapid urbanization, rising per capita incomes, and increasing possibilities for commodity substitution. It was reasoned that: (a) cassava was an inconvenient, bulky, perishable, and less-desired commodity that would—like many other basic staples—gradually become less important as economic development and urbanization proceeded; and (b) that the Latin American experience may be a portent of the future for Asia and Africa. The corollary to this reasoning was that there would be little demand for improved production technology for a crop with a declining market. On the other hand, it seemed precipitous to abandon a crop of such importance for income generation by poor farmers and with the potential of providing inexpensive calories for consumers. It was necessary, therefore, to determine whether or not this trend would continue in Latin America, whether it would apply to Africa and Asia, whether alternative uses of this multipurpose crop would come more into play with the evolving economic conditions, how new technology would affect the future demand, and how all of these factors would affect the research agenda.

Methodology. Because consumption patterns, government policies, and the resource endowment and production costs for cassava and alternative crops vary so greatly among and within regions and, in some cases, within countries, it was not possible to consider future demand on a global basis. Thus, the studies were disaggregated by regions and for selected key countries.

Coverage. The **Latin American** studies, considered to be the most critical by the EPR and the TAC, were conducted most intensively. Under the leadership of the senior economist of the Cassava Program, three postdoctoral economists were contracted for a two-year period each. They conducted individual country studies of Brazil, Colombia, the Dominican Republic, Ecuador, Jamaica, Mexico, Panama, Paraguay, Peru, and Venezuela. These studies, conducted collaboratively with economists from national programs in the respective countries, used secondary data and, where necessary, collected primary data to:

> Analyze the current and potential role of cassava for human consumption.
>
> Evaluate the income generation and employment opportunities created by cassava production and processing.
>
> Describe the current and potential incorporation of cassava into animal feed.
>
> Identify the regions where cassava production can be expanded and the markets that it will enter.

Special attention was given to production costs for cassava and possible competing crops to determine those cases where cassava could or could not compete. Current government policies that may artificially affect such competition and possible changes of policy that would benefit the economy were also considered.

In addition to these Latin American economic studies, a doctoral student conducted his dissertation research on consumer trends in Colombia to determine the factors behind the decline in per capita consumption in urban areas and consumer preferences for cassava in relation to other starchy foods.

The **Asia** demand study relied exclusively on secondary data. It was conducted by the senior economist of the Cassava Program, with the valuable contribution of senior economics consultants from Thailand and Indonesia. Individual country studies were conducted for China, India, Indonesia, Philippines, and Thailand. In the case of Indonesia, CIAT was fortunate to draw upon the intensive studies on cassava carried out by the Food Research Institute at Stanford University.

African demand studies will be carried out jointly by CIAT and IITA, beginning in early 1988. These will take more time and will be more costly as more primary data will need to be gathered. A three-year project involving four economists has been jointly developed by the two Centers. Each is placing half of the estimated costs into its core budget request for 1988-90. While it is obviously important to understand the trends better and explore the future potential for cassava in Africa, the importance of the crop for human food and the fact that some of the factors responsible for the changes in consumption patterns in Latin America and Asia (that is, increased per capita income and rapid urbanization) have not progressed as far in Africa suggested that this study was less urgent than those for the other continents.

Highlights of the results. It is obviously impossible to do justice to the wealth of valuable information on the potential for cassava for various uses in a wide range of ecological, social, economic, and political conditions coming out of the demand studies in any brief summary statement such as this. The reader is therefore urged to read the Executive Summary[1] of the studies. Even that summary cannot provide adequate information on methodology, data, and qualifications to satisfy the skeptic that the conclusions are based on sound economic analyses. Those so inclined should read the full reports (one report each for Asia and Latin America)[1].

Overall, these results demonstrate a buoyant market potential for increased cassava production, but this is not true for all uses in all countries. The studies show that:

> The observed decline in fresh consumption in Latin America is principally due to the urbanization process. High marketing costs have shifted relative prices of cassava and grain staples between rural and urban areas, causing consumption to be lower in urban Latin America. Fresh cassava has a positive income elasticicity and consumption can be expected to grow modestly. New preservation technology is likely to reduce marketing costs and accelerate this growth.
>
> Where consumption of processed cassava by humans has declined, this has largely been the

1. Copies of these documents may be obtained by writing to CIAT's Marketing and Distribution Office, Communication and Information Support Unit, Apartado Aéreo 6713, Cali, Colombia.

result of government subsidies of competing cereals. These trends are already being reversed as these subsidies are removed, and demand for cassava in processed form can be expected to grow. These products will continue to serve as an important source of inexpensive calories to the very poor.

Starch, much of which is used in the production of various foods, is expected to provide a growing demand for cassava, especially in Asia.

A major potential for growth in demand for cassava is seen as a component of animal feed, chiefly for domestic use in Latin America, and for both domestic use and export in Asia.

The growing market for cassava in Asia has already reached the point that production is not keeping up with demand.

Cassava is an important tool for equitable development. Its characteristics are such that the benefits of new technology can be targeted on the very people who have normally been left out of the development process.

Empirical observations

The world did not stop while the demand studies were being carried out. Important changes in the economy were taking place, and a number of developments were under way. It was clear from the outset that a good deal could be learned by following these developments that would complement the economic studies.

When the studies were initiated, a pilot project to help small farmers' associations develop drying and chipping capacity to process their cassava and sell it to animal feed manufacturers was getting under way in Colombia. This has been a remarkable success. To date, 37 such farmers' associations have been established. Analyses of the impact have shown that: the farmers' incomes improved markedly, both from the sale of their produce and from the distribution of association profits; the new agroindustry has generated considerable employment in an economically depressed area; yields have increased as farmers have incentives to apply improved production technology; and, surprisingly, the benefits have gone chiefly to small farmers. Although large-scale farmers are present in the region, the maximum benefits from the project have been obtained by farmers with farms of around 3 hectares.

The success of the Colombian project led to the development of a similar agroindustry in Ecuador. In 1986 that experiment seemed to be running into trouble. Rainfall, usually a limiting factor in the area, was abundant, resulting in a bumper maize crop and a depressed market for the cassava chips. It was then discovered that dry cassava chips when finely milled are an excellent substitute for imported binding agents used in shrimp concentrates. This cassava flour sells at over US$300 per ton, a price higher than for wheat flour. The implications of this discovery for potential cassava demand for the vast and growing shrimp culture industry is still unknown, but could be tremendous.

Dried cassava is currently being produced profitably in Colombia, Ecuador, Mexico, and Panama, demonstrating that the potential for use of this crop in this form to increase small-farmer income and generate rural employment is no longer hypothetical, but an economically viable reality. Brazil, Cuba, Nicaragua, and Peru all have active plans under way to develop similar agroindustries.

Thailand, at the peak of its export of cassava chips to the EEC in 1982, sold 6.7 million tons to that market. Later that year, through an international agreement, the "voluntary" quota for imports of Thai cassava chips to the EEC was reduced to 5 million tons, with a further reduction to 4.5 million tons in 1985. There was great concern as to what Thailand would do with its excess production and what alternative crops the Thai cassava farmers could plant now that they could no longer sell all of their product at the artificially high prices in the protected EEC market. These developments were certainly watched with interest, as they would give an indication as to how cassava pellets could compete in the cold world of international markets. Cassava production in Thailand has continued to rise, reaching just under 20 million tons in the 1984-85 crop season. This has been possible through the opening up of new export markets and increased domestic use in animal feed rations.

Conclusions

The demand studies and empirical observations in a rapidly evolving economic scene have clearly demonstrated that there is sufficient potential demand for increased cassava production. They have also confirmed that because of its unique qualities, cassava is a "natural" for the CGIAR system. On the other hand, cassava is different from most of the commodities dealt with by the CGIAR centers. Its different end uses under different socioeconomic and ecological condi-

tions dictate a decentralized strategy for research and development. The nature of consumption patterns, marketing requirements, and multiple end uses of this remarkable crop also dictate that the traditional germplasm approach will not be sufficient for cassava research and development to yield its maximum social benefits. Production research must be integrated with work on processing, utilization, marketing, and policy-making. These all affect the strategy and activities of CIAT's Cassava Program. A revised program strategy, based on these realities, follows:

A Global Cassava Program

Goals and objectives

The goals of the CIAT Cassava Program are to contribute materially to increased income and food supplies of small farmers and to improve food availability in tropical developing countries. Within the context of these goals, the Program pursues the following nine objectives to:

Develop components of production technology that form the basis for stable, cassava-based cropping systems with low costs per unit output.

Develop technology that allows cassava to be grown on presently underexploited lands.

Develop processing technology that makes cassava a low-cost, high-quality, convenient food.

Develop both production and processing technology that is cost-competitive, increases farmer income, and is sufficiently labor intensive to generate employment for landless labor.

Develop marketing strategies for cassava that reduce the marketing margin.

Stimulate the development of markets for cassava that provide a stable price floor for the raw material, thus providing farmers the incentive to increase production and so reducing price fluctuations for the consumer.

Assist in the development of new uses of cassava that increase the overall demand for the crop.

Develop waste-reducing technology that increases the percentage of total production that is finally consumed.

Stimulate other agencies to play an active role in the cassava research and development process.

Strategies

Operational principles. As a CIAT commodity research program, all activities of the Cassava Program are governed by the set of operational principles underlying all the Center's activities. Included among these principles are Relevance, Equity, Complementarity and Cooperation, Comparative Advantage, and Sustainability.

1. Relevance. The efforts of the Cassava Program are directed towards increased food production that favors the poorer segments of the population, rather than increasing the body of scientific knowledge per se. Research is focused on solving the most important problems in the regions served by the Program.

2. Equity. In seeking to contribute to increased food production, the Cassava Program attempts to benefit primarily the small, resource-poor farmer, as well as the low-income urban and rural consumers.

3. Complementarity and cooperation. The Cassava Program's activities represent only one segment of the cassava research and development spectrum. Consequently, all activities are designed to complement those of other organizations. Of particular importance are the efforts in support of cassava by national agricultural research and development agencies in countries that the Cassava Program seeks to serve. The Program maintains strong linkages with these agencies and coordinates its work program closely with those of collaborating national programs.

4. Comparative advantage. The Program concentrates on resolving those problems and developing those techniques and methodologies for which it has a clear comparative advantage in relation to other agencies, be they international or national, public or private. The comparative advantage arises from certain characteristics of commodity research programs in international centers, including: (a) the ability to provide the necessary backup of scientists to solve problems; (b) the facility to move information, biological control agents, and genetic materials across borders; (c) a high degree of continuity of effort; (d) location in the tropics; (d) being in a position to coordinate activities of different entities on a regional or international level; (e) the ability to capitalize on economies of scale; and (f) the ability to take a long-term view of the overall research and development process.

5. Sustainability. The Cassava Program, in its endeavor to make a major and lasting contribution to cassava production and consumption, emphasizes

long-term cumulative gains over dramatic short-term impacts. Hence, it seeks to develop production technology that promises environmental harmony, relatively broad adaptation to important production constraints, and relatively low requirements for purchased inputs.

Operational strategies. Cassava research must operate within an evolving context where principal constraints on the development of the crop often shift from production to utilization to processing and marketing. An effective research strategy for cassava must focus on the complete commodity system. In so doing it will provide an effective integration between research on production; research on processing and postharvest utilization; and research on consumer preferences, market demand, and appropriate methodologies for technology introduction. In this way the return on investment in production research is maximized. Moreover, the number of potential interventions in the commodity system allow for maximum flexibility in beginning to target the technology on the aforementioned objectives. This holistic strategy allows a particularly effective approach to ensuring impact on equity objectives.

To attain the aforementioned interlinking objectives it is necessary to develop an interdisciplinary team of sufficient size and with the multitude of specialized expertise required to address these objectives. However, it must have a flexible structure that allows continuous interaction amongst the various specialists. Such a team would address the following areas of endeavors:

1. Assembly of a basic body of knowledge of the crop. In order to develop new technology for any crop, it is necessary to have a systematic understanding of it. This includes knowledge on: the crop's basic biology and growth processes; its reaction to different environmental conditions; its interactions with pests and diseases together with an intimate knowledge of their biology and epidemiology; and the crop's physical and chemical characteristics. Before engaging on strategic research in any of these areas, the Cassava Program first of all evaluates the comparative advantage it has to carry out the work and the possibilities of cooperating with other agencies. Only when there is a clear advantage or it is likely that no other agency will become involved does it proceed with the setting up of a research effort.

2. Genetic conservation and improvement. It is evident that any attempt to develop efficient production technology is highly dependent upon the existence of a good variety. The development of effective varieties, in turn, is dependent upon the availability of a gene pool that possesses desirable characteristics. CIAT is in a unique position to collect, characterize, and conserve the world's cassava germplasm in such a manner that it can readily be used by other agencies. In this context, the use of germplasm by other agencies, in particular national breeding programs, can be made much more efficient if desirable characters for specific ecosystems or end uses are already concentrated in elite gene pools. The Cassava Program, therefore, provides breeding programs throughout the world with gene pools that: combine high harvest index with high total biomass production; tolerance to diseases, pests, and adverse soil conditions; and high levels of starch in the roots.

3. Integrated pest management. The reduction of losses caused by diseases and pests in a long growth cycle crop, grown by small farmers, is most effectively achieved through an integrated approach to pest management. As a first step, the Cassava Program evaluates the importance of individual pests or pest complexes in terms of losses caused and the potential area over which they can cause damage. Work is then concentrated on developing the basic building blocks of an integrated pest management program for the most damaging pests and diseases. This includes a thorough knowledge of the organisms and the cassava plant's response to them, as well as the evaluation of alternative strategies such as phytosanitary control, biological control, and host-plant resistance. When host-plant resistance or biological control are deemed to be important components of an integrated pest management strategy, the Program identifies resistant lines and collects and evaluates biological control agents. In the case of host-plant resistance, the sources are incorporated in the elite gene pools. Biological control agents are distributed to agencies working on biological control of cassava pests. CIAT's Cassava Program is in a unique position to carry out these activities as it is located in the center of origin of cassava and the pests and diseases that have coevolved with cassava. The economies of scale that result from having one center collect and evaluate the sources of resistance and the biological control agents are considerable.

4. Sustainable agricultural production systems. Production systems are inherently location specific. Nevertheless, certain basic technological components and principles can be applied over a wide range of conditions. Of particular importance, are measures to reduce and control soil erosion (which range from appropriate management practices to the use of inter-

cropping and a variety of ground covers) and to counteract soil depletion (through appropriate crop rotation and the use of fertilization at the minimum threshold level). The Cassava Program aims to utilize the basic knowledge, developed through its strategic research efforts, to understand the crop in applied research on crop management. Most of this applied research is carried out in close cooperation with the national programs and the results of such cooperation are compiled and analyzed by the Cassava Program in order to develop further the principles of improved crop management. These findings are then used by the national programs in their own adaptive research programs.

5. Improved root quality. The development of new varieties and the rapid move of cassava into new end uses have highlighted the fact that cassava roots of different varieties are characterized by considerable variation in their quality characteristics. No one characteristic can be selected as optimal for all end uses. The situation is further complicated by the fact that at this time, little is known about the basic nature of differences in quality. This makes screening and selection not only a slow, but also haphazard, process. Given that the varietal component is of such paramount importance in determining root quality, additional systematic attempts to improve root quality must be based on the world germplasm collection at CIAT. This research will be carried out in conjunction with various agencies with expertise in this field, including the Tropical Development and Research Institute (TDRI) and a food research institute in the U.K.

6. Improved preservation and processing technology. The movement of cassava into new markets is dependent on its being converted into a competitive, low-cost, and convenient product. This requires the development of improved methods of postharvest handling. These technologies should be relatively nonlocation-specific and their transfer to new application sites should require only minimal adaptive research. Certain postharvest technologies are already well developed or are being investigated by other agencies. In general, these technologies are for large-scale industrial use—an area in which the Cassava Program does not, and will not, play an active role. In the development of small-scale processing technology, however, the Program has already taken a lead role. In the future, emphasis will be on refining the techniques for fresh cassava conservation and the development of technology for the production of high-quality flours. This latter product will then form the basic raw material for developing a variety of new food products. In the area of animal feed, efforts will be limited largely to refining technologies so as to ensure continuous availability of cassava in an appropriate form for use either in the feed industry or on the farm. Other agencies are expected to carry out feeding trials and adaptive testing of available technologies.

7. New products and alternative markets. The changing economic and social conditions in the developing world are leading to changes in people's habits, life styles, and the products they purchase. The CIAT Cassava Program will continually be monitoring the overall patterns of these socioeconomic parameters with a view toward identifying: likely new markets for cassava-based products, or new ways of bringing traditional products more effectively into the changing market structure. Such identification should assist in the improvement of the nutritional status and/or economic well-being of low-income urban consumers. This work will provide a constant input into the other efforts of the Program to ensure that new varieties and processing technology are appropriate to the new marketing niches as they emerge.

8. Development of an appropriate policy environment for cassava. The world agricultural scene today is frequently characterized by economic distortions and conflicting policies that neither serve the best interests of the countries nor favor the poorer, more marginal sectors of the population. Large, economically powerful agricultural groups, often organized in commodity federations, have the resources to analyze the situation of the particular commodity they deal with and use this analysis (often one-sided) to further their cause at the expense of marginal sectors. CIAT is in a unique position to assist national programs in the analysis of the possible effects of policy decisions that affect cassava. Through continued economic analyses of the role of cassava and other crops for which it can substitute, the Cassava Program will provide information to national policymakers to assist them in assessing the potential benefits and disadvantages of the various policy options available to them.

9. Institutional models for development with equity. To meet the goals of equitable development through increased cassava production and improved postharvest handling and marketing, it is necessary to integrate the efforts of diverse agencies. In the past, public sector agricultural development projects have tended to concentrate on the production side. Even in the case of integrated rural development programs, the production side has frequently been divorced from the processing and marketing aspects.

Both the theoretical and empirical bases for the institutional structure to support the integrated development of production, processing, and marketing programs are poorly developed. Recent experience, however, has shown that the form of institutional structure is critical to successful programs and that the form can steer the program to provide benefits to the target population. Although it is true that each project will differ, depending on the specific agronomic, climatic, social, and economic environment, there are a series of common guiding principles for implementing successful projects. These principles can only be deduced from a hands-on approach and close contact with development projects. The Cassava Program will continue to assist national programs in setting up pilot development projects. The careful monitoring of these projects will permit an evaluation of the most effective approaches.

CIAT will be instrumental in stimulating the development of a network of agencies involved in cassava-based development projects, through which the rapid diffusion of the most effective methodologies will be ensured. It should be noted that CIAT's role is not that of a development agency, but that of a source of information and advice on the most effective means of achieving equitable development.

Activities

The fact that cassava is uniquely produced in the tropics has had, and continues to have, a profound effect on the organization of world research on the crop. There is no research (apart from that currently linked to IARCs) on cassava in developed countries, meaning that funds for cassava research have had to come from developing countries or international aid funds. This situation has had three profound effects: (1) the research history on cassava is extremely limited, especially when compared to grain crops; (2) the basic research on the crop, on which sound applied research is based, is virtually nonexistent; and (3) world research on cassava will continue to be limited to the tropics but because of the very limited funds for cassava research, there is need for a more rational division of labor. The CIAT Cassava Program has had to bridge well prioritized strategic research with appropriate applied research and the latter with methodology development for adaptive research and technology introduction. The Program has filled this breach, while working toward the development of a worldwide cassava research network which makes the most effective use of the limited research funds for cassava.

Thus, the Cassava Program's activities can, in broad terms, be divided into the general areas of: (1) strategic and applied research of a more general nature, which is carried out by the central, largely headquarters-based program, as well as collaborative research, normally of a strategic nature, with research agencies in both developed and developing countries; (2) regional activities that are interwoven with national agricultural research and development agencies and that are of an applied or adaptive nature; and (3) networking.

Strategic and applied research of global significance

A strong backup staff of cassava researchers at headquarters forms the basis of this activity. This concerted effort is directed toward nonlocation-specific research, the benefits of which are expected to be felt in the cassava-growing areas of the world in approximate proportion to their present shares of total world production.

Physiology of the crop and identification of desired characteristics. The basic physiology of the crop is investigated, and characteristics of the crop that lead to high, stable yield under adverse conditions are identified for use by the breeders in crop improvement. Particular emphasis is placed on the identification of drought tolerance and the improvement of productivity through variation in the photosynthetic capacity of the crop.

Germplasm collection, development, and distribution. Germplasm is a critical component of the research strategy but in turn that strategy does not depend just on improved varieties. Because cassava is strictly a rainfed crop, grown across a wide range of edaphoclimatic conditions, and under single or multiple stresses, the breeding strategy has to accommodate this significant variability. The strategy developed is two pronged: (1) developing elite gene pools for the principal ecosystems, the description of which are continually refined by the CIAT's Agroecological Studies Unit; and (2) selection from broad-based seed material in the target area, where the gene pool has been matched to the national program's selection site. This system optimizes the needed diversity that goes to a national program, while the selection is done under the stresses relevant to the production region. The selection process is backed by periodic visits to national programs by CIAT breeders. This breeding approach epitomizes the decentralized research strategy of the program: well-developed research methods

and broadly targeted technology which in turn incorporates sufficient malleability to be adapted to local conditions.

Germplasm from all over the world is collected, evaluated, and conserved. Currently, emphasis is on the collection from specific ecosystems which are poorly represented in the present collection. New breeding methodologies are developed and tested, and the possibilities of using biotechnology are evaluated. In the case of biotechnology, further research on anther culture could lead to the development of hybrids and the production of cassava from true seeds. This would make it easier to store seed and reduce disease transmission via seeds. A compromise solution that is being explored is the use of somatic embryos, which could be considered as pseudo seeds. In the crossing program, selected lines are used to develop elite gene pools specifically directed at different ecosystems. These materials are then distributed to national programs for testing and evaluation.

The CIAT breeders keep close contact with their counterparts in national programs to ensure that the specific requirements of collaborating national programs are met. This involves continued visits to the different breeding programs and the joint evaluation of lines.

Colombia, because of its wide range of climatic conditions, has served handily as a base for development of the elite gene pools in priority ecosystems. However, refining the descriptions of these ecosystems for Latin America, and more recently for Africa, has highlighted the importance of semiarid regions and subtropical ecosystems, which do not exist in Colombia. These ecosystems, however, exist in Brazil and, moreover, a large and diverse germplasm pool adapted to these environments also exists there. Several of these elite gene pools will have to be developed in Brazil, backed by a systematic survey and collection of existing varieties.

Diseases and pests. Research on cassava diseases and pests takes advantage of the fact that through a number of testing sites and a wide range of growing conditions in Colombia, most of the important diseases and pests can be adequately covered within the country. Where this is not possible, close links are established with national agencies in other countries to develop the required information on these problems.

The identification of viruses and the development of effective indexing methods is emphasized, and clonal materials are routinely cleaned and tested to ensure that they are free of viruses before shipment. Although virus transmission is not a problem in the case of sexual seeds, they must be certified clean of fungal and bacterial pathogens.

Utilization. The quality characteristics of cassava roots for various end uses are studied in order to establish guidelines for developing techniques for the rapid measurement of root quality. These techniques then become a routine part of the breeding program.

Fresh cassava conservation technology will be further improved. New products for controlling microbial deterioration are being tested, and the possibility of biological control using fluorescent bacteria will be explored.

The basis for new, convenient food products is the conversion of cassava to a more stable form. The prototype technology for low-cost, drying systems to produce high-quality flours now exists and will be tested and modified under commercial conditions. Once it is possible to produce these flours commercially, research activities will concentrate on their introduction as a partial substitute for wheat flour and on the development of new, cassava flour-based products.

Socioeconomic studies of cassava production and marketing. The demand studies underlying the research strategy espoused here highlight the importance of socioeconomic information in determining research priorities. Such information should also prove highly useful for policymakers. Although the intensity of such data collection and analysis activities, outside of Africa, will decline in coming years, the Cassava Program will continue to carry out this type of work in strategically selected countries.

Regional programs

Cassava as a plant species is adapted to a wide range of edaphoclimatic conditions, although any single genotype, if well suited to its environment, has only a narrow range of adaptation. In an analogous manner, cassava as a commodity is well adapted to economies at very different stages of development but, similarly, this adaptation, especially in product utilization, takes very different forms. This malleability with respect to different market conditions in turn makes cassava a useful instrument in meeting a range of policy objectives in developing countries. Because the structure of the agricultural sector and the stage of development is so different between Asia, Latin America, and Africa, different strategies are required. The Cassava Program, therefore, adjusts applied research of a region-

specific nature to the adaptive research needed to achieve impact.

Africa. 1. Collaboration with IITA. Within the CGIAR system CIAT has global responsibility for cassava, while IITA has regional responsibility for the crop in Africa. CIAT's strategy in Africa is very clearly to complement the IITA research program. This includes more basic or strategic research, applied research in priority areas on which IITA has decided not to work, and research in Latin America that directly supports the research effort in Africa. A research base in Latin America has already been shown to be critical to the success of research on biological control of mealybug and green spider mite in Africa. The same is expected to apply, in the future, to: the development of gene pools for particular ecosystems in Africa, to some of the utilization and root quality research, and even to the areas of market development.

2. Agroeconomic studies of cassava in Africa. The importance of cassava in Africa is beyond doubt. Nevertheless, the data available for the purposes of planning research and development programs based on cassava are deficient. This makes it difficult for the two Centers and national programs to develop a coherent research strategy for this continent. Consequently, CIAT and IITA propose to set up a major short-term (three-year) agroeconomic study of cassava that will: characterize the present production, processing, and marketing systems in Africa; assess the potential for producing cassava in new areas; and assess changes in demand that are likely to occur in the coming years. These studies will form the basis for a coordinated CGIAR system plan for cassava in Africa, which will be jointly presented by CIAT and IITA.

The funding for the agroeconomic studies referred to here is projected to be forthcoming through a special project arrangement.

Asia. In Asia a multiple market structure for cassava has already developed in most countries. Markets are in place that can absorb significant increases in production and, if prices can be lowered, new markets are poised to come on line. Hence the efforts of the Cassava Program are directed towards establishing an effective cassava production research network. The structure of that network was discussed at a workshop held in June 1984 and the results were published as "Cassava in Asia, its Potential and Research Development Needs."

Genetic variability in cassava is limited in Asia, indicating that the potential exists for increasing productivity through the introduction of new germplasm. CIAT is developing and servicing a network for testing and evaluating both CIAT and local germplasm throughout the area. Scientists from the region are being trained in handling germplasm and making special crosses to suit the conditions of the region. Nevertheless, new varieties alone cannot remove all the constraints to obtaining highly productive cassava-based systems. In the intensive Asian cropping systems, maintenance of soil fertility and the control of erosion are critical. Over the past decade, a considerable body of basic information on the principles of mixed cropping, soil fertility maintenance, and erosion control has been developed in Colombia. In order to apply this knowledge to the Asian situation, a regional Cassava Program agronomist assists Asian programs in developing improved cropping systems. The regional team (that is, the soil scientist/agronomist referred to above, and a plant breeder) not only work in their specific areas, but also play an important coordinating role in the region to ensure the full integration of cassava research in the regional network.

The initial phase of the CIAT economic studies was designed to determine the potential demand for cassava in the region. Yet to be carried out at the microeconomic scale is: (a) a critical evaluation of how new technology will fit into the intricate cropping patterns of the region; and (b) an identification of constraints on the adoption of new technology.

For cassava production to increase markedly in the region, the fresh roots will have to be processed. At present, the available processing technology is relatively efficient and is not seen as an immediate constraint. CIAT will limit its activity in this area to transferring new processing technology developed at headquarters to Asian national programs through training and conferences.

Latin America. In Latin America demand for cassava still relies chiefly on food markets, which in turn have inhibited the development of alternative markets. It has been shown that cassava can compete in such markets, especially the animal feed market, but incentives to invest in processing, capacity have been masked by the nature of price formation in cassava food markets. To overcome this constraint CIAT has developed the concept of integrated production, processing, and marketing projects in order to foster increased cassava production and utilization and better market integration. Moreover, these projects utilize this unexploited demand potential as a means of increasing small farmer incomes in Latin America,

especially farmers in more marginal areas. Much field-based research has been spent on developing methodologies and project design components which will maximize the equity potential of cassava development in Latin America.

Moreover, the integrated projects, which have now been established in Mexico, Panama, Colombia, Ecuador, and, more recently, Brazil, provide a focal point for germplasm testing and agronomic research. This research is thus well targeted, has backup from the project, has continuity, and provides the capacity for field-level problem identification for feedback to CIAT. The projects are thus the laboratories for much of CIAT's decentralized research on agronomy, biological control, and processing methods.

1. Integrated production, processing, and marketing projects. These projects are run and managed by the national programs. CIAT's role is to assist and give technical advice. The funding for this activity is from bilateral funds or, as in the case of Colombia, paid for by the government. The basis of integrated projects rests on a study of possible markets and areas of production for cassava. This is followed by the selection of the most appropriate processing technology, and the setting up of a pilot project to evaluate the possibility for subsequent expansion into a major development project. While this procedure is simple, its execution is complex. It requires the testing of production technology, an analysis of the best forms of organizing the production to ensure equitable distribution of benefits, and systematic market development.

2. Support for integrated projects. If current trends are any indication, it can be expected that there will be an increasing number of integrated development projects in coming years. Some of the older ones will achieve their objectives and will essentially disappear from the scene, while new ones will develop. A CIAT headquarters-based "integrated projects team" will provide a continuity of effort in this area and will use the experience of the various projects to develop generalized methodologies for the successful implementation of such projects. This team will then use this experience to stimulate national agencies to develop their own such projects. It will also assist national programs in the planning stages, provide technical support in the establishment phases, and help in the design of systems to monitor their success in meeting objectives. The team will consist of: a social scientist (specialized in economics) who is intimately involved in determining the initial feasibility of developing a project, in designing the project, and in monitoring and evaluating the project; an agronomist who will be closely involved in the area of evaluating the potential for production, as well as working with national agencies in the development of production packages that ensure a steady supply of raw material to the project; and a processing specialist who will be involved in advising on appropriate types of processing techniques and in the planning and carrying out of adaptive research to develop technology suitable for local conditions.

Networking

Networks function differently in the work of the Cassava Program from most other crop programs. Finished technologies do not flow within the cassava network. Rather, the Program focuses on introducing a significant degree of diversity or malleability in the "technology" at the level of the national program or project site. The network focuses on both broadening and deepening the methods by which technology is adapted to local conditions and in the identification of research areas not covered within the network. A national, field-level research capacity and pooling of research results are critical to the functioning of the network. A range of different networks on cassava has evolved as follows:

The international cassava research and development network. Its members are: national research and development agencies interested in cassava; individuals in national agencies working on cassava; advanced research institutions in developed and developing countries working on cassava; and international and regional agencies with an interest in the furtherance of the crop. This is a large and amorphous group, held together by the cassava newsletters, the information/documentation services on cassava, and frequent but nonsystematic contacts between and among members.

Regional and subregional germplasm exchange networks. Because of the marked differences in the adaptation of germplasm in different regions and subregions (that is, a strong genotype-by-environment interaction), germplasm exchange networks are most meaningful and effective if they are regionally based, although they can as well cut across particular agroclimatic zones. Germplasm exchange in cassava moves principally as sexual seed, originating from elite germplasm pools. Such gene pools have been developed in Colombia, are in the process of being devel-

oped in Asia, and are projected to be developed in Brazil. In addition to the exchange of germplasm, the networks focus on methodology development and interchange of information.

Specialized networks. These networks seek to unite cassava research that lies outside the national cassava programs. In Asia much research on cassava processing and utilization is done in specialized research centers, unconnected to national cassava research programs. Plans call for the organization of an Asian cassava utilization network to rationalize and support research in the region. In Latin America a network of agencies involved in cassava integrated projects is being organized, again principally to interchange methodological approaches and organizational options.

The Cassava Program will continue to act as a catalyst in the development of these networks and in servicing them to the extent possible. The principal resources available to support this effort are training, international and regional conferences, newsletters, and the world cassava documentation and information center based at CIAT. While the Program seeks to be instrumental in the efficient functioning of the networks, it also seeks to make sure that the Program itself is not placed in the focal point as the principal source of information and materials. Rather, it seeks to stimulate active participation on the part of all network members and attempts to ensure that the networks are marked by a horizontal exchange of ideas, germplasm, and technologies.

Projection of resource requirements

The following table provides an overview of actual (1987) and projected (1988-1992) senior staff positions of the CIAT Cassava Program. It is followed by a description of all currently existing and projected positions.

For the time being, TAC has endorsed the position of "CIAT Cassava Specialist at IITA" and "Virologist" for inclusion in the 1988 core budget. The remaining new and, as yet, not funded positions will be presented by CIAT in 1988 in conjunction with its proposal for a five-year budget for the period 1989-1993.

Actual (1987) and projected (1988-1992) staffing pattern of the CIAT Cassava Program.

Position	1987	1988	1989	1990	1991	1992
Headquarters						
Leader	1	1	1	1	1	1
Pathologist	1	1	1	1	1	1
Entomologist	1	1	1	1	1	1
Physiologist	1	1	1	1	1	1
Breeder(s)	1	2	2	2	2	2
Economist	1	1	1	1	1	1
Agronomist	1	1	1	1	1	1
Utilization Specialist(s)	1	2	2	2	2	2
Virologist[a]	0	1	1	1	1	1
African region						
CIAT Cassava Specialist at IITA	0	1	1	1	1	1
Agroeconomic Study Team[b]		[4]	[4]	[4]		
Asian region						
Breeder	1	1	1	1	1	1
Agronomist[c]	1	1	1	1	1	1
Economist	0	1	1	1	1	1
Latin American Region[d]						
Breeder/Agronomist (Brazil)	0	1	1	1	1	1
Total	10	16[+4]	16[+4]	16[+4]	16	16

a. Position attached to the CIAT Virology Unit.
b. For Agroeconomic Studies of Cassava in Africa which are expected to be special-project funded. Although this is a joint project with IITA, all positions are shown here.
c. Position presently funded on special-project basis.
d. Additional positions are expected to become available, through bilateral and other noncore funding, for a fixed-term involvement in integrated cassava development projects in particular countries.

Headquarters-based staff. 1. *Program Leader.* The coordination and leadership required to ensure a fully integrated multidisciplinary, decentralized approach to global cassava research and development is provided through the Leader position at headquarters. Technical supervision and monitoring of all activities of the headquarters and outposted team members, as well as technical collaboration with IITA and collaborating advanced research institutions, remain the central responsibility for the scientist in this position.

2. Pathologist. Research on the fungal and bacterial disease complexes of the crop, particularly as these relate to key cassava ecologies, will continue, with emphasis not only on germplasm improvement, but also in providing a sound framework in which specific integrated disease control methodologies for those ecologies can be applied in the development of sustainable cassava cropping systems. Monitoring research on the means for the safe and efficient international transfer of germplasm will continue.

3. Entomologist. The research on cassava pests will continue to strengthen the existing inter-Center effort on biological control of major cassava pests through the identification, rearing, and distribution of beneficial insects from the center of origin. In addition, attention will continue to focus on germplasm evaluation for pest resistance and tolerance as a basic input into germplasm improvement.

4. Physiologist. The research will continue to concentrate on further unravelling the basic physiology of the C3-C4 intermediate in collaboration with scientists in advanced institutions. At the same time, genotype responses and the underlying mechanisms of those responses to a range of stress factors will be assessed. Such assessment will reflect the environmental focus of cassava, in particular water-use efficiency, water-stress tolerance, and low soil fertility adaptation (with particular emphasis on phosphorus and potassium nutrition, and the role of mycorrhizae). The basic role of the physiologist at CIAT is to stimulate and conduct research on a crop that has not received sufficient global attention, with a view to providing a basic knowledge framework for germplasm improvement and developing sustainable cropping systems.

5. Breeder I. The existing position at headquarters will continue to focus on genetic improvement of cassava within the framework of a decentralized improvement program. The program will continually evaluate the growing cassava germplasm collection and incorporate sources for tolerance or resistance to a wide range of stresses into high-yielding background populations which have appropriate quality characteristics for cassava's wide range of end uses. The breeder will have specific responsibility for developing germplasm resources for the humid and subhumid lowland areas of Latin America and Asia. Research will include collaborative decentralized breeding and selection activities with national program scientists and backup services for outposted CIAT breeders in Asia and Brazil.

6. Breeder II. This new position projected at headquarters will strengthen the decentralized improvement program by: concentrating on the middle-altitude tropical highlands and the subtropical ecologies of Latin America; and by providing improved populations through IITA for these same ecologies in Africa and elsewhere. Both headquarters-based breeders will increasingly adapt new tissue culture methodologies in the germplasm improvement effort as these become available, for example, through the possible use of haploids, through anther culture, and in somatic embryogenesis for producing artificial seeds. The scientist in this position will provide the main channel for collaborative breeding activities with IITA to ensure that the full range of genetic variability available can be applied in Africa. The scientist will also provide the input required from the Cassava Program for the management of the international cassava collection in collaboration with the Germplasm Resources Unit. (Note: Although projected to be eventually core funded, this position has not yet been endorsed by TAC and is not included in core budget request for 1988.)

7. Economist. The economist will continue to focus on studies of socioeconomic factors affecting cassava research and development through the production, processing, marketing, and utilization of various end products. The principal role of the economist is to provide an economic framework in which integrated cassava development can take place in identified areas of greatest potential. The economist is an integral part of the headquarters team which is devoted to the catalytic activities associated with CIAT's collaboration with development projects in Latin America. It also provides the means for the intercontinental transfer of socioeconomic experience. In this regard, a close association of the economist with the IITA-CIAT agroeconomic studies planned for Africa will ensure that experiences obtained elsewhere in cassava development can be better applied within the African context once the study period is completed.

8. Agronomist. The headquarters-based agronomist forms part of the subteam specifically devoted to

collaborative activities in integrated cassava development in the Latin American region. In particular the subteam works with national programs in decentralized research to ensure that appropriate agronomic practices, leading to sustainable cassava-based cropping systems, are developed. The recognition of the need for more location-specific agronomic research gives a specific focus for the agronomist as he collaborates with ongoing national integrated cassava production projects and those projected by collaborating agencies.

9. Utilization Specialist I. The existing utilization position will continue to focus on the engineering and logistical aspects of cassava processing for the wide range of end uses, and to develop, not only new methodologies, but also improvements for traditional processing systems. The feasibility and necessity of new or improved methodologies for Africa will be established by the planned IITA-CIAT collaborative agroeconomic study of cassava in Africa. This scientist also forms part of the headquarters subteam devoted to CIAT's role in integrated cassava development in Latin America and the Caribbean.

10. Utilization Specialist II. The acceptance of new varieties is highly dependent upon the quality characteristics of the fresh roots as related to the final end market. Little is known at present about the parameters that determine root quality. An additional position is projected in the utilization section at headquarters to work closely with the breeders to define these biochemical parameters and develop screening techniques that will accurately discriminate among genotypes. Guidelines will also be developed and methodologies designed to improve the quality of cassava products after processing. This cassava-quality work will have direct application to the wide range of cassava products in Africa. (Note: Although projected to be eventually core funded, this position has not yet been endorsed by TAC and is not included in core budget request for 1988.)

11. Virologist. As a vegetatively reproduced crop, cassava is prone to virus problems transmitted through the planting material. This not only affects production on farmers' fields, but also inhibits the free exchange of germplasm. It is essential to characterize the cassava viruses accurately, develop techniques for their detection and elimination, and devise control methods. In order to do this, the Biotechnology Research Unit, which provides an administrative and resources umbrella for all virology work at CIAT, is projected to increase its personnel by one senior staff position. (Note: This position has been endorsed by TAC for inclusion in the 1988 core budget request of CIAT and is included in the present budget request.)

African region. 1. CIAT Cassava Specialist at IITA. The nonlocation-specific research done by the overall CIAT effort can bring great benefits to African cassava producers. CIAT does not, however, apply this technology directly to African conditions. The information, germplasm, and biocontrol agents are transferred directly to IITA, who incorporates these elements into its regional efforts in Africa. To establish an effective liaison between the two Centers, IITA and CIAT have agreed that a CIAT cassava specialist be posted at IITA. He is to ensure that African needs and requests, that can make use of CIAT-based resources, are rapidly met. Both Centers agree that in the light of scarce resources this scientist should form an integral part of the IITA cassava effort and carry out an active research program. (**Note:** This position has been endorsed by TAC for inclusion in the 1988 core budget request of CIAT and is included in the present budget request.)

2. Agroeconomic studies of cassava in Africa. The importance of cassava in Africa is beyond doubt. Nevertheless, the data available for planning research and development programs based on cassava are deficient. This makes it extremely difficult for CIAT and IITA and the national programs to develop a coherent research strategy for this continent. As a result, CIAT and IITA are proposing to set up a major short-term (3-year) study of cassava. This study will characterize the present production, processing, and marketing systems in Africa; assess the potential for producing cassava in new areas; and assess the changes in demand that are likely to occur in the coming years. The study will have a team envisaged as headed by a study director (an agricultural economist), and comprising three economists, each of whom will assume responsibility for a separate geographical region. This team is to be supported by a series of national study coordinators. CIAT and IITA are seeking special project resources to be able to carry out these studies.

The results of these studies will form the basis for a coordinated CGIAR system plan for cassava in Africa which will be presented jointly by CIAT and IITA.

Asian region. 1. Breeder. The regional cassava program for Asia is projected to have ultimately three scientists. The program focuses on the decentralized regional breeding program and collaborates with the national researchers within a regional germplasm development network. Backup from headquarters in terms of a providing a broader germplasm base for

Asia is balanced by a concerted program to stimulate genetic recombinations and selection for specific local environmental constraints and end uses. The specific role of the regional breeder is to provide guidance to national efforts and to stimulate intercontinental exchange of improved germplasm. The lower incidence of cassava diseases and pests in Asia permits greater concentration on yield, quality, and adaptation to environmental stress.

2. Agronomist. In the complex Asian cropping systems in the upland areas, sustainability of production is a major concern. An agronomist is stationed in Asia to assist national programs to develop production systems that reduce erosion and maintain soil fertility. This position is special project-funded through 1989, whereupon it is projected to be incorporated into CIAT's core budget. (Note: Although projected eventually to be core funded, this position has not yet been endorsed by TAC and is not included in core budget request for 1988.)

3. Economist. An integral member of the Asian team will be a social scientist (economist) whose main task will be to ensure that the new technology fits into the intricate Asian cropping systems and is acceptable to farmers. This will involve working closely with the CIAT agronomist and the national program agronomists in the testing of new technology packages at the farm level and in the monitoring of adoption of new technology. In addition, the economist will analyze the overall direction of cassava development in the region to ensure that other research activities are directed to resolving problems related to changing socioeconomic conditions. (Note: Although projected eventually to be core funded, this position has not yet been endorsed by TAC and is not included in core budget request for 1988.)

Latin American Region. 1. Breeder/Agronomist for Brazil. At present it is not possible for the headquarters team in Colombia to dedicate adequate attention to two important cassava ecologies even though they are within the species' center of origin. These ecologies are the subhumid tropics and the cool-season subtropics. In view of the overall importance of cassava in Brazil and the existence of these two ecologies there, CIAT has projected a new position in Brazil. The location of the Breeder/Agronomist will depend upon discussions with EMBRAPA, but most likely will be in northeast Brazil. In addition, the scientist would supervise a research associate to be located in the south to handle the development of breeding populations for the cooler ecosystems. The Breeder/Agronomist at the base location will mainly be developing specific cassava germplasm pools adapted to the drier areas of the lowland tropics.

The future role of this particular germplasm in the subhumid savannas of Africa will be studied in collaboration with IITA. The richness of the germplasm resources available in Brazil is a key element in this decentralized strategy. (Note: Although projected eventually to be core funded, this position has not yet been endorsed by TAC and is not included in core budget request for 1988.)

2. Integrated cassava development projects. In the foregoing definitions of the role of existing and projected senior staff positions, three scientists from the core-financed headquarters team of the Cassava Program are given specific responsibilities to provide collaborative linkages to integrated cassava development projects in Latin America and the Caribbean, that is, in addition to their normal activities in the Program. These scientists are the Agronomist, Economist,and Utilization Specialist. I. CIAT plans to stimulate integrated cassava development projects in carefully defined regions with the greatest potential and across the range of end uses for cassava. These projects will be funded through special projects to CIAT and/or through bilateral projects funded directly to the collaborating country institutions.

Achievements of the Program

(See Cassava Program section under "Summary of Achievements", p. 9-11).

Special projects

Cassava development in Brazil. This project aims to establish pilot projects for the production, processing, and marketing of cassava in two areas of Brazil—the south and the northeast—and to develop the methodology for expanding cassava production in these regions. In the longer term, experience gained in the pilot projects will be used to develop national program capacity to carry out cassava-based development programs that will bring benefits to the rural population of Brazil. These methodologies will contribute to the other rural development programs forming part of the network of cassava-based integrated rural development projects. This project was not yet finally approved by the W. K. Kellogg Foundation as of June 1987, but was expected to be approved shortly thereafter.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel (2 senior scientists)	77	179
Honoraria, stipends, and allowances	10	15
Supplies and services	13	31
Travel	10	20
Equipment replacement and capital	34	16
Indirect costs	17	35
Contingencies	-	-
Subtotal	161	296

Exploration and evaluation of cassava mite predators. This collaborative research project with IITA is a component of the Africa-wide Project for Biological Control of Cassava Pests. The following activities are involved: (1) survey of cassava mite predators in the Americas; (2) evaluation of the efficiency of these predators, including field ecology and phenology studies; and (3) preparation of the predators for shipment to Africa. This project is supported by IITA.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	72	83
Honoraria, stipends, and allowances	11	11
Supplies and services	11	12
Travel	36	20
Equipment replacement and capital	9	-
Indirect costs	-	-
Contingencies	14	13
Subtotal	153	139

Cassava and rice research in Panama. This is a bilateral agreement whereby: (1) CIAT's Rice Program helps IDIAP to evaluate segregating populations in order to obtain advanced lines and varieties under Panamanian and Central American conditions. It also carries out observation, yield, and regional trials of promising lines and selections. (2) CIAT's Cassava Program assists in the baseline study of: socioeconomic and physical-biological conditions of cassava production in Panama; the development of appropriate production and processing technology; and development, at the experimental level, of cassava processing and drying technology for a future national-level project. This project is financed by USAID.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	-	-
Honoraria, stipends, and allowances	2	2
Supplies and services	57	57
Travel	-	-
Equipment replacement and capital	18	18
Indirect costs	4	4
Contingencies	1	1
Subtotal	82	82

Agroindustrial development of cassava in Colombia. In collaboration with the Integrated Development Program (DRI) of Colombia, CIAT will provide technical assistance in the execution of this agroindustrial development project on cassava production and drying for small farmers on the north coast of the country. This project is financed by DRI and IDRC.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	25	28
Honoraria, stipends, and allowances	11	13
Supplies and services	12	15
Travel	1	1
Equipment replacement and capital	-	-
Indirect costs	-	-
Contingencies	-	-
Subtotal	49	57

Farmer participation in technology design and transfer. (See under "Special Projects in Bean Program section, p. 20).

Germplasm collection for beans, cassava, and tropical pastures. (See under "Special Projects" in Genetic Resources Unit section, p. 53).

In vitro active gene bank. (See under "Special Projects" in Biotechnology Research Unit section, p. 57).

Specialized information centers. (See under "Special Projects" in Communication and Information Support Unit section, p. 77-78).

RICE PROGRAM

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Program Leader	1	1	1	1	1	-	1	1	1	1	1	3	3	3	3
Agronomy (production systems)	1	1	1	1	1	1	2	2	2	2	7	9	9	9	9
Breeding (Santa Rosa)	1	1	1	1	1	2	2	2	2	2	12	12	12	12	12
Breeding (Palmira)	1	1	1	1	1	2	3	3	3	3	22	22	22	22	22
Pathology	1	1	1	1	1	3	3	3	3	3	11	11	11	11	11
Integrated pest mgt.	-	-	-	-	-	-	1	1	1	1	-	4	4	4	4
Economics	-	1	1	1	1	-	1	1	1	1	-	2	2	2	2
Physiology (Santa Rosa)	1	1	1	1	1	2	2	2	2	2	6	6	6	6	6
Total	6	7	7	7	7	10	15	15	15	15	59	69	69	69	69

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	775	1016	1016
Honoraria, stipends, and allowances	-	-	-
Supplies and services	157	100	100
Travel	80	93	93
Equipment replacement	11	21	21
Contingency	-	-	17
Subtotal	1023	1230	1247
Support units[a]	-	-	366
Price provision	-	-	49
Total	1023	1230	1662

a. Resource allocation from support units to the Rice Program.

Program Commentary

The CIAT Rice Program focuses on the Western Hemisphere including Mexico, Central America, the Caribbean, and South America. It collaborates closely with IRRI's efforts in global rice research and with IITA in areas of mutual interest. Research on major regional constraints is encouraged through an active network of rice specialists cooperating in the International Rice Testing Program (IRTP).

Annual growth rates for rice in Latin America during the past two decades have averaged 3.3%, 2.3%, and 1.0% for production, area, and yield, respectively. Per capita consumption of rice has been rising and is currently about 35 kg of milled rice annually. Rice provides, on the average, 9% of total calories in the Latin American diet. Countries with the highest rice contribution to total caloric intake are Panama, Dominican Republic, Cuba, Brazil, Costa Rica, Colombia, and Peru.

Traditionally Latin America, as a region, has been a minor net importer of rice. The largest exporters were Uruguay, Suriname, Argentina, and Guyana and the major importers were Cuba, Brazil, Mexico, and Peru.

If demand increases continue at the annual rate of about 3.5% as observed during the past 20 years, production must double by the year 2000 to satisfy internal demand at current relative price levels. This indicates an increase from the current 17 million tons to over 30 million tons by the end of the century. Unless production is stimulated rapidly, the countries that will face serious rice deficits are Mexico, Nicaragua, Cuba, Jamaica, Brazil, Colombia, Ecuador, Peru, and Venezuela. Except in the Caribbean region, land and water resources are sufficient to permit this growth. However, in several key countries where growth has been rapid a production plateau has been

reached. In these areas production costs are very high. Thus, rice farming is becoming a less attractive proposition. The high costs are partly due to excessive pesticide use and inappropriate, inadequate, and expensive weed control. The challenge is to distinguish among physical, biological, agronomic, economic, and political constraints to rice production growth. With proper identification of the principal problems, training, research, and cooperation with national programs can be oriented effectively.

1988 Budget request for Rice Program

Activity	Amount (1988 US$ in thousands)
Soil management and conservation research	2.5
Germplasm	
Research on conservation and diversity	83.5
Conservation, characterization, and documentation	57.7
Enhancement	9.4
Plant breeding and improvement	448.7
International trials (distribution and exchange)	72.9
Seed production	33.2
Crop systems research	71.3
Plant protection research	227.7
Plant nutrition research	25.6
Machinery research and development	5.7
Human resource enhancement	
Specialized courses (short term)	103.5
Individualized internships	39.9
Conference and seminars	34.5
Documentation and dissemination	33.4
Research on approaches, concepts, methodologies, and procedures	25.2
Counselling and advising NARS	112.3
Technical assistance	38.5
Coordination of networks	83.7
Economic and social analysis at microlevel	55.4
Market analysis	26.6
Policy analysis	50.0
Nutrition and consumption analysis	20.9
Total	1662.1

Production Systems and Constraints

Trends in rice production, area planted, and yield vary widely among countries and over time. The major contribution to production during 1965-1975 came from increase in area, particularly in Brazil. This was reversed in the more recent period of 1976-1982 when essentially all regional growth came from yield increases. The unfavored upland area in Brazil began to decline, but was offset by increased productivity from irrigated areas in Rio Grande do Sul and Santa Catarina, where yields are good.

Fourteen of the 23 more important rice-producing countries now have average yields of over 3 t/ha. The Latin American average of 2 t/ha reflects the massive impact of the national average of 1.5 t/ha in Brazil. The basic causes for this low yield are found in the predominance of the unstable production system in the Brazilian Cerrado. This system accounts for approximately 50% of the rice area under production in the entire region and, because of unreliable rainfall, yields average about 1 t/ha. Several distinct production systems exist in the region. Often rice production is divided, somewhat misleadingly, into two main systems, irrigated and upland. In 1983-1984 irrigated rice covered 2.4 million ha (32% of the area), averaged 4.2 t/ha, and contributed 61% of regional production. The favored upland systems, which have more in common with irrigated rice than with unfavored upland, covered 0.7 million ha, averaged 2.4 t/ha, and produced 11% of regional production. In comparison, unfavored upland rice was grown on 4.1 million ha (about 55% of the total area), yielded 1 t/ha, and contributed 26% of regional production. The rainfed and manual upland ecologies together contributed only 2% of Latin American rice.

Irrigated rice. This system receives high CIAT priority because of its major contribution to regional production and its comparative advantage in maintaining and further increasing productivity and stability of supply. It is found in all countries and predominates in southern Brazil, Colombia, the Caribbean region, Guyana, Nicaragua, Peru, Suriname, Venezuela, and the Southern Cone countries. Irrigated rice is increasing in countries that formerly were upland producers. Average national yields range from 3 to over 5 t/ha. Important constraints include increasing production costs, weeds, water control, rice blast and other diseases, lodging, and, in some countries, the availability of suitable grain quality for export markets.

Favored upland rice. This system is generally confined to flat areas receiving 1500 to over 2000 mm of rainfall in eight or nine months of the year. Normally, there are no short dry periods during the rainy season. The soils are alluvial, slightly to moderately acid and well-drained. This system uses modern dwarf varieties and improved agronomic practices. Yields average 2.5 t/ha, but better farms can produce 4-5 t/ha. The system is found in parts of Brazil, Central America, Colombia, and elsewhere in tropical America. Major constraints are grassy weeds, diseases, and general instability due to irregular precipitation in some years. CIAT assigns high priority to this system.

Unfavored upland rice. This system, found in areas having irregular and low total rainfall, has low planting densities and utilizes tall varieties producing an average yield of less than 1 t/ha. Yield variance is extremely high. Much of Brazilús rice is produced with this system on relatively infertile and moderately acid soils.

The main system constraint is dry periods occurring during the growing season. This stress is compounded by poor root development associated with aluminum toxicity in the subsoil. The degree of drought enhances the severity of fungal diseases, particularly blast, in this system. Phosphorus and other deficiencies are a serious overall constraint. CIAT does not conduct research directly on unfavored upland rice since the system is mainly utilized in Brazil and at the present time the Program has no comparative advantage for work in this area. However, lines under development may play a role as parents for characters such as acid-soil tolerance and disease resistance.

The main unfavored upland rice system areas in the region have two main environmental constraints, that is, low and/or unreliable rainfall together with infertile acid soils. In the tropical lowlands of the Americas there are vast areas of well-watered savanna lands which have not been opened up for arable agriculture. In these areas rice does have a future potential provided the problems of adaptation to low soil fertility and soil acidity can be successfully resolved. CIAT has commenced research on these problems.

Rainfed lowland rice. This system is a transition between irrigated and upland and utilizes rainwater trapped and held by field levees. Nevertheless, water deficits and/or deep flooding are common. Dwarf varieties can be grown when water control is provided, but tall varieties predominate. Average yields are 2.5 t/ha. The crop may be transplanted or directly seeded and few purchased inputs are used. Rainfed rice is important only in coastal Ecuador, Colombia's northern coast, and in the Dominican Republic. Given that rainfed lowland rice contributes only 1% to Latin American production, CIAT does not directly research this system.

Program Objectives

The three specific objectives for Rice Program activities in collaboration with national institutions in the Western Hemisphere are the:

Continued development of germplasm-based technology designed to overcome the principal constraints to increased production of irrigated rice and the more favored upland production systems.

Development of widely applicable production technology. This includes the introduction and evaluation of appropriate farm machinery that is oriented toward weed control and other related cultural practices in order to reduce costs and increase stability of supply.

Strengthening of national rice research programs in the region through assistance in the preparation of national production plans, training, conferences, and technical collaboration activities. Through these mechanisms the Rice Program can further stimulate the highly effective regional rice research network which is now in place.

General Research Strategy

Since its beginning in 1967, the Rice Program's basic strategy was to improve yields and production of irrigated rice in the region. This strategy was adopted because: irrigated rice offered the greatest opportunity for rapid gains; irrigated rice technology was more easily generated and transferred than that for other production systems; and limited core resources did not permit simultaneous work on all production systems.

Varietal improvement has been the key element in CIAT's irrigated rice research strategy. Tall varieties were used throughout the area before 1968, when IR 8 was introduced. An immediate increase in productivity of 2 t/ha confirmed the decision to work exclusively on dwarf materials for this system. The research has sought varieties combining dwarfism, strong stems, insensitivity to photoperiod, long grain with clear endosperm, resistance to the *Sogatodes* leafhopper,

and blast resistance. Earliness and improved adaptability to acid soils are more recent varietal objectives.

In recent years, with the exception of rice blast, the fungal diseases of dirty panicle, brown spot, leaf scald, eye spot, narrow brown leaf spot, and sheath blight have increased in severity and now constitute yield constraints, partially as a consequence of increase in fertilizer use and of expansion of upland rice and irrigated rice on infertile soils. These problems, along with the resurgence of the hoja blanca virus, have intensified the need for resistance breeding for all ecologies.

To address these needs, the Program moved its main breeding site to the Colombian Llanos, near Villavicencio, where disease pressure is high for the most serious foliar and grain pathogens. Material is selected under enhanced epidemics of leaf and neck blast, leaf scald, and grain discoloration. A large-scale, semi-controlled field screening method has been successfully implemented for the hoja blanca virus.

The hoja blanca-resistant lines were tested under natural and heavy virus epidemic conditions in Ecuador. As expected, they proved to be highly resistant. An exhaustive characterization of the components of the resistance being used indicates that it is true resistance to the virus (as opposed to simply differential feeding behavior of the insect vector on differential genotypes), and that it is not likely to break down quickly, if ever. Resistant lines are being advanced rapidly in Ecuador and Colombia and should be released in approximately two years.

Iron toxicity is an increasing problem in acid, irrigated soils in Brazil, Argentina, Colombia, and Venezuela. An efficient, simple screening method capable of handling several thousand lines per year was developed. Many advanced lines are highly tolerant, allowing IRTP to send only known tolerant materials to areas where iron is a constraint.

As improved dwarf lines and varieties are produced, research is extended to developing appropriate cultural practices for the high-yielding varieties. Seeding rates and methods, fertilizer practices, and timing of weed control are emphasized. Farmers have learned to manage modern varieties, but severe cultural practice deficiencies remain. These include red-rice and weed infestations, seed quality, land preparation, water control, and the lack of simple appropriate equipment for small-farm operations.

In the irrigated sector the number of crosses has increased substantially in response to new disease problems, need for iron-toxicity tolerance, and the specific low temperature constraints and grain quality requirements for the temperate Southern Cone. This latter activity is expanding rapidly now that dwarfs are known to be well adapted throughout the temperate production areas, and that anther culture technology has permitted large-volume production of fixed lines that combine the necessary characteristics for these conditions. Field evaluations of these lines in Chile and seedling evaluations under laboratory conditions show that some of the lines have high levels of cold tolerance combined with excellent grain quality. The high-yielding, high-quality, cold-tolerant lines developed from this project will have direct application to Chile and should prove to be excellent parents for a wide variety of breeding objectives. Anther culture is now being evaluated for its applications to tropical breeding as well.

The unexpected adoption of the newer dwarf varieties in recent years in the more favored upland systems allowed the Program to modify its original strategy. Entries for nurseries, especially for the more favored upland systems, are selected from the advanced irrigated breeding lines and distributed to national programs for continued local selection and evaluation. Thus, CIAT contributes directly to upland systems while focusing on irrigated varieties. In 1981 CIAT began to intensify its activities in upland rice.

Breeding for the more favored upland ecologies and high-rainfall, acid-soil, savanna upland has increased dramatically. Crossing is currently focused on disease tolerance, grain and plant type, earliness, and general adaptability to upland soils. Work must be undertaken on the multiple mineral nutrition stresses of upland soils with specific breeding attention to tolerances to zinc, phosphorus, iron, and manganese deficiencies along with aluminum and manganese toxicities in acid soils. It seems clear that one way to reduce fungal disease pressure in upland rice is through breeding for tolerance to problem soils.

Specific research strategies for the remainder of the decade of the eighties and beyond have been developed for the various production systems identified for priority attention.

Research strategy for irrigated rice. This system will continue to receive major attention. Enhanced tolerance to diseases (for example, blast, other fungal diseases, hoja blanca) and soil problems (for example, iron toxicity and straighthead disease) should increase yields, lower production costs, and increase production stability. The approach will combine breeding

directly for disease resistance with breeding for tolerance to soil stresses and emphasize weed control and lower seeding and fertilizer rates. Lowered inputs should result in decreased fungal disease severity. Additionally, breeding will focus on better lodging resistance and, simultaneously, seek modest gain in yield potential.

Improvement in farm cultural practices is indispensable to narrow the gap between varietal yield potential and farm productivity. Research on cultural practices has lagged behind varietal development. General rice weeds, including red rice, constitute the most serious problem in rice production. As most countries have effective herbicides, the reduction of the problem is focused on improved land preparation and levelling, largely through more appropriate equipment, especially for smaller farms, including steel tractor wheels, small tractors, and tillers.

Work in integrated pest management shows that costly insecticide applications can be eliminated for most insects under most conditions. Studies of all major insect targets for insecticides showed that economic thresholds, field monitoring, varietal tolerance, and biological control can eliminate insecticides for most pests. Prophylactic seed treatments are being developed for the few pests that cause risk during the first two weeks after seeding.

Fungicide applications for the complex of fungi associated with dirty panicle, a rapidly increasing, worldwide disease were shown to be ineffective. Their elimination will contribute to reduce production costs.

Dirty panicle, widely distributed in Latin America and elsewhere and formerly considered to have a fungal etiology, is now known to be caused in many cases by a complex of seed-transmitted, systemic bacteria. The pathogen is eradicated with extremely severe dry heat therapy that does not reduce seed germination. National programs are being urged to heat treat genetic and foundation seed to control the disease on farms. International centers and Latin American national programs were advised of the cause and control of dirty panicle to eliminate international movement of the pathogen.

Many new irrigated rice areas are coming into production, principally by small producers. They lack appropriate small machinery to facilitate the transition from transplanting to direct seeding where labor is scarce. Such machines (hand seeders, boom sprayers, harvesters, and threshers) are commercially available. The Rice Program will emphasize the introduction of appropriate machinery through national programs.

Research strategy for the more favored upland systems. Selected lines from the irrigated breeding program can contribute to the varietal component for expanding this system in the region. Nevertheless, a breeding program is designed to address the peculiar stresses of upland soils, particularly moisture and mineral nutrition, and their interaction with fungal diseases in several sites reflecting a range of ecologies from moderately to highly favored upland. Vigorous dwarf varieties tolerant to problem soils, diseases, and short dry periods should increase and stabilize yields at an average of 3 t/ha, 0.5 ton higher than existing average productivity.

Weed infestations constitute a powerful yield constraint in upland rice and are more difficult to control than in irrigated rice. Since available herbicides are relatively effective, research will focus on appropriate terrestrial delivery systems to improve timing and reduce dosages.

New production systems research strategy. The vast savanna regions of Colombia, Venezuela, and Brazil are favored by abundant well-distributed rainfall, but the soils are extremely acid and infertile. Although little upland rice is produced on these soils there is a clear need for a crop component in the pasture system being developed by the Tropical Pastures Program to facilitate and finance land preparation for pasture establishment. Upland rice could become a pioneer crop, thus, encouraging the economically sound development of acid, high-rainfall savannas.

A minimum-input, upland rice system, using cultivars tolerant to acid soils and diseases, appears attainable. Initial research with soil-adapted cultivars consistently gives plot yields of 3.5-4.0 t/ha without soil amendments or chemical protection. Thus, a 3-ton commercial yield seems reasonable and economically viable. A high-volume crossing program is underway with upland materials from Africa, Brazil, Japan, and other sources. Specific breeding objectives are identified and parental sources are available. Although typical, high-yielding, irrigated germplasm is not useful for this ecology, many rices are well adapted to those infertile, acid soils having over 80% aluminum saturation. Breeding will stress tolerance to manganese and aluminum toxicities and to phosphorus, zinc, and other deficiencies. The ideal plant type remains unclear but intermediate grain quality, multiple fungal tolerances, hoja blanca, sogata, and sugarcane borer resistance are the main requirements.

A spinoff of the savanna project may well be the diversification of the irrigated/favored-upland germ-

plasm. Many lines emerging from this program combine dwarf plant type, typical of irrigated material, with deep, thick roots and diverse high-level disease resistant levels, typical of traditional African upland material. The incorporation of superior lines from the savanna program into our irrigated/favored-upland program is underway.

Research on cultural practices will concentrate on weed control, methods of seeding and applying fertilizer, and conversion into pastures after one or two rice crops.

Research Sites

The research program has largely decentralized its activities from the Palmira CIAT headquarters. However, the crossing program, quality laboratory, germplasm storage, sogata and hoja blanca screening, and IRTP remain in Palmira.

Three locations in Panama and two in Guatemala were made available by IDIAP and ICTA within collaborative programs, for selection of segregating generations of upland and irrigated materials. In 1983 CIAT acquired the Santa Rosa experiment station near Villavicencio, in the Colombian Llanos, which now is the central breeding location for favored upland and irrigated rice. Also in 1983 ICA provided long-term use of 16 ha of acid savanna on its La Libertad station adjacent to Santa Rosa. Irrigated and upland selection and evaluation work continues in Peru under a cooperative project with INIPA. Implementation of the Caribbean Cooperative Rice Research Network will add the Juma Experiment Station in the Dominican Republic as an additional research site.

Achievements of the Program

(See Rice Program section under "Summary of Achievements", p. 8-9).

Special Projects

Caribbean rice improvement network

This project aims to contribute to the strengthening of national rice improvement and production systems through the development of a dynamic rice improvement and technology transfer network that will allow for horizontal transfer of production and seed technology and strengthen CIAT/IRRI collaboration with national programs in the region. Network activities will comprise: (a) coordination of collaborative adaptive research on common problems, dividing responsibilities among national programs; (b) testing of germplasm for resistance to relevant production constraints; (c) reinforcement of national research and extension capabilities through incountry courses and inservice training; (d) training in seed technology; (e) regional workshops and monitoring tours to improve communications and cooperation in area. (One senior staff position [Project Network Coordinator] is provided by IRRI through the IRTP; and CIDA is funding three Canadian scientists: an agronomist, an economist, and an agricultural engineer.)

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	32	100
Honoraria, stipends, and allowances	44	85
Supplies and services	10	34
Travel	7	23
Equipment replacement and capital	28	28
Indirect costs	14	36
Contingencies	11	27
Subtotal	146	333

Beans and rice research in Peru

(See under "Special Projects" in Bean Program section, p. 19).

Farmer participation in technology design and transfer

(See under "Special Projects" in Bean Program section, p. 20).

Cassava and rice research in Panama

(See under "Special Projects" in Cassava Program section p. 37).

TROPICAL PASTURES PROGRAM

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Program Leader	1	1	1	1	1	2	4	4	4	4	7	7	7	7	7
Germplasm evaluation															
Germplasm evaluation	1	1	1	1	1	3	2	2	2	2	15	15	15	15	15
Agronomy (CMG)[a]	1	1	1	1	1	2	2	2	2	2	12	12	12	12	12
Regional trials	1	-	-	-	-	1	-	-	-	-	4	-	-	-	-
Pathology	1	1	1	1	1	3	2	2	2	2	10	10	10	10	10
Entomology	1	1	1	1	1	3	3	3	3	3	9	9	9	9	9
Microbiology	1	1	1	1	1	3	3	3	3	3	10	10	10	10	10
Forage breeding	1	1	1	1	1	3	3	3	3	3	11	11	11	11	11
Legume breeding	-	-	-	-	1	-	-	-	-	2	-	-	-	-	7
Pasture evaluation															
Seed production	1	1	1	1	1	2	2	2	2	2	19	19	19	19	19
Soil/plant nutrition	1	1	1	1	1	1	2	2	2	2	14	14	14	14	14
Pasture develop. (CMG)	1	-	-	-	-	2	-	-	-	-	9	-	-	-	-
Pasture quality and productivity	1	1	1	1	1	2	3	3	3	3	17	20	20	20	20
Ecophysiology	1	1	1	1	1	2	2	2	2	2	8	9	9	9	9
Pasture evaluation in farm systems															
Livestock systems	1	1	1	1	1	3	3	3	3	3	11	11	11	11	11
Economics	1	1	1	1	1	2	3	3	3	3	2	2	2	2	2
Total	15	13	13	13	14	34	34	34	34	36	158	149	149	149	156
Decentralized regional programs															
Tropical South America															
Cerrados ecosystem[b]															
Agronomy (reg. trials)	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-
Soil pasture develop.	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-
Humid tropics ecosystem															
Agronomy (regional trials)	1	1	1	1	1	1	1	1	1	1	6	6	6	6	6
Pasture reclamation	-	1	1	1	1	-	1	1	1	1	-	6	6	6	6
Central America and Caribbean															
Agronomy (reg. trials)	-	1	1	1	1	-	1	1	1	1	-	9	9	9	9
Africa															
Regional liaison (ILCA)	-	-	-	1	1	-	-	-	-	-	-	-	-	2	2
Total	2	5	5	6	6	1	3	3	3	3	6	21	21	23	23

a. CMG: Carimagua Station in the Llanos of Colombia.
b. In Brazil.

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	2415	2634	2634
Honoraria, stipends, and allowances	-	-	-
Supplies and services	526	330	330
Travel	299	301	301
Equipment replacement	23	54	54
Contingency	-	-	40
Subtotal	3263	3319	3359
Support units[a]	-	-	1395
Price provision	-	-	144
Total	3263	3319	4898

a. Resource allocation from support units to the Tropical Pastures Program.

1988 Budget request for Tropical Pastures Program.

Activity	Amount (1988 US$ in thousands)
Soil management and conservation research	201.4
Agroclimatology research	10.8
Germplasm	
Research on conservation and diversity	151.1
Collection	225.3
Conservation, characterization, and documentation	315.1
Enhancement	492.2
Plant breeding and improvement	172.7
International trials (distribution and exchange)	531.6
Seed production	160.4
Livestock	257.6
Crop-livestock systems research	139.7
Plant protection research	136.6
Plant nutrition research	167.3
Machinery research and development	43.2
Livestock nutrition research	425.2
Livestock reproduction research	48.9
Human resource enhancement	
Specialized courses (short term)	265.8
Individualized internships	164.2
Conferences and seminars	70.9
Documentation and dissemination	8.3
Research on approaches, concepts, methodologies, and procedures	234.0
Counselling and advising NARS	118.1
Technical assistance	95.0
Coordination of networks	279.3
Economic and social analysis at microlevel	66.4
Exploratory research	116.3
Total	4897.4

Program Commentary

Importance of the Program's products

The Tropical Pastures Program has four major products: beef, milk, conservation of tropical ecosystems, and resource base expansion. A short summary of the importance of these products follows.

Beef. Beef is one of the staple foods for people in Latin America, including the urban and rural poor. The availability of beef is one of the principal reasons why protein malnutrition is less acute in tropical America than in Africa or Asia. However, during the last 15 years the annual growth in demand for beef in tropical America (5.6%) has exceeded increases in production (3.6%). This gap is resulting in real price increases which will cause a decrease in beef consumption by families of the lower 25% income strata which presently use 8% to 16% of their total budget to buy beef. The high price and income elasticities of demand for beef also suggest that increase in beef production leading to lower real prices would have a larger impact on consumption and quality of diet than production increases of most other major staple food crops consumed by the Latin American poor. In order to accomplish this, production costs, particularly social costs, must be reduced, and this is more likely to be possible in the underutilized, marginal, and frontier areas of acid infertile soils because of their low opportunity costs.

Milk. Milk production trends in tropical America are similar to those of beef with low per capita production (one-quarter that of the U.S.). Imports of milk and dairy products have been tripling in the last 10 years. The program's target area survey has shown that milk production from dual-purpose cattle farms is

an important source of income in many areas and that its importance increases as farm size decreases.

Conserving tropical ecosystems. The Oxisol/Ultisol savanna and Cerrado regions of tropical Latin America, covering almost 300 million ha, are no longer only "potential" areas of expansion. As new roads are built, development is taking place at an ever-increasing rate. Much of this development occurs without appropriate pasture and soil management technology, resulting in land abandonment, soil erosion, and unstable farming systems with low productivity. Extensive native pasture-based beef production is the most widespread land use in the region. Well-managed, adapted, productive, and persistent grass/legume pastures not only improve cattle productivity but also provide excellent protection against soil erosion and improve soil fertility through nitrogen fixation and nutrient recycling by plants and grazing animals. On the other hand, poorly managed, nonadapted pastures can be disastrous, especially on more sloping sites.

The Latin American humid tropics are exposed to intensive deforestation as a result of socioeconomic pressures emanating from surrounding poor and overpopulated regions (colonization of the Amazon by Andean settlers), or geopolitically motivated subsidies from governments in their efforts to occupy these vast territories (Brazilian Amazon).

Timber, shifting cultivation, and cattle are the main exploitation and farming systems developed in these regions. It is estimated that, at present, the cattle population of the Amazon is more than 8 million heads. These herds are important sources of food and income for settlers in farming systems ranging from mixed (agriculture-cattle-fallow) to extensive cattle ranching.

Cattle production systems in the area are generally characterized by degradation of traditional pastures (such as *Panicum maximum* and *Hyparrhenia rufa)* into weedy or low productivity swards. Although, at establishment, these pastures can take advantage of the relatively high soil fertility available immediately after the clearing and burning of forest, they rapidly degrade as the soils degrade with the leaching of nutrients and chemical fixation by clay particles, resulting in low levels of fertility and high acidity to which traditional pastures cannot adapt. Traditional pastures also lack resistance to pests and diseases. Such degraded pastures have such low productivity that they are neither economically nor ecologically justifiable.

New technologies based on adapted, nitrogen-fixing, high-cover, and high-productivity pastures are being developed by the Program, in cooperation with national programs, in Pucallpa (Peru), and are expected to be utilized for the reclamation of degraded lands. These improved, highly productive, and sustainable pastures are expected to make efficient use of already disturbed forest areas, thus reducing the pressure to clear additional virgin forests.

Expanding the land resources base. In addition to its ecological implications, pasture-based beef production can serve as a catalyst for settling the Oxisol/Ultisol regions, primarily because the initial infrastructure investment required is much lower than for crop production. The development of well-managed pastures increases the value of the land. When roads provide improved access to market, it becomes more profitable to intensify the farm operation by devoting part of the land to crop production. Well-managed, well-adapted, legume-based pastures that increase nitrogen and organic matter levels in the soils may reduce the fertilizer requirements for crops in rotation with pastures, providing for a more productive and socially efficient land-use alternative. Intercropping annual or perennial crops with pastures is also a feasible and efficient alternative. Therefore, beef operations can serve as a wedge to develop this important resource base and open the way for integrated agricultural development. Furthermore, increases in beef production in Oxisol/Ultisol regions permit alternative uses of better soils located closer to markets which should be used for more intensive crop production. This is particularly the case in Central America where cattle production is taking place in small-size, mixed farming systems on acid and moderately acid soils.

Program Objectives

The objective of the Tropical Pastures Program is to develop and transfer, together with national programs, improved, low-input pasture technology in the acid, infertile lowlands of the humid and subhumid tropics, with the principal responsibility being for tropical America. The aim is to increase beef and milk production, conserve and improve soil resources of tropical ecosystems, and provide a basis for an economically and ecologically sound utilization of underexploited land resources.

Program Strategies

The Program's research team is organized into three functional groups: germplasm evaluation (including

sections for germplasm, agronomy, plant pathology, entomology, and breeding); pasture evaluation (including sections for soil plant nutrition and microbiology, ecophysiology, pasture development, pasture quality and production); and pasture evaluation in production systems (including sections for seed production, farming systems, and economics). These three units coordinate their work to ensure a dynamic flow of germplasm in which characterization of germplasm screening by ecosystems, assembly of appropriate pasture production technology, and economic evaluation of new pasture technology in farm systems constitute major research areas. While thousands of germplasm entries are worked with during the initial phases of the flow of germplasm through the Program activities, only very few highly promising germplasm materials succeed in being selected for the assembly of pasture technologies and further evaluations.

The Program exploits the natural variability of germplasm to identify grass and legume species adapted to the various ecosystems in the region. Germplasm is assembled from a wide range of conditions throughout the acid infertile soil regions of tropical America as well as Southeast Asia and Africa. At present, the CIAT germplasm bank contains some 18,000 accessions. This germplasm is screened for tolerance to high soil aluminum and acidity, low phosphorus availability, and tolerance to diseases and insects. Ecotypes which pass this first screening are characterized in terms of tolerance to drought, flooding, burning, grazing, minimum nutrient requirements, nutritive value, and compatibility in grass/legume mixtures. Subsequently, pastures based on highly promising ecotypes are assembled, relevant establishment technology is developed, and cattle liveweight gains are measured. The most promising pasture combinations undergo long-term productivity and economic evaluation, and the respective technological packages are further adapted to the requirements of the predominant farm system in the area. Finally, the improved technology is evaluated in economic terms. This entire research process is carried out in close collaboration with national programs throughout the area of interest.

To date the four main screening sites, which represent major ecosystems, are:

The Carimagua Research Station in the Eastern Plains of Colombia, jointly administered with the Colombian Agricultural Research Institute (ICA), and representing the isohyperthermic savannas, including the "Llanos" of Colombia and Venezuela and the "campos" of northern Brazil (Amapá and Roraima Territories).

The Brazilian Agricultural Center for the Cerrados (CPAC) of EMBRAPA in the central cerrado plateau, near Brasilia. This center represents the isothermic savannas of the continent, including the "Cerrados" of Brazil and well-drained savanna areas of Bolivia and Paraguay.

The Cattle Production Research Station of the Veterinary Institute for Tropical and High-Altitude Research (IVITA), at Pucallpa, Peru, where CIAT participates in a cooperative project to develop low-input pasture technology for the reclamation of already degraded lands in the humid tropics of the continent. CIAT's partners in this project are IVITA and the Peruvian National Institute for Agricultural Research and Promotion (INIPA).

Three sites in Costa Rica (operated in coordination with CATIE and the Ministry of Agriculture of Costa Rica), covering the moderately acid soils and semi-intensive double-purpose farming systems.

The International Tropical Pastures Evaluation Network (RIEPT) has been developed in cooperation with national programs to evaluate promising germplasm in sites which represent subecosystems in the Llanos, the Cerrados, the humid tropics (including the poorly drained savannas), and moderately acid soils. This allows the Program, in collaboration with national programs, to test germplasm throughout the area of interest and to evaluate the adaptation and productivity of promising germplasm to the different ecosystems and subecosystems in the lowlands of tropical America. The information obtained through this evaluation network is recorded in computerized data banks which allow for effective analyses of germplasm performance across locations. Periodically, participants of the network are brought together in workshops to discuss alternative methodologies for germplasm evaluation and to exchange data recorded in different regional trials. These network activities allow for a high degree of feedback which assists in moving germplasm significantly faster to more advanced stages of evaluation under grazing for eventual release by national programs.

Status of the Program

The Tropical Pastures Program is well on its way to developing, in collaboration with national programs,

low-input pasture production technology that has the potential to intensify the pioneer animal production system in the vast frontier lands of tropical Latin America. Available research results confirm the soundness of the Program's strategy to develop legume-based pasture technology that rests on germplasm adapted to specific ecosystems.

The availability of alternative viable techniques is expected to contribute to the gradual recovery of several million hectares that are at present in different stages of degradation throughout the humid tropics in Latin America and the Caribbean. In 1987 the Program was able to decentralize further by establishing a major screening site in Central America. Staffed by a CIAT agronomist, this screening site is designed for the selection of germplasm adapted to the predominant moderately acid soils and semi-intensive double-purpose farming systems (beef and milk) in the region. This project is carried out in coordination with CATIE and the Ministry of Agriculture of Costa Rica (that is, Atenas, characterized by a subhumid climate; Guapiles, in the rainforest; and San Isidro, in an area of semi-evergreen seasonal forest).

As germplasm moves into more advanced stages of evaluation under grazing in the different countries, more frequent visits are required to assist national programs in designing, analyzing, and interpreting trial results, as well as in coordinating the required backup from Program specialists. This is more efficiently and economically done by outposted personnel in charge of regional network activities than by scientists stationed at headquarters. This implies decentralization of the network activities of the Program. The plan is to develop four parallel networks in: Central America and the Caribbean; the Llanos ecosystem in Colombia, Venezuela, and northern Brazil; the humid tropics ecosystem in Colombia, Ecuador, Brazil, and Peru; and the Cerrados ecosystem in Brazil, Paraguay, and Bolivia. The agronomists responsible for screening in the respective ecosystems are assuming these regional network responsibilities. This is allowing the Program to significantly accelerate technology transfer and to reinforce the work of national programs. These regional networks are critical for horizontal transfer of technology among national programs operating in the respective regions and to bring about economies of scale through networking of formerly isolated efforts.

The Program has progressed to the stage where several genera and species have already been identified as being well adapted to conditions of one or more of the ecosystems of interest. These genera and species include *Andropogon gayanus, Brachiaria* spp., *Panicum maximum, Arachis* spp., *Stylosanthes* spp., *Desmodium* spp., *Pueraria phaseoloides,* and *Centrosema* spp.

The potential productivity of a large number of pasture-grazing alternatives in the savanna ecosystem has been determined. Various grass/legume associations in controlled grazing, low-input experiments, have produced annual liveweight gains per animal of more than 180 kg. On a per hectare basis some associations have produced more than 300 kg per year.

As part of the regional trials network there are, at present, more than 200 germplasm adaptation and grazing trials in selected sites of Latin America and the Caribbean. Several germplasm sets have also been sent to requesting institutions from Asia and Africa. The most promising germplasm is already moving into grazing trials in several Central and South American countries, as part of RIEPT, with partial support from the Canadian International Development Research Centre (IDRC).

Data obtained from regional trials in the humid tropics have shown that a large number of grass and legume species selected by the Program are highly productive in this ecosystem with acid infertile soils. These are showing promise for replacing the present commercially available species which become unproductive 4-5 years after forest clearing.

The highly promising *Andropogon gayanus* CIAT 621, released by Colombia as cv. Carimagua 1 and by Brazil as cv. Planaltina, has also been released by Venezuela as cv. Sabanero, by Peru as cv. San Martin, by Panama as cv. Veranero, and nominated for seed multiplication and farmers' use in Cuba. The adoption of *A. gayanus* in the central Cerrados of Brazil is rapidly accelerating. It is estimated that more than 250,000 ha have already been planted to this species in Brazil. In Colombia, about 30,000 ha have been established.

Since the release of *A. gayanus* in Colombia the Program has put considerable emphasis on the development of a companion legume for this grass. This has been achieved for the Llanos with anthracnose-resistant *Stylosanthes capitata* CIAT 10280, which has been released by Colombia as cv. Capica, a blend of five ecotypes. The seed of this legume is now being multiplied for commercial plantings. Similarly, as a result of the collaboration between CIAT and IVITA in Peru, the latter has released *S. guianensis* CIAT 184 cv. Pucallpa for the Peruvian humid tropics.

Achievements of the Program

(See Tropical Pastures Program section under "Summary of Achievements", p. 5-6).

Special Projects

Role of pastures in mixed farming systems in the western Amazonia

The purpose of this outposted position is to study the role of pastures in mixed farming systems in the western Amazonia. The project is financed by the Rockefeller Foundation.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	25	25
Honoraria, stipends, and allowances	-	-
Supplies and services	3	3
Travel	-	-
Equipment replacement and capital	-	-
Indirect costs		-
Contingencies	-	-
Subtotal	28	28

Farmer participation in technology design and transfer

(See under "Special Projects" in Bean Program section, p. 20).

Germplasm collection for beans, cassava, and tropical pastures

(See under "Special Projects" in Genetic Resources Unit section, p. 53).

Legume germplasm

(See under "Special Projects" in Genetic Resources Unit section, p. 53-54).

Specialized information centers

(See under "Special Projects" in Communication and Information Support Unit section, p. 77-78).

RESEARCH SUPPORT

Visiting Scientists and Postdoctoral Fellows

Core Resources

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	-	-	-
Honoraria, stipends, and allowances	486	639	639
Supplies and services	-	-	-
Travel	-	-	-
Equipment replacement	-	-	-
Contingency	-	-	-
Subtotal	486	639	639
Support units[a]	-	-	(639)
Total	486	639	-

a. Resources allocated to other programs.

Program Commentary

This section includes all funds for visiting scientists and postdoctoral fellows.

Visiting scientists

The Center seeks to attract outstanding scientists working in research institutions in developed and developing countries to spend short (six to twelve months) periods at CIAT to contribute, in their areas of specialization, to the objectives of CIAT's research or research support programs. In a large number of cases, visiting scientists spend time at CIAT as part of a sabbatical leave arrangement whereby CIAT provides additional support as necessary.

Senior research fellows

CIAT has made provisions to provide for intermediate positions between postdoctoral fellows and regular senior staff. Senior research fellows normally are appointed on a fixed-term basis; employment conditions are approximately in line with those provided to postdoctoral fellows, with provisions made to recognize the additional experience of Senior Research Fellows.

Postdoctoral fellows

Most postdoctoral fellows are contracted in support of research activities. Contracts are for one year and extendable to a maximum of three years. A small portion of postdoctoral fellowships is reserved for postdoctoral fellows from cooperating countries who stay at CIAT for short periods before returning to institutions in their home country.

Visiting scientist funds provide for about 7 man-years. Senior Research Fellow and Postdoctoral funds provide for 9 man-years.

Genetic Resources Unit

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Head of GRU	1	1	1	1	1	-	-	-	-	-	6	6	6	6	6
Germplasm processing	-	-	-	-	-	3	3	3	3	3	18	17	17	17	17
Seed health	-	-	-	-	-	1	1	1	1	1	2	2	2	2	2
Total	1	1	1	1	1	4	4	4	4	4	26	25	25	25	25

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	267	299	299
Honoraria, stipends, and allowances	-	-	-
Supplies and services	56	75	75
Travel	10	27	27
Equipment replacement	-	5	5
Contingency	-	-	5
Subtotal	333	406	411
Support units[a]	-	-	71
Price provision	-	-	17
Total	333	406	499

a. Resource allocation from support units to the Genetic Resources Unit.

1988 Budget request for Genetic Resources Unit.

Activity	Amount (1988 US$ in thousands)
Germplasm	
Research on conservation and diversity	36.6
Collection	45.6
Conservation, characterization, and documentation	281.7
Enhancement	9.9
International trials (distribution and exchange)	11.4
Seed production	5.3
Plant protection research	36.5
Human resource enhancement	
Specialized courses (short term)	19.6
Individualized internships	11.9
Documentation and dissemination	11.1
Counselling and advising NARS	14.8
Technical assistance	14.8
Total	499.2

Program Commentary

The objective of the Genetic Resources Unit is to provide suitable germplasm for crop improvement. In the short term the most important function of the Unit is to supply germplasm to CIAT programs and to fulfill requests from agricultural researchers throughout the world. The long-term function is the maintenance of genetic variability, which is rapidly being lost on the fields of farmers, for use in the distant future.

At present, the major activities of the Unit are concentrated on *Phaseolus* beans for which CIAT has the largest collection and, more important, the most extensive of germplasm in the world. The Unit also maintains the pasture seed collection and germplasm data base for the CIAT pasture program, but the collection and mosto of the seed multiplication of this germplasm are the responsility of CIAT's Tropical Pastures Program. At present, the handling of cassava germplasm is outside the responsibility of the Unit, but

plans have been made to transfer cassavagermplasm handling, including an extended tissue culture facility, to the Unit.

The most effective storage of *Phaseolus* bean and pasture germplasm is in the form of seed, dried to a low-moisture content, and placed in cold storage. The present storage consists of three cold rooms:

One medium-term store of 150 m^3 kept at 8 °C with a capacity for 42,000 samples;

One medium-term store of 35 m^3 kept at 8 °C with a capacity for 20,000 samples;

One long-term store of 35 m^3 kept at -15 °C with a capacity for 16,000 samples.

These cold stores are almost 10 years old and are obsolescent. New storage has been planned, with a greatly increased capacity under technically improved conditions. Construction began in early 1987. This should greatly reduce the need for expensive field rejuvenation, and maintain the viability of the samples.

The collection of *Phaseolus* in Latin America, previously funded by the IBPGR, is now funded by CIAT. There still remains an unexpectedly large diversity of landraces not previously represented at CIAT. This indicates that, for some areas, interesting landraces still exist and that there is a need for further collection. Special emphasis on collecting wild relatives of beans has produced seed of 12 species not previously known from living collections. Introduction from existing collections continued, with special emphasis being placed on existing European and African collections. Intensive collecting in Africa, a secondary center of diversity for beans, is planned for 1988.

A previous bottleneck in the introduction of germplasm was the need for third-country quarantine for African *Phaseolus*. An agreement with the National Vegetable Research Station in England has allowed the rapid processing of many hundreds of samples. This is now particularly important as Africa has become an important target area for the Bean Program and African material is needed for breeding.

An agreement with the Brazilian National Germplasm Center (CENARGEN) has been reached, covering the duplication of the entire CIAT *Phaseolus* collection. This duplicate is being placed in long-term storage by CENARGEN for security and will remain CIAT property. A similar agreement for storage of unique CIAT collections of beans has been signed with CATIE, Costa Rica.

Data handling for *Phaseolus* was improved by the introduction of a new data management system. This will allow a closer linking of information from the Bean Program and from the Unit. Direct access to the U.S. Department of Agriculture germplasm data base (GRIN) has been negotiated. The IBPGR World Data Base for *Phaseolus* has been made available to CIAT this year.

To fulfill its international obligations to distribute disease-free seed, CIAT has expanded its Seed Health Laboratory within the Unit, where a variety of tests for pathogenic fungi, bacteria, and viruses can be carried out on outgoing seed samples.

Seed distribution continued with G 709 germplasm samples of beans and 2211 samples of pasture species being distributed internationally in 1986. Much larger quantities were passed to the respective CIAT programs.

The location at CIAT of an IBPGR liaison officer for Latin America continues and has permitted the strengthening of collaboration with IBPGR, especially in collection of *Phaseolus*, and training, with four trainees from national germplasm programs passing through the GRU in 1986.

A Belgian associate expert attached to the GRU is responsible for investigating interspecific crossing in *Phaseolus* and evaluating the potential of *Phaseolus coccineus* x *P. polyanthus* (in cooperation with the University of Gembloux, Belgium).

A new survey, also by a Belgian expert began on *Phaseolus lunatus*, a species of high potential for hotter areas.

Achievements

The Genetic Resources Unit was established to conserve plant germplasm for the future use of CIAT Programs. Germplasm within the responsibility of the GRU includes *Phaseolus* beans and tropical pastures species. Routine germplasm management begins with surveys of the germplasm needs of programs. Targeted collecting in many countries of the world produces samples which are introduced to Colombia through quarantine and multiplied to provide sufficient seed for storage, evaluation, and distribution. Although established to service CIAT programs, the GRU has taken on an additional role in supplying germplasm to agricultural researchers in national programs worldwide.

The free supply of germplasm by the International Agricultural Research Centers is a considerable and continuing achievement. Centers provide the only international source of germplasm of the crops and pasture species of most importance to developing countries. Center collections are often the only source of duplicate material of samples lost during national storage. In 1986 CIAT returned the national bean collection to Iran and arranged to return 500 samples collected in Spain and not in the Spanish national collection. Twenty-three countries received bean germplasm and twenty-two pasture germplasm.

Germplasm has been directly distributed to CIAT programs in Africa—for example, 1100 samples of beans were sent to Ethiopia for evaluation. These samples represented a wide range of bean types. Information on types performing well will enable more examples of these types to be included in later trials—this provides a method of sampling, in trials of a reasonable size, the great range of diversity in the CIAT collections.

Special emphasis was placed on collecting wild relatives of beans. Living material of twelve species was collected for the first time. These increasingly provide useful genetic traits to increase the range of characters available to bean breeders. Taxonomic and biochemical investigation of wild *Phaseolus*, which is already under way, is expected to throw light both on the origins of bean cultivation and the potential for the further use of wild species in future breeding programs.

Planning was completed for a large extension of cold storage facilities, mainly to supply secure long-term storage for CIAT collections. A tissue culture laboratory was included in the planned building to allow a transfer of the cassava tissue culture collection from the Biotechnology Research Unit to the GRU.

Agreements have now been signed with EMBRAPA/CENARGEN, in Brazil, and CATIE, in Costa Rica, for duplicate storage of CIAT germplasm collections. The GRU has placed considerable emphasis on growing out samples of beans and tropical pasture species for rejuvenation before long-term storage both at CIAT and (for beans) as duplicate collections in these other institutes.

The work of both importing and exporting germplasm was smoothed as a result of an ICA quarantine officer being posted at CIAT. The Seed Health Laboratory has continued to develop techniques for recognizing seed-borne disease of all crops handled by CIAT and is now used for the routine inspection of outgoing trails. Tissue culture samples of African grasses have successfully been introduced in quantity, and the third-country quarantine facility for beans from Africa, located in England, had its first full season of operation, handling 600 samples.

Special projects within the GRU include seed multiplication and evaluation of *Phaseolus coccineus* and of *P. lunatus*. The former of these, which included crossing with *P. vulgaris*, has reached a successful advanced stage with the distribution of international trials. The latter has just started, and is producing useful information on the potential of beans for hotter regions.

Special Projects

Germplasm collection for beans, cassava, and tropical pastures

This project involves the: (a) analysis of available plant genetic resources data for *Phaseolus vulgaris* cultivated and wild forms in Latin America; (b) transformation of existing cassava collections in Brazil, Guatemala, Mexico, and Paraguay into in vitro cultures for transportation to CIAT to be stored in cassava germplasm collection and to be utilized in crop improvement; and (c) collection of tropical forage species in Indonesia. This project is supported by IBPGR.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel (1 senior scientist)	9	9
Honoraria, stipends, and allowances	5	5
Supplies and services	7	7
Travel	10	10
Equipment replacement and capital	-	-
Indirect costs	-	-
Contingencies	6	6
Subtotal	37	37

Legume germplasm

This project is carried out in coordination with the University of Gembloux, Belgium. It includes: (a) research on interspecific hybridization of *Phaseolus vulgaris* and *P. coccineus*, including a complete evalua-

tion and characterization of the latter; (b) characterization of the existing *P. lunatus* collection and drawing up recommendations in relation to further germplasm collection activities in species; and (c) consultation by Belgian experts with CIAT staff on taxonomic problems related to forage legume species collection at CIAT. This special project is financed by the Belgian government.

Biotechnology Research Unit

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Biotechnology research	1	1	1	1	1	4	4	4	4	4	9	8	8	8	8
Virology	-	1	2	2	2	-	2	5	5	5	-	4	10	10	10
Total	1	2	3	3	3	4	6	9	9	9	9	12	18	18	18

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	172	280	434
Honoraria, stipends, and allowances	-	-	-
Supplies and services	34	43	61
Travel	11	18	27
Equipment replacement	37	6	10
Contingency	-	-	5
Subtotal	254	347	537
Support units[a]	-	-	70
Price provision	-	-	18
Total	254	347	625

a. Resource allocation from support units to the Biotechnology Research Unit.

Program Commentary

In view of potentially becoming an important user of the emerging technologies, CIAT anticipated its involvement in monitoring and applying biotechnological tools in its long-term plan in 1981. The second EPR of CIAT in 1984 recommended the establishment of an interdisciplinary research structure comprising those disciplines that would interact increasingly with all commodity programs. CIAT responded with the creation in 1985 of the Biotechnology Research Unit devoted the the emerging field of plant biotechnology, and included the Central Virology Laboratory.

Plant Biotechnology

Objectives

The work of the Plant Biotechnology section is complementary to that of the commodity programs.

1988 Budget request for Biotechnology Research Unit.

Activity	Amount (1988 US$ in thousands)
Germplasm	
Research on conservation and diversity	27.1
Collection	13.9
Conservation, characterization, and documentation	45.2
Enhancement	13.9
Plant breeding and improvement	31.3
International trials (distribution and exchange)	18.1
Plant protection research	141.7
Human resource enhancement	
Specialized courses (short term)	31.3
Individualized internships	42.3
Conferences and seminars	31.3
Documentation and dissemination	32.7
Research on approaches, concepts methodologies, and procedures	43.0
Counselling and advising NARS	13.2
Technical assistance	12.5
Coordination of networks	36.1
Exploratory research	91.8
Total	625.4

Hence, the research activities are based on program needs and priorities and are actively supported by the commodity programs. In addition, it is the section's responsibility to keep abreast of new techniques and advise the commodity programs on potential applications. Thus, the Plant Biotechnology is charged with the following two functions:

To develop techniques as a direct response to needs expressed by the commodity programs on problems which escape solution through conventional means, or would better be handled by using biotechnology.

To conduct exploratory research to make the programs aware of new technologies which may be applicable to CIAT crops.

Achievements

The activities of Plant Biotechnology in the last two years included the following areas: (a) routine utilization of tissue culture techniques for germplasm management of cassava and tropical grass pastures such as in vitro conservation and exchange, and disease elimination; (b) development of electrophoretic techniques for genotyping cassava, beans, and tropical legume pastures; (c) collaboration with the Rice Program in developing anther culture techniques for obtaining rapid homocygocity and their use in rice breeding; (d) exploratory research to develop plant regeneration techniques in cassava and beans, to evaluate somaclonal variability in *Stylosanthes guianensis* plants regenerated from callus cultures, and to evaluate a wide-crossing technique using protoplast fusion of *Stylosanthes* spp.

Other activities of Plant Biotechnology involve the monitoring of agricultural biotechnology research in institutions of developed and developing countries. As a result, collaborative efforts for applying molecular techniques to construct a genetic linkage map in *Phaseolus* beans, and for developing gene vector techniques in cassava have been initiated. Also, a study on the current situation and perspectives of agricultural biotechnology in Latin America and the Caribbean was conducted in 1986 in order to provide a basis for discussion by the directors of national agricultural programs.

In 1986, 165 cassava clones were cleaned from frogskin disease and another 350 clones were also cleaned as a preventive measure. The cleaning technique consists in using thermotherapy and meristem-tip culture. Elimination of four cassava viral diseases (FSD, CsXV, CCMV, and CMD) was demonstrated by indexing techniques. Elite clones were shipped in vitro to nine countries in Latin America and Southeast Asia. Two hundred and twenty-eight cassava clones from Southeast Asia, Peru, and Africa were introduced to CIAT using in vitro techniques. A simple in vitro technique for field collection of germplasm was developed for cassava. The amount of cassava germplasm maintained in the in vitro gene bank increased this year to over 3000 clones, which constitutes 72% of the entire CIAT collection.

In vitro embryo germination was used to recover plants from wild and aboriginal *Phaseolus* crosses with very poor germination and scarce seed availability.

Using in vitro techniques, over 300 pasture grass accessions, mostly *Brachiaria*, were distributed from CIAT to Brazil and Peru.

In a collaborative project with the University of Manitoba, Canada, isozyme/protein electrophoretic techniques have been developed to characterize cassava, *Phaseolus vulgaris*, and legume pastures (*Centrosema, Desmodium,* and *Stylosanthes*). These techniques were tested with accessions which were morphologically similar, or which presented problems due to mixture or taxonomic classification. The techniques had already proved useful in the elimination of duplicates from the cassava germplasm collection.

Cassava plants regenerated by somatic embryogenesis were transplanted to the field for evaluation. Plants displayed characters of juvenility and, in one variety, a few clones showed variation in electrophoretic pattern of an isozyme system. It was found that cassava somatic embryos originate from many cells of the embryogenic tissue which in turn develops from immature foliar segments. This finding may be relevant to the genotypic stability of regenerated plants.

Cells of suspension and callus cultures of *Stylosanthes guianensis* showed cytogenetic variation. Cells with polyploid and aneuploid chromosome number were found. Among regenerated plants, the frequency of tetraploid plants increased up to 25% when the cultures were maintained in the callus stage for up to 90 days. Variability in plant vigor, flowering, and seed production, and reaction to anthracnose were detected in the field in the progenies of regenerated diploid and tetraploid plants. Some unusual phenotypes were displayed within particular clones, such as plants with bifoliated leaves, chlorophyll-deficient plants, and bushy plants. The potential usefulness of this technique will be further assessed.

Preliminary evidence was shown on wide-crossing by protoplast fusion between *S. guianensis* with *S. capitata* or *S. macrocephala*. Putative somatic hybrid plants have been transplanted to soil for further morphological and genetic evaluations.

Central Virology Laboratory

The first virology position at CIAT was created in 1978 for the Bean Program. This position demanded a considerable investment in special equipment. In 1981, a Postdoctoral Fellow was incorporated into the Cassava Program to investigate the virus diseases of cassava in Latin America. This second virologist was able to conduct the necessary laboratory research thanks to the existence of the Bean Virology Laboratory. Since 1981, however, the Cassava Program has been contributing to the improvement of the virology facilities at CIAT. By 1983, the Rice Program had to face a serious virus threat in Latin America and, thus, rice virus research was initiated at CIAT with the available resources. One year later it became obvious that the promising forage germplasm collected by the Tropical Pastures Program was also being affected by viruses. Therefore, in response to the increasing demand from all four commodity programs at CIAT for specialized plan virus research, a Central Virology Laboratory (CVL) was created in 1984 and was attached to the Biotechnology Research Unit.

Objectives

The rationale behind the creation of the Central Virology Laboratory was to centralize the costly and specialized equipment necessary to conduct virology research and accommodate the research personnel working in this area for the four commodity programs.

Highlights

The Laboratory is adequately equipped to perform the critical steps of virus isolation and characterization. Among the basic equipment available the laboratory has low- and high-speed centrifuges, spectrophotometer, density gradient fractionator, diverse electrophoresis equipment and gel scanners, ion-exchange columns, a cold room, and fume hoods for toxic and radioactive materials. For immunology there is an animal-rearing facility, the basic equipment for production of polyclonal antisera, and ELISA equipment, including an ELISA reader. The laboratory houses a JEOL 100-SX electron microscope, evaporator and an ultramicrotome for cytological work. Additionally, there is a laboratory specially equipped to handle radioactive materials for use in nucleic acid hybridization tests based on complementary-DNA technology. Also available is a dark room for electron microscopy film processing, and autoradiography, with photographic equipment and a transilluminator for nucleic acid analyses. All necessary chemicals and reagents are imported or purchased locally.

Virology research at CIAT has already made several contributions to the overall efforts of the four research programs. For instance, all improved bean germplasm now being released is resistant to common mosaic (except for virus-free areas), and effective control measures are being implemented to counteract the serious yield losses inflicted by whitefly-transmitted geminiviruses. For cassava, various diagnostic techniques have been implemented to free valuable germ-

plasm of viruses. In rice, a complete characterization of the causal virus of rice hoja blanca disease, led to the development of an efficient screening methodology. In the case of forage legumes, preliminary work has demonstrated the economic and phytosanitary importance of viruses in this highly promising germplasm.

Future developments

It is expected that with the creation of a second senior staff position (to replace the existing Senior Research Fellow position of the Cassava Program) the Central Virology Laboratory will be able to meet the increasing virus research needs at CIAT. The establishment of collaborative research projects with advanced virology institutions abroad is a promising avenue to exploit the new technology developed in the field of biotechnology and molecular virology. This new technology has very practical applications at CIAT to improve its research efforts.

Special Projects

In vitro active gene bank

The objective of this project is to assess and demonstrate the technical and logistical aspects of establishing and running an in vitro active gene bank to agreed standards, using cassava clones. Monitoring activities for viability and stability of source plans and cultures at various storage periods are also included. This project is supported by IBPGR.

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel (1 Postdoctoral Fellow)	53	53
Honoraria, stipends, and allowances	-	-
Supplies and services	7	7
Travel	-	-
Equipment replacement and capital	-	-
Indirect costs	-	-
Contingencies	-	-
Subtotal	60	60

Research Services

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Food quality and nutrition	-	-	-	-	-	1	1	1	1	1	-	-	-	-	-
Laboratories	-	-	-	-	-	1	1	1	1	1	14	14	14	14	14
Greenhouses	-	-	-	-	-	1	1	1	1	1	3	3	3	3	3
Maintenance	-	-	-	-	-	1	1	1	1	1	1	2	2	2	2
Total	-	-	-	-	-	4	4	4	4	4	18	19	19	19	19

Direct costs (1987 US$ thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	190	181	181
Honoraria, stipends, and allowances	-	-	-
Supplies and services	93	83	83
Travel	2	1	1
Equipment replacement	33	2	2
Contingency	-	-	-
Subtotal	318	267	267
Support units[a]	-	-	(267)
Total	318	267	-

a. Resources allocated to other programs.

Program Commentary

The Laboratory Services Unit is under the control and supervision of the Research Services Committee and provides the following services:

Routine analyses of soil, plant tissue, water, and fertilizer samples submitted by program scientists for research purposes;

Routine quality evaluation and consumer acceptance of CIAT's commodities, especially beans and cassava;

Maintenance and repair of all CIAT laboratory instruments and equipment, and coordination of the use of laboratory facilities;

Control, washing, and sterilization of glassware used by pathology and microbiology programs;

Management and maintenance of CIAT's greenhouses, screenhouses, and growth rooms, including soil storage and sterilization facilities; and

Maintenance of colonies of small animals such as rabbits and mice.

In the recent past, these activities were supervised on a part-time basis by various senior staff members who were part of the Research Services Committee. With the addition of a senior staff position in 1988, the supervision of these activities can be provided on a more systematic basis. The senior staff will also provide administrative leadership to the Biotechnology Research Unit and the Virology Laboratories.

Station Operations

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Station operations	1	1	1	1	1	1	1	1	1	1	28	28	28	28	28
Popayán	-	-	-	-	-	1	1	1	1	1	5	5	5	5	5
Quilichao	-	-	-	-	-	2	2	2	2	2	20	20	20	20	20
Santa Rosa (Meta)	-	-	-	-	-	1	1	1	1	1	6	4	4	4	4
Tractor pool	-	-	-	-	-	-	-	-	-	-	4	4	4	4	4
Labor pool	-	-	-	-	-	-	-	-	-	-	21	21	21	21	21
Total	1	1	1	1	1	5	5	5	5	5	84	82	82	82	82

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	579	559	559
Honoraria, stipends, and allowances	-	-	-
Supplies and services	301	194	194
Travel	7	6	6
Equipment replacement	96	8	8
Contingency	-	-	-
Subtotal	983	767	767
Support units[a]	-	-	(767)
Total	983	767	-

a. Resources allocated to other programs.

Program Commentary

The Station Operations Unit provides logistics support for the land use of the research programs. The Unit is in charge of agricultural machinery, land preparation, planting, irrigation, field work, and harvesting at headquarters in Palmira, and at the three substations in Quilichao, Popayán, and Santa Rosa (Villavicencio). The Unit is also in overall charge of the general upkeep and maintenance of the experimental fields, and of the continous upgrading of the experimental sites in the four locations. In addition, the Unit is in charge of commercial seed production (rice, beans, tropical pastures) and commercial crop production (sorghum, maize, beans, and cassava) on experiment station land that is temporarily not utilized for research purposes.

The Unit is in charge of the management, repair, and maintenance of the farm machinery in all CIAT stations as well as the vehicles used in Quilichao, Popayán, and Santa Rosa.

Carimagua Station

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Support unit	-	-	-	-	-	-	-	-	-	-	1	2	2	2	2
Administration	-	-	-	-	-	2	4	4	4	4	5	4	4	4	4
Total	-	-	-	-	-	2	4	4	4	4	6	6	6	6	6

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	71	143	143
Honoraria, stipends, and allowances	-	-	-
Supplies and services	219	190	190
Travel	15	35	35
Equipment replacement	69	-	-
Others	221	227	227
Contingency	-	-	-
Subtotal	595	595	595
Support units[a]	-	-	(595)
Total	595	595	-

a. Resources allocated to other programs.

Program Commentary

The Carimagua Research Station is located 350 kilometers east of Villavicencio, near the Meta-Vichada border, at latitude 4°30' N, and longitude 71°30' W in the Eastern Plains of Colombia. Carimagua's climate, soil, vegetation, and topographic conditions are typical of one of the greatest land resources in the world that is just beginning to be exploited—the tropical American savannas, which comprise 300 million hectares.

In 1969 ICA purchased 22,000 hectares of land, and field work was initiated in early 1970. In February 1977 an agreement was signed between ICA and CIAT for the development of a cooperative research program in the Eastern Plains. Under the terms of the agreement, an advisory committee composed of three ICA managers and three CIAT senior staff members is responsible for coordinating and directing operations of the station.

Costs of this research station are shared equally by ICA and CIAT. The budget shown is for CIAT's share of the cost of personnel, supplies and services, and travel costs.

Data Services

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Statistical and computing services	1	1	1	1	1	9	10	10	10	10	9	9	9	9	9
Total	1	1	1	1	1	9	10	10	10	10	9	9	9	9	9

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	309	340	340
Honoraria, stipends, and allowances	-	-	-
Supplies and services	125	164	164
Travel	10	9	9
Equipment replacement	20	6	6
Contingency	-	-	-
Subtotal	464	519	519
Support units[a]	-	-	(519)
Total	464	519	-

a. Resources allocated to other programs.

Program Commentary

The Data Services Unit provides advice, training, and assistance in all mathematical, statistical, and computational aspects of the work of the scientific programs of CIAT. The Unit has two sections, Biometrics and Computing, whose functions and responsibilities are detailed below.

Biometrics Section

The functions and responsibilities of this Section are:

To provide statistical advice on all aspects of CIAT's work, including planning, data collection, analysis, and interpretation.

To keep abreast with current developments in statistical methodology by internal and external education, and utilize and develop such techniques for the betterment of agricultural research at CIAT.

To provide a statistical computing service.

To carry out collaborative research with other workers with the aim of producing joint scientific publications.

To provide advice and assistance and engage in collaborative research work on operational research topics, such as simulation mathematical programming and decision theory.

To provide training in statistical methods both for staff within CIAT and for CIAT program courses.

Computing Section

The functions and responsibilities of this Section are:

To provide and maintain appropriate computer hardware for the scientific and associated programs at CIAT;

To provide and maintain appropriate computer software for the scientific and associated programs at CIAT;

To provide adequate documentation of all software and hardware;

To investigate all aspects of work at CIAT which might benefit from computerization;

To keep abreast with current developments in computing;

To carry out collaborative research;

To write suites of programs of general applicability;

To ensure sufficient training is obtained within and outside the section; and

To provide the hardware and software to build and maintain scientific data bases and ensure that these are accessible to the appropriate range of personnel within a commodity network.

An IBM 4331 Group 1 computer with one megabyte of real memory was installed at the end of 1981. During 1983 the machine was upgraded to a Group 2 and a further megabyte of memory was added. Early in 1984 the real memory was increased to the maximum for the machine, namely four megabytes. Administrative work was moved to an IBM System 36 purchased in 1983.

During 1985 the CPU was upgraded to 4361 Group 5 and real memory increased to six megabytes. The machine currently has a mip rating of 1.3, about six times its original rating as a 4331 Group 1. At present IBM has no further upgrade path other than a potential memory of 16 megabytes. In 1986, a further disk unit was attached, faster tapes were purchased to replace the 8808s and a work station adapter was purchased to facilitate the connection of more terminals and microcomputers.

The present configuration of the 4361 is as follows:

1 4361 Group 5 CPU with 6 megabyte real memory
4 3370 Fixed Disks Units in 2 strings with a totai of 2.4 gigabytes
1 3262 Line Printer rated 650 lines per minute
1 5210 Letter Quality printer rated 60 characters per second
1 Communication Adaptor with 6 lines
1 Work Station Adaptor
1 Calcomp Model 965 Plotter with 909 Controller
2 3430 Magnetic Tape Units 1600/6250 bpi 312 kbyte per second
3 Cluster Controllers type 3276
26 Displays type 3278 including Operator Consoles
19 IBM PC Microcomputers connected as 3278s.

The machine runs under the operating system VM/CMS. Installed data base software includes the products IDMS/R (Cullinet Software, Inc. Westwood, Massachusetts, USA), ISIS (IDRC Canada), and STAIRS (IBM). Statistical and Mathematical packages include SAS (SAS Institute, Raleigh, North Carolina, USA), GENSTAT, GLIM, and NAG Library (Numerical Algorithm Group, Oxford, England), and MINOS (Stanford University, California, USA).

There are 80 registered users of the 4361 and the system is running at about 50% of the capacity of the upgraded CPU. IDMS data base systems have been written and are currently in use in the four major CIAT programs and a collaborators' Mailing List System has been provided for the Communication and Information Support Unit and Research Programs. These systems continue to be developed in the Computing Section. In spite of the increase in data base activities, statistical processing by the Biometrics Section of the Unit still takes a considerable (30-35) percentage of the computing resources.

To facilitate the interchange of information the Computing Section publishes a newsletter and there is a Users' Group made up of representatives of the programs and staff of the Data Services Unit.

Status of Program

During the last two years much has been done to improve and streamline the mainframe and linked microcomputing network and improve both the Biometric and Computing Service for the commodity programs.

The major software development task of the Computing Section has been the setting up of a data base for the commodity programs on the mainframe IBM 4361 computer, using Cullinet's Integrated Database Management System (IDMS/R). Although the original Cullinet product was a CODASYL network system, some relational features have been built into the software, hence the extension /R. The relational part of the system was used to develop the CIAT Directory of Collaborators (some 15,000 entries). This list is used by CISU on a routine basis and, in addition, program users can join this centrally maintained data base to their own, usually more detailed, supplementary base of information about their own program collaborators.

The Bean Program network schema was first produced some three years ago, but is now integrated with the Cassava and Agroecological schemas. In due course the Pastures schema should also be integrated into this overall schema. With the exception of the Rice Program, all CIAT's breeding records are now stored in the IDMS data base and can be accessed online by IDMS Dialogs or programs. All the Bean, Pastures, and Cassava germplasm accessions are also in the data base, although some Genetic Resources passport data still has to be entered. Data from series of evaluation experiments have already been entered into IDMS and the structure exists for any other experiments. The Agroecology climate data base has now been loaded into IDMS, and the structure for the cassava microregions has now been designed. Dialogs and programs for accessing the data have been converted from the original Fortran code. Data base areas currently allocated amount to some 500 megabytes and will be increased when disk space is available.

A new software product currently being developed at SAS Institute will interface data from the IDMS data base with SAS programs for statistical analysis. This should prove to be very useful both to the Data Services workers and to users in the commodity programs as it will integrate the efficient storage/retrieval facilities of IDMS with the comprehensive statistical features of SAS.

Agroecological Studies

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Agrometeorology	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4
Total	1	1	1	1	1	1	3	3	3	3	4	4	4	4	4

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	131	143	143
Honoraria, stipends, and allowances	-	-	-
Supplies and services	12	11	11
Travel	12	13	13
Equipment replacement	-	3	3
Contingency	-	-	2
Subtotal	155	170	172
Support units[a]	-	-	66
Price provision	-	-	7
Total	155	170	245

a. Resource allocation from support units to the Agroecological Studies Unit.

1988 Budget request for Agroecological Studies Unit.

Activity	Amount (1988 US$ in thousands)
Agroclimatology research	166.7
Crop-livestock systems research	44.1
Documentation and dissemination	9.8
Economic and social analysis at microlevel	24.5
Total	245.1

Program Commentary

One of the most important underlying reasons for agroecological analysis is that crop and pasture improvement for less-favored areas and their wider diversity of production constraints imposes severe problems on new technology design, development, and transfer. Less-favored production zones, that is, most nonirrigated areas in the tropics with a wide range of soil constraints and insect and disease pressures, are the main targets of CIAT research. The rate of progress in genetic improvement of any species is generally inversely proportional to the number of constraints to be overcome through new genetic variability. It is clear that accurate information on the relevant constraints in each zone is essential at all stages of increasing production and productivity of basic food commodities in the tropics. This need is even more critical in the small-farm situation since the environmental conditions on farms in this sector—particularly those in Latin America—are generally more severe and constraints are more varied than in the case of the large-farm sector. Given the great diversity of prevailing climates, soils, cropping systems, and socioeconomic conditions, the need for an inventory of production conditions in the small-farm sector is pressing.

Objectives for Agroecosystems Analysis

Some general areas have been identified that represent common needs across CIAT programs with respect to agroecosystem information for the areas of interest in each commodity. These needs are reflected in the following objectives:

> To develop a system for environmental and socioeconomic assessment of introduction constraints in the production areas of present or

future importance in each CIAT commodity. Such assessment will allow for a more accurate definition of research priorities, and therefore of allocation of research resources among the wide range of alternatives available for action.

To develop an agroecological information system which can be integrated with the germplasm development process. This improved process will provide for a more cost-effective and efficient operation of the cooperative germplasm transfer and evaluation programs with collaborating national institutions. The objective is essentially to reduce the burden on national institutions imposed by testing all germplasm in all locations.

To develop a data system which will permit the evaluation of responses of new genetic variability when exposed to a wide range of selected conditions in terms of meteorological, edaphic, and agronomic factors. One example would be crop/weather relations in international nurseries and in other experiments.

To develop a data system which will provide a firm base for comparative socioeconomic studies on the wide diversity of production zones. This system will enable both *ex ante* and *ex post* assessments of the impact of new technology, in particular within the small-farm sector, so that the research process can be further focused on real needs. In addition, the data system would provide a medium in which to assess economically the development priorities for underutilized frontier lands and to analyze marketing and associated economic constraints to increased production and productivity.

Research Strategy

A computer-based information system designed for the needs of four ecologically divergent commodity programs must be flexible in order that the degree of detail and scale provided is appropriate in each case. In addition, the collection of data, and its storage, retrieval, and analysis, must be at a level of definition appropriate to the resources available. In other words, CIAT could not implement a massive new survey involving a great deal of field work. Accordingly, a methodology has been developed which relies on prior surveys, census information, and local knowledge of the situation in each zone. Information is gained on an opportunistic basis by CIAT personnel during duty travel and from the large number of visiting scientists and trainees from the region who visit CIAT. In this way, a cost-effective collection system has been developed which appears sufficiently accurate. Any attempt at a more detailed approach would probably be frustrated by lack of accurate local data.

Progress of Agroecosystem Analysis in Commodity Programs

The following examples illustrate some of the work completed and planned in the various programs.

Tropical Pastures. The study on the South American lowlands[1] has enabled a classification of the major ecosystems making up the Program's area of interest. Aggregation of the land system units within each major ecosystem has permitted a quantitative assessment of the natural resources available in each ecosystem. The basic philosophy of the Program outlined in this plan revolves around this classification.

With the expansion of the mandate of the pastures program to include the moderately acid soils of Central America and the Caribbean, the study needs extending. of ecosystems need refining to cover the much more varied environments of the new mandate region. This is now underway and an extensive data collecting mission is due to start in April 1987.

Coincident with this survey, the overall land system data will be loaded into the recently developed target area data base and will then form the CIAT-wide soils and land-form information base for all programs.

Beans. The Program has been considerably aided by early studies in defining research priorities and strategies and in the location of its primary sites for the first two stages of the germplasm evaluation program.

These early analyses are now overshadowed by the potential for climatic analysis from the climate data base of over 10,000 recorded stations from Africa and Latin America. These data are being used to produce maps of climatic similarity to assist the team in selecting sites for the African network and in comparing these sites with known areas in Latin America. As in the case of the soils data, this data base, started for a specific commodity program, is now available for all the CIAT commodity programs.

1. Cochrane, T. T.; Sánchez, L. G.; de Azevedo, L. G.; Porras, J. A.; and Garver, C. L. 1986. Land in tropical America: computer summary and soil profile descriptions of the land systems. CIAT, Cali, Colombia, and EMBRAPA-CPAC, Planaltina, Brazil.

The inventory of African and Latin American bean production is now well under way. Maps are being produced at the scale of 1:5,000,000. Following the methodology devised for the cassava studies, these will be used in the next stage of environmental characterization and microregion definition.

Rice. During the last year the data base has been used to produce two important reports for the Rice Program: an evaluation of possible rice-producing areas in the Bolivian savannas, and a mapping of the areas suitable for the new savanna rice varieties being produced at the La Libertad station. This provides an example of the power of using the joint target area data base.

Cassava. Major advances have been made in the analysis of the cassava program target area. A comprehensive classification of cassava environments has been produced from the initial 1:5,000,000 scale mapping of cassava production in Latin America. This is, at present, being used to classify potential cassava-growing environments in Africa, and will be of great assistance to the forthcoming collaboration between CIAT and IITA.

The climate section of the data base has found considerable application, particularly in the production of maps of climate homologues to guide the collection of cassava pest predators in Latin America for subsequent release to specific zones within Africa.

Great strides have been made in the development of a methodology for microregion definition. The north coast of Colombia, eastern Paraguay, and the central coast of Ecuador were chosen as test cases and to provide valuable information to the Cassava Program. A method, using secondary data, informal survey, and semistructured rapid rural survey techniques was found to give excellent results[2]. This gives hope that large areas of the target area may be characterized in relatively little time.

2. Carter, S. E. 1986. Cassava micro-regions in part of eastern Paraguay: an explanation of their form and comparative study of cassava production within some of them. Agroecological Studies Unit, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

Seed Unit

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Seed specialists	2	2	2	2	2	6	6	7	7	7	8	11	11	11	11
Total	2	2	2	2	2	6	6	7	7	7	8	11	11	11	11

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	402	367	367
Honoraria, stipends, and allowances	-	-	-
Supplies and services	80	80	80
Travel	55	37	37
Equipment replacement	-	3	3
Contingency	-	-	5
Subtotal	537	487	492
Support units[a]	-	-	69
Price provision	-	-	14
Total	537	487	575

a. Resource allocation from support units to the Seed Unit.

1988 Budget request for the Seed Unit.

Activity	Amount (1988 US$ in thousands)
Germplasm	
Research on conservation and diversity	1.7
Collection	1.1
Seed production	34.7
Machinery research and development	11.6
Human resource enhancement	
Specialized courses (short term)	86.7
Individualized internships	46.2
Conferences and seminars	92.4
Documentation and dissemination	52.0
Counselling and advising NARS	40.4
Technical assistance	80.9
Coordination of networks	92.4
Economic and social analysis at microlevel	5.8
Market analysis	11.6
Policy analysis	11.6
Conversion and utilization research	11.6
Total	580.7

Program Commentary

The need for a Seed Unit at CIAT grew out of two different problem contexts. First, the CIAT commodity programs—beans, rice, tropical pastures, and cassava—have reached a stage of development where a centralized support service for the production, conditioning, and distribution of breeder and basic seed represents the most rational and obvious route for the streamlining of seed-related activities at the Center. Second, the flow of new materials emanating from CIAT's research programs was hampered by the fact that in many Latin American and Caribbean countries there was only an incipient seed industry at the national level and which needed determined and systematic assistance from the international level to accelerate development. Regarding the latter point, CIAT was an obvious choice for the location of an international input in the development of national seed programs. In addition, CIAT was concerned about a need for a stronger seed sector in Latin America and the Caribbean that is capable of delivering seed of improved materials to the producer level. The Center had available the necessary conditions for hosting a successful seed effort: physical facilities for basic seed production, an extensive training infrastructure, expertise on seed-related aspects, and an international mode of operation.

The first phase of the Seed Unit special project, financed by the SDC, was for the three-year period, January 1979 to December 1981. The second phase was for the period, January 1982 to December 1983. During the third phase, 1984-86, the Unit continued as a restricted core activity with SDC support. The 1987-88 period continues with approximately two-thirds of the support from the SDC and the remainder from the core budget.

To date, the objectives of the Seed Unit at CIAT have been:

To train personnel in government and private institutions, primarily from Latin American and Caribbean countries, in various aspects of seed industry and seed program development.

To extend technical collaboration to countries in the region interested in seed program development, with the aim of expanding the production of high quality seed of improved cultivars at all levels from the breeder to the commercial stage, with emphasis on, but not restricted to, the commodities with which CIAT works.

To conduct specific research in seed technology which is relevant to CIAT commodity interests and relevant to problems that collaborators at the national level are faced with.

To provide CIAT with a single unit to cooperate with commodity programs in multiplying, processing, storing, and distributing advanced experimental materials, or Breeder and Basic Seed, to collaborating countries for further multiplication.

To disseminate information on seed activities, advances in seed technology, and the availability of promising materials in the region.

The project includes two internationally recruited scientists with a full complement of support services, resources for consultants and visiting scientists, plus scholarship monies for postgraduate interns. Also included in the initial project were resources for the remodelling of existing buildings and for the construction of additional facilities for the operation of seed-related activities (seed conditioning, storage, laboratory spaces for training purposes, and office/working spaces for staff of the Seed Unit).

During the period 1979 to the present, the Unit has mainly concentrated its efforts on:

Training. A combination of intensive seed production and seed technology courses, advanced short courses, individualized in service training, and M.Sc. thesis research opportunities are offered. In the period 1979-86, some 576 professionals have received CIAT-based training by the Seed Unit. In addition, the Seed Unit is supporting incountry training courses in the areas of seed production and seed technology.

Workshops. The Seed Unit organizes and conducts an average of one workshop per year to provide a forum for professionals with similar interests to exchange experiences and to work together in developing plans, recommendations, and fresh approaches to help seed activities advance more rapidly.

Technical collaboration. Assistance to seed programs, industries, and associations contribute to developments at the national level. Subregional activities in Central America and the Andean Zone have reinforced seed network developments.

Seed production and supply. The Seed Unit has supported the CIAT commodity research program—especially rice, beans, and tropical pastures—with the production, drying, conditioning, and supply of basic seed of promising materials and already released varieties.

Research. A limited research input in the area of seeds is provided by the Seed Unit primarily through M.Sc. thesis programs.

Communication and information. The preparation and dissemination of technical publications, workshop proceedings, and audiotutorial units have spread seed technology and production information in the region. In addition, a newsletter every four months improves communications on developments in the region and contributes to the strengthening of the seed network.

Status of the Seed Unit. The emphasis by the Seed Unit on training has resulted in 20 courses of different levels and specialization at CIAT over the past eight years, involving 532 participants. Seed technology and production training provided by the Seed Unit at the subregional and incountry level has involved a further 893 people. The challenge during the next five years is to capitalize on this base of trained people.

The seed sector involves public and private activities, ranging from the crop research programs to the seed enterprises and marketing groups that sell seed to farmers. Successful national seed programs are those that develop clear goals and strategies and identify mechanisms to help all segments of the sector develop and work together. A recent survey showed that one-fourth of former course participants have contributed in a special way to seed program development at the national level. In the future increased follow-up is needed with these people to help them, other leaders in the seed sector, and their governments, to focus more sharply on solutions that can help overcome limitations restricting the production and use of improved varieties by farmers. The Seed Unit continues to focus on ways to assist, especially small farmers, to grow and use better seed of improved varieties. As a result of Seed Unit activities, many national programs are directing more attention to the seed needs of small farmers.

Significant differences exist among the countries in the region with respect to development of their seed programs. The countries with the greatest need are in Central America, the Caribbean, and the member countries of JUNAC (also known as Grupo Andino). Mechanisms are being sought to provide special assistance to these subregions through outreach programs linked to the Seed Unit to help accelerate the development of seed programs and industries in these areas.

The basic seed production activities of the Seed Unit are helping to improve the availability of seed for further multiplication. This need is felt most acutely with tropical pastures seed. Increased effort is needed on systems for cassava-propagation material. At the national level, better organized and functional basic seed units are needed in many countries to strengthen the link between the crop research program and the rest of the seed multiplication and supply chain. Helping this aspect of national programs to become more dynamic and effective remains a priority with the Seed Unit.

Seed production and technology research in the region is largely done in a few universities with special interest in seeds. The Seed Unit's research role mostly has been limited to the work done by a few research scholars involved in degree programs. The Unit has a comparative advantage for a few high-priority areas of special interest to the CIAT commodity programs and sister centers. Opportunities exist to assist the development of collaborative research network in the region to solve region-wide problems. A workshop held in 1985 started joint thinking on priority areas of research for the region. The follow-up to proposals by that workshop can result in more work on high-priority areas and increased cooperation among researchers in the region.

The Seed Unit provides the mechanism for continued communication among seed programs and seed scientists in the region. The continued improvement of the newsletter, the frequent updating of the "Directory of Seed Personnel and Institutions", development of a seed science and technology data base focused on the needs of the region and subregion, and regional courses will continue this network development process.

Donor and technical assistance agencies will need to continue assisting seed programs in the region for at least another decade. Through the knowledge accumulated and country status reports, the Seed Unit is in an excellent position to work closely with these agencies in developing projects and supporting their implementation. Similarly, links with CIAT's sister international centers with program interests in the region will be strengthened. As seed units are started in other parts of the world, mechanisms are needed, and will be sought, to collaborate fully with them in their development and program implementation.

The Future of the CIAT Seed Unit

Based on an indepth study by a team of consultants in early 1987, CIAT developed a medium-term plan for the Seed Unit for the period 1988-92. The essential features of this Board-approved plan are as follows:

Objective

The Seed Unit's objective is to assist the Center's work in contributing to increased food production and resource productivity in Latin America and the Caribbean region. The Unit is to foster and assist, in close coordination with CIAT's and other IARC commodity programs, the prompt and sustained development of national seed production and supply systems and policies. This should allow the rapid adoption of improved varieties as they are released by the national programs.

The above objective involves a set of specific objectives to be pursued, fostered, and supported by the Unit in close coordination with CIAT's commodity programs and with CIMMYT's Maize Program. This set of specific objectives is as follows:

To identify and diagnose seed systems-related constraints to the adoption of improved varieties of beans, rice, cassava, tropical pastures, and maize at the country level.

To develop and implement national seed production plans for the specific commodities, which should include appropriate policies, as well as functional and technical solutions for seed systems and seed quality-related constraints.

To study the seed systems (and their components) that have proven to be effective in servicing small-farm groups.

To identify and/or develop appropriate technology for small-scale production, conditioning, storage, and marketing of seeds within major ecosystems, particularly for humid and tropical conditions.

To strengthen seed-training capabilities in countries of the region.

In collaboration with CIP, to work with the Latin American potato network by providing assistance in organizational aspects of seed-production schemes for small producers.

To establish and support seed research and technical collaboration networks that address specific problems common to various countries and crops in such areas as seed systems for small farmers, seed policy, seed legislation, and seed trade.

Research and cooperation strategies

In line with CIAT's commodity programs, the Unit's research and cooperation strategy takes the form of two complementary and coordinated approaches: the country-and-commodity approach, and the regional network approach.

The country-and-commodity approach. The removal of seed system-related constraints to adoption of improved varieties should explicitly take into account the specific political and institutional environments, as well as the socioeconomic production circumstances, on a crop-by-crop and a country-by-country basis. The essential catalyst for involvement by CIAT in these specific country activities will, of course, be the availability of onfarm-proven seed-based technology. The identification and solution of the most relevant seed production, processing, and marketing problems require well-defined interfaces among those research institutions producing breeder and basic seed; enterprises dealing with certified and commercial seed, and their production, processing, and marketing; and the extension system which advises farmers on appropriate crop management practices.

The Seed Unit will, in conjunction with the respective commodity research programs, help catalyze national seed plans for the respective commodities. These plans should specify clear goals, strategies, and policies. They should include well-defined roles and responsibilities for the different public institutions and the private sector, forming a functional and integrated system that will effectively link research, extension, and the seed sector.

Moreover, the Seed Unit will, in close coordination with the respective commodity program, support the implementation and monitoring of such plans through research, technical consultation, and a targeted training program. A highly focused training program is needed in order to achieve the required minimum of well-trained professionals within each of the institutions and enterprises participating in the implementation of the respective national plans. The Unit will assign priority for admission to its regular seed production and seed technology courses to groups of professionals from these institutions in order to assist in the prompt takeoff of the program. As the training needs are expected to be far beyond the Unit's capacity, the majority of the professionals will need to be trained in incountry courses. The Unit and the respective commodity program will assist in the initial organization and development of these courses.

Although the major focus is along commodity lines, the Unit will be alert and responsive to possibilities of integrating efforts on seed systems development for other crops if this be feasible and cost-effective. This could be particularly important for achieving economies of scale in the case of: systems servicing small-farm groups; those institutions that have basic seed units and seed certification systems; and / or enterprises such as producers' cooperatives and organizations and seed processing and marketing enterprises.

The regional network approach. A complementary approach to that of providing direct support to seed system development of individual countries is that of fostering the development and support of regional and subregional seed research and technical collaboration networks. Such networks can be synergistic and increase the effectiveness of individual country programs when addressing problems that are common to the participating countries. By focusing on common researchable problems, for example, seed drying and storage under humid tropical conditions and seed systems for small farmers, members of research networks can profit from the experience and the comparative advantages of participating institutions, scientists, and seed technologists.

To be successful, these networks must be able to bring together the different disciplines relevant for tackling a given problem. When problems are crop specific, the Seed Unit will foster the integration of interested seed specialists and key institutions in existing commodity networks in order to prevent duplication of efforts. When the problems to be addressed are not crop specific, the Unit will promote full integration in the respective network of researchers and extensionists that face these problems in the various crops with which they work.

Because of the need to focus the Unit's activities sharply on the most relevant regional seed system-related constraints to the adoption of improved varieties, only a few key networks will be sponsored in the medium term.

Activities planned

In order to implement the aforementioned strategies, the Seed Unit will need to carry out a series of

activities that will be described in detail in two-yearly rolling work plans to be reviewed one year in advance by the Seed Advisory Committee.

Research on seed technology. Research on seed technology will concentrate, along commodity lines, on the most important technical constraints. It will be carried out in close coordination with the respective commodity programs and, in the case of beans, cassava, and maize, will emphasize technology for small-scale operations. Emphasis will be also placed on appropriate technology for tropical and humid environments—a neglected area in many crops. The general areas of research include:

Identification of critical seed-related constraints hampering the adoption of improved varieties such as high cost of seed, low quality seed, seed-borne diseases, and their potential technical solutions.

Technology for seed production in the field, such as techniques to overcome field deterioration during maturation and red-rice control in the field.

Seed drying, conditioning, and storage technology, for example, low-cost drying methods and storage techniques, small-scale quality upgrading treatments, and field and commercial techniques for conditioning seed of tropical pastures species.

Quality testing and effects of seed quality on crop yield such as devising simple low-cost tests to determine moisture viability, purity and germination testing procedures for tropical pasture species, and effect of seed quality, that is, germination and vigor, on yielding ability of new plants.

Research on organization of seed systems. This area of research includes the identification, analysis, and documentation of:

Organizational constraints to effective performance of seed systems such as seed policy, seed legislation, absence of institutional linkages, excessive controls, and lack of incentives to the private sector.

Case studies of successful experiences on seed program development, for example, organization of seed systems servicing small countries or small farmers effectively.

Support for the development of national seed production plans. The primary objective of this type of activity is to facilitate the buildup of effective national seed systems for the respective crops. This will require an initial diagnosis mission, followed by planning missions that may take from two to six weeks per country and involve staff from the Unit, from the commodity programs and, eventually, from management to address selected questions at the institutional and policy level. CIAT should be prepared to assist in the implementation of these plans by offering training opportunities, providing assistance for the conduct of incountry courses, making regular consultation visits, and providing backup research.

Training in seed technology. The scarcity of well-trained personnel in the different areas of seed technology is the principal limitation in most institutions and countries. Targeting all training activities to the achievement of the Unit's specific objectives is vital to the success of the regional crop networks. The Unit, in conjunction with the commodity programs, will organize advanced, specialized, and intensive seed technology courses on: basic seed production; seed drying, conditioning, and storage; organization and management of commercial and small-scale seed production; distribution and marketing of seeds; and seed quality. Staff from the Unit and the commodity programs will be prepared to support the initial organization and development of incountry seed courses. The actual number of courses will be specified in the two-yearly rolling work plans.

In order to achieve this objective, there must be increased opportunities for inservice training of professionals as trainers for incountry courses and for implementing the national commodity seed plans. The expanded research on seed technology (in relation to key constraints) and the organization of seed systems for small-farm groups can be achieved more efficiently through expanded thesis research opportunities than by staff appointments. Such theses will be jointly supervised by staff from the Unit, the respective commodity program, and the thesis supervisor from the respective university. This will also permit increased collaboration with the two universities in the region that offer M.Sc.-level degrees on seed production and technology. It is expected that, in terms of cost, the increase in inservice and thesis research training will be offset by the reduction in fellowships required for intensive courses at CIAT.

Production of breeder and basic seed. CIAT's commodity programs normally make available small quantities of breeder seed to national programs. Basic seed production is the responsibility of national programs. Strong seed units at the national level are critical to ensure the maintenance and availability of

pure, healthy, basic seed for further multiplication. When basic seed units are in their initial development stages, national programs often request the assistance of CIAT in making available moderate quantities of basic seed to accelerate the initial multiplication phases. Similarly, small countries are rarely able to mount the required physical facilities. In both cases, upon specific requests by the respective national programs and provided that no impediments to domestic basic seed production are created, the Seed Unit will produce and sell the requested amount on a full-cost recovery basis.

Support of regional seed research networks. CIAT will support the development of regional seed research networks by means of: (a) collaborative research conducted by the Unit and the respective commodity programs; (b) training opportunities in relevant research areas; (c) sponsoring of workshops to discuss research results of and coordinatation among network participants; and (d) providing appropriate specialized information and communication services. In addition to these essential activities, a considerable amount of the Seed Unit staff time and secretarial support is required to help catalyze network activities and goals.

Only a few networks with specific objectives will be sponsored in the medium term. These will be identified during 1987 with the assistance of the proposed Seed Advisory Committee.

Seed workshops and seminars. Workshops and seminars are highly valuable for: (a) focusing attention on seed-related research issues, establishing priorities, and defining interinstitutional collaboration; (b) consulting on seed program strategies and selected issues with national counterparts; and (c) discussing issues of direct interest to the seed sector, but which may be less relevant for achieving the objectives specified for the Seed Unit. While CIAT is prepared to host the last activity (c), the Center will sponsor only the first two types. Consultation workshops (b) will be held approximately every three years, while network workshops (a) will be held on a yearly basis, if necessary. The two-yearly rolling work plans will include details on the specific objectives and funding requirements for each event.

Seed documentation and information services. The packaging and dissemination of the scientific and technical information on seeds, generated by the seed networks and by the Seed Unit and commodity programs, are essential to accomplish the stated objectives. In designing and developing the materials, CIAT makes a distinction between three purposes: (a) network publications, (b) scientific and technical publications, and (c) training materials.

Seed network publications include a seed newsletter, proceedings of the workshops of the networks, compendiums of research results, and methodological manuals developed by network participants. These complementary mechanisms are all important to keep members abreast of new technical developments, upcoming events, and relevant research and development results from the network and elsewhere.

The development of technical publications is highly relevant in achieving the Unit's objectives. Such publications include monographs on artisanal bean-, cassava-, or maize-seed systems; a seed glossary; a simple test to determine moisture and viability; and survey and sampling techniques to assess the quality of the seed used by small farmers.

Relevant didactic training materials, including seed manuals and integrated training packages such as audiotutorials on specific topics, methods, or techniques, have proven to be highly effective in facilitating incountry and regional courses, thereby permitting the Unit to reach a much larger audience of trainees. As in the case of the commodity programs, the Seed Unit will be able to rely on CIAT's Communication and Information Support Unit for the production and distribution of all the aforementioned publications and training materials.

Seed Advisory Committee

One of the major features of the Seed Unit is the formal implementation of a Seed Advisory Committee. With seed being the vehicle of new technology into specific growing environments, seed systems relate to all disciplines and fields from agricultural research to production. The rationale for proposing the creation of the Advisory Committee is to benefit from a wider group of disciplines and expertise than those that could be made available within the Unit.

Staffing and financial requirements

In order to achieve the stated objectives, the Seed Unit will require acertain minimum of highly qualified, internationally recruited, principal staff and locally hired support staff.

It is proposed to maintain the number of senior staff at the current level (two positions), but to increase the number of postdoctoral and senior research fellows from one to two man-years, starting in 1988.

At the level of support staff, it is proposed to add a Research Associate position for the specific purpose of assisting the Cassava Program in resolving bottlenecks related to the production and dissemination of cassava planting material. This position will play a principal role in the setting up of pilot cassava seed projects, in the evalution and modification of such projects, and in the use of these projects as training programs. These activities will be an integral part of many of the integrated cassava development projects in which CIAT's Cassava Program will be involved.

INTERNATIONAL COOPERATION

Training and Conferences

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Training and conferences	1	1	1	1	1	10	11	11	11	11	9	9	10	10	10
Total	1	1	1	1	1	10	11	11	11	11	9	9	10	10	10

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	392	388	388
Honoraria, stipends, and allowances	747	594	740
Supplies and services	114	109	109
Travel	229	161	161
Equipment replacement	-	8	8
Contingency	-	-	14
Subtotal	1482	1260	1420
Support units[a]	-	-	76
Price provision	-	-	46
Total	1482	1260	1542

a. Resource allocation from support units to Training and Conferences.

1988 Budget request for Training and Conferences.

Activity	Amount (1988 US$ in thousands)
Human resource enhancement	
Specialized courses (short term)	590.7
Individualized internships	550.7
Conferences and seminars	350.3
Documentation and dissemination	15.6
Technical assistance	9.8
Coordination of networks	24.6
Total	1541.7

Program Commentary

In previous years a shift in training activities from at-the-Center course to incountry and regional courses was foreseen. At the same time, emphasis on individualized specialization internships of national research program personnel was to be maintained at high levels, and degree thesis training was to receive relatively higher priority. These forecasts were fulfilled with one exception: due to the continuing strong demand for at-CIAT courses expressed by national agricultural research systems, this activity was maintained in addition to increased incountry training.

Conferences, through their various communication and training functions, continued to constitute a fundamental means of linking CIAT with the national programs. Two types of results of the overall training and conferences activities are visible: the strengthening of national agricultural research and development capacities related to CIAT commodities; and the better articulation of and, therefore more productive, agricultural knowledge systems which comprise both national and international components.

Achievements

During 1986, 10 courses were held at CIAT and 24 in Latin American countries. In the former, 206 participants accumulated a total of 254 man-months and 614 professionals participated in incountry courses. A total of 157 professionals spent 421 man-months in individualized specialization internships at CIAT, and 16 carried out postgraduate thesis projects. Nearly 400 persons participated in 10 conferences organized partially or completely by CIAT and another 500 participated in one major seminar.

These figures illustrate the size of the training and conferences effort. The effectiveness has been assessed in the past by external reviewers as being commendable. Since then, further progress has been made in the continuing effort of tailoring the training opportunities to the needs of national programs and in selecting the participants accordingly. With regard to satisfying these needs, it is pertinent to mention that the 24 incountry courses were organized by national institutions and received CIAT support along three main lines: course design, resource persons, and training materials.

In keeping with the aim of bridging the gap between research and extension, the participants were largely professionals engaged in technology transfer and development activities. A series of special courses held at CIAT complemented the response of CIAT to the expressed needs of national programs to strengthen their capacity to get CIAT technology to the farmers. The continuing need to strengthen the research capacity was addressed by means of the more traditional multidisciplinary courses and through the individualized specializations, as well as with degree thesis work.

Communication and Information Support Unit

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Editor/Writing	1	1	1	1	1	2	2	2	2	2	1	1	1	1	1
Editor/Publications	1	1	1	1	1	5	5	6	6	6	2	2	2	2	2
Training materials	-	-	-	-	-	3	5	6	6	6	2	2	2	2	2
Distribut. and marketing	-	-	-	-	-	1	1	1	1	1	2	3	3	3	3
Graphic Arts Production	-	-	-	-	-	4	4	4	4	4	26	25	25	25	25
Unit Head and Info. Serv.	1	1	1	1	1	9	9	9	9	9	21	19	19	19	19
Total	3	3	3	3	3	24	26	28	28	28	54	52	52	52	52

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	896	1004	1004
Honoraria, stipends, and allowances	-	-	-
Supplies and services	459	364	364
Travel	23	33	33
Equipment replacement	32	21	21
Contingency	-	-	10
Subtotal	1410	1422	1432
Support units[a]	-	-	(335)
Price provision	-	-	33
Total	1410	1422	1130

a. Resources allocated to other programs.

1988 Budget request for Communication and Information Support Unit.

Activity	Amount (1988 US$ in thousands)
Human resource enhancement	
Specialized courses (short term)	79.4
Individualized internships	38.5
Conferences and seminars	7.1
Documentation and dissemination	926.8
Research on approaches, concepts, methodologies, and procedures	5.4
Coordination of networks	72.9
Economic and social analysis at microlevel	0.1
Total	1130.2

Program Commentary

Communication strategies

The Communication and Information Support Unit makes agricultural information from all over the world readily accessible to the Center's staff and to its national program collaborators in the commodity research networks. The Unit also supports all of the Center's communication efforts with publications, training materials, graphic arts, and audiovisual materials.

CIAT presently employs four communication strategies in support of increased production and productivity in the area of its four mandated crops. They can be summarized as follows:

Communication is used to catalyze collaboration and to increase and reinforce networking among research groups working in CIAT's commodity areas and sharing similar objectives.

Educational and informative materials are used to disseminate the technologies that are developed through collaborative research and the new methodologies for conducting research. The materials are also to reinforce the research network's capacity to conduct research, through training its new members.

Members of the network are kept informed and up to date about relevant technologies being developed outside the network through information retrieval and delivery systems.

Communication is also used to inform administrators and policymakers about the work of the research networks, to keep them aware of its importance, and to show them the value of supporting agricultural research.

CIAT's communication strategies, which define both audience and purpose for each product and stress an integrated approach to information and communication, result from close collaboration between the commodity support programs and scientific support units and CISU. Specialists in agricultural education, information transfer, communication, and development and production of materials in various media work together as a multidisciplinary team to implement the strategies that are designed and provide CIAT and collaborating scientists with top quality communication and information support.

Training materials

Training support materials emphasize the mastery of concepts related to specific training objectives. Depending on the objectives and course design, key topics may be presented in manuals, study guides, technical sheets, video segments, or filmstrips; or, if the message requires it, a complete, self-contained audiotutorial unit may be produced. The materials are designed to teach research methodology, develop practical skills, and foster attitudes that facilitate technology transfer.

Research monographs and journal articles

Scientific reports of basic and applied research on production constraints and methodologies for their solution are most often published as journal articles, technical bulletins, or research monographs. The Unit provides full editorial and production services for those that are published within CIAT, and assists scientists, especially those for whom English is a second or third language, in the preparation of journal articles and other research publications.

Promoting networking

One of the most important communication strategies of CIAT is that of promoting collaborative research and the sharing of research results among the members of the commodity research networks in which the Center's scientists participate, through various kinds of publications. Commodity newsletters contain short research briefs on new research and production technology that has been developed at any of the sites in the networks, as well as book reviews, conference announcements, and news of and interviews with people working within the research networks. Annual program reports provide an indepth, yearly progress report on every area of CIAT research. The reports are working documents written in technical language. Conference proceedings are often generated when the members of the networks convene. Some of the proceedings are developed as research monographs, and others are published as working documents that preserve a permanent record of the plans and accomplishments of a whole group of collaborators under one publication.

Reporting the Center's activities

CIAT Report is a full-color annual publication that highlights CIAT research for the previous year and communicates the Center's activities and achievements in a popular style. The report is written in Spanish and English.

CIAT International, a trimestral newsletter, is devoted to keeping decision makers and other CIAT contacts informed on program developments at CIAT and national program efforts toward new production and research methodology and utilization of germplasm. This popular bulletin is produced in both Spanish and English.

Other publications and the broadcast media are also useful mechanisms for keeping CIAT's audiences informed. Press releases, interviews, and general interest articles, are usually produced by specialists in the specific media involved working closely with CIAT writers to get the latest research news to a broad sector of audiences.

Specialized information services

An important factor in the success of the research networks is having access to the scientific literature produced in other institutions across the tropics and throughout the world. CIAT believes this to be of such priority and importance that a very complete library and information service unit exists to serve this need, not only for CIAT staff, but for national program researchers as well.

The Library contains some 43,000 volumes, specialized collections containing 25,000 documents and 150 audiovisual materials, and a fast-growing microfiche collection that is supported by portable readers and a fiche-to-paper photocopying system. A current awareness service (**Pages of Contents**) helps users, especially those outside the Center, to keep up to date with the most current research. Retrospective bibliography files are produced by the Library to assist staff with specific information needs.

Three specialized Information Centers collect, abstract, and systematically file the scientific literature on three of CIAT's commodities (common beans, cassava, and tropical pastures). Searches in CIAT's own computerized data base provide references to the world's scientific literature on these commodities. A complete document delivery service allows the user to access the full text of each article. Online searches of major data bases can be conducted to allow the user to obtain information outside the commodity-specific collections.

Specialized bibliographies are produced by both Library and Information Centers staff. Fact sheets, directories, translations, reference volumes, and other such products are also generated and produced by the Information Centers.

Information networks help to support the research networks, and CIAT is an active participant in several: SNICA, AGRINTER, AGLINET, and AGRIS. They promote networking at national, regional, and international levels. A new communication network, RICA, is also being actively supported by CISU.

Marketing and distribution

Increasing attention to delivery systems is ensuring that CIAT's publications, training materials, and information services reach an ever wider audience of researchers, extension workers, agribusiness managers, students, and professors in both tropical and temperate areas. Professional booksellers make CIAT publications available in countries where CIAT's own distribution systems are least strong. Specialized catalogs supplement the general catalogs and CIAT bibliographies that list and index the entire production of publications and training materials. A computerized data base of collaborators and information users supports multilevel distribution and marketing efforts.

Computerized inventory control enables CISU staff to study user demand for different kinds of materials. Evaluations of specific products are conducted from time to time to obtain feedback from the users themselves.

Highlights of the year's activities

All of the areas were highly productive during 1986, meeting increasingly complex demands with an increasing level of success. Gains in productivity can be seen in many areas, for the fifth consecutive year (recording of statistical data began in 1982).

The appearance of CIAT's communication and information products is always improving. The Publications/Editorial Section and the Graphic Arts Section worked closely together during 1986 to produce new designs and to improve existing designs for CIAT's major publications. A new CIAT logo and letterhead were also produced.

Additionally, there was a notable increment in the number of media reached with news of CIAT and its research results. Stories about the success of new varieties and technologies that resulted from research carried out by commodity networks have appeared in the press, in magazines and scientific journals, and on the radio in Latin America, the Caribbean, USA, and Europe.

Some new directions were begun in the area of training materials. Two experimental videos were undertaken, and while these are not programmed to result in finished teaching films, they have been very useful to the scientific staff as a way of documenting the use of technologies developed in collaborative research programs. They were useful to the CISU staff as a method of learning more about a media that may be useful in future training strategies.

A second major literature recovery project—this time for African cassava literature and economic and production data—was undertaken. The project, involving collaboration with IITA, is also a new initiative for the group. Two consultants will be travelling to twelve countries to ask for the cooperation of the national institutions in providing research publications to the Cassava Information Center, maps to the Agroecological Unit, and economic data to the IITA-CIAT team of economists.

Computerization continued to influence procedures in most of the sections of CISU. The Graphic Arts Section began work on processes for computer-based graphics, working with the unit computer specialist and with many of the CIAT scientific staff, who have learned to produce their own graphs and figures on the microcomputers assigned to the individual programs. A multi-ink plotter arrived in December and will begin to have a greater effect on processes during 1987. All of the publications continued to be produced, using word-processing packages on microcomputers or on stand-alone word processors, and then passed electronically to the photocomposition equipment.

The data bases of the specialized Information Centers were brought online, after two years of work, but the inclusion of the older records remains to be done in 1987, and is, to a great degree, dependent on the availability of disk space on the mainframe computer. Acquisitions processes and billing were brought online during 1986, and two microcomputers arrived in November, for the computerization of bibliographic processes.

Special Projects

Specialized information centers

The aim of this project is to reinforce operations of the specialized information analysis centers on cassava, beans, and tropical pastures. Specific objectives are: (a) for cassava, to include strengthening the scientific component in staffing of the center, increasing outreach activities in Asia and Africa, and producing state-of-the-art reviews or manuals; (b) for beans, to improve the capacity to collect and organize relevant documents and produce state-of-the-art reviews of manuals; (c) for pastures, to upgrade the information bulletin **Pastos Tropicales** to become a medium of publication for brief research reports and

	Budget (1987 US$ in thousands)	
	1987	1988
Personnel	41	-
Honoraria, stipends, and allowances	32	39
Supplies and services	73	68
Travel	-	-
Equipment replacement and capital	25	28
Indirect costs	16	11
Contingencies	-	-
Subtotal	187	146

to produce a state-of-the-art review; and (d) for all three centers, to strengthen the common services available by computerizing their data bases, improving acquisition facilities in Asia and Africa, duplicating microfiche sets, producing minibibliographies, and improving promotion. This project is financed by IDRC.

ADMINISTRATION

Board of Trustees

Core Resources

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	-	-	-
Honoraria	56	52	52
Supplies and services	25	26	26
Travel	99	72	72
Equipment replacement	-	-	-
Contingency	-	-	-
Subtotal	180	150	150
Support units	-	-	-
Total	180	150	150

Program Commentary

The CIAT Board of Trustees has 17 members. Normally the Board holds one annual meeting. Its executive committee, program committee, audit committee, and nominations committee meet at the time of the annual meeting, plus at various intervals throughout the year as deemed desirable and necessary. Described in the table above are the costs for international and national travel, honoraria, per diems, and other expenses directly associated with the meeting of the Board and its committees.

Office of the Director General

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Director General	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
Assistant Director	1	1	-	-	-	-	-	-	-	-	1	1	-	-	-
Assistant to the D.G.	-	-	1	1	1	-	-	-	-	-	-	-	1	1	1
Internal Auditor	-	-	-	-	-	3	3	3	3	3	1	1	1	1	1
Visitors' Office	-	-	-	-	-	3	3	3	3	3	2	2	2	2	2
Deputy Director General	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3
Director of Finance and Administration	1	1	1	1	1	1	2	2	2	2	1	4	4	4	4
Total	5	5	5	5	5	10	11	11	11	11	10	13	13	13	13

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	818	867	867
Honoraria	31	17	17
Supplies and services	53	36	36
Travel	104	101	101
Equipment replacement	7	6	6
Other expenses	31	51	51
Contingency	-	-	10
Subtotal	1044	1078	1088
Support units[a]	-	-	41
Price provision	-	-	37
Total	1044	1078	1166

a. Resource allocation from support units to the Office of the Director General.

Program Commentary

Three Division Heads, the Assistant Director (or Assistant to the Director General), and the Internal Auditor report to the Director General. The following three divisions make up the organization of CIAT.

Research Division I. This Division consists of the Bean Program, Cassava Program, and the following research support units: Genetic Resources, Biotechnology Research, Station Operations, and Research Services (except Data Services). This Division is headed by a Deputy Director General.

Research Division II. This Division comprises the Tropical Pastures Program, the Rice Program, the Data Services Unit, the Seed Unit, and the Coordinating Office for Training and Conferences. The Division is headed by a Deputy Director General.

Finance and Administration. This Division is responsible for the general services and financial administration, and is headed by the Director of Finance and Administration.

The Office of the Internal Auditor is headed by a General Administrative Staff (GAS) member who also reports to the Director General.

Budgeted in the Office of the Director General are special resources for the international travel of directing staff of collaborating national institutions. These resources are used to make possible selected trips of such staff to CIAT for consultation purposes.

Administrative Support

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Controller	-	-	-	-	-	10	9	9	9	9	25	25	25	25	25
Executive Officer	1	1	1	1	1	3	3	4	4	4	11	11	11	11	11
Human Resources	-	-	-	-	-	2	2	2	2	2	13	13	13	13	13
Supplies	-	-	-	-	-	4	4	4	4	4	23	23	23	23	23
Systems and procedures	-	-	-	-	-	6	7	7	7	7	3	3	3	3	3
Total	1	1	1	1	1	25	25	26	26	26	75	75	75	75	75

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	1096	1086	1086
Honoraria	54	68	68
Supplies and services	178	198	198
Travel	34	33	33
Equipment replacement	40	18	18
Other expenses	42	70	70
Contingency	-	-	13
Subtotal	1444	1473	1486
Support units[a]	-	-	55
Price provision	-	-	45
Total	1444	1473	1586

a. Resource allocation from support units to Administrative Support.

Program Commentary

The responsibilities of Administrative Support are to provide support to all CIAT activities in order that they can carry out the research and training activities of the Center. The section includes the many necessary housekeeping and administrative/fiscal units necessary to ensure that researchers have facilities to operate such as:

Functions directly responsible to the Director of Finance and Administration:

Executive Officer
Controller
Treasurer
Administrative Data Processing
Miami Office
Special Projects Office

Functions that report to the Executive Officer:

Human Resources
Purchasing/Supplies
Maintenance
Travel Office
Bogotá Office
Security
Food and Housing
Aircraft Operations
Carimagua Administration

Some of the functions reporting to the Executive Officer also appear in self-supporting activities as they are designed to provide support through general income. However, because of the nature of the service provided, they receive income from Core and Special Project sources.

An IBM System 36 computer is used exclusively for fiscal and administrative support. Approximately 90% of initially planned applications have been implemented.

CIAT opened its own office in Miami during 1986 in order to provide better purchasing, shipping, and importation services to CIAT in Colombia, as well as in other CIAT-operating sites.

GENERAL OPERATING EXPENSES

Core resources

Resources	Senior staff					Scientific and supervisory					Clerical and other				
	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90	Act. 86	Bud. 87	Bud. 88	Bud. 89	Bud. 90
Personnel (Positions)															
Physical plant															
Maintenance	-	-	-	-	-	4	4	4	4	4	54	53	53	53	53
Security	-	-	-	-	-	-	-	-	-	-	41	40	40	40	40
Gardens	-	-	-	-	-	-	-	-	-	-	13	11	11	11	11
Cleaning	-	-	-	-	-	-	-	-	-	-	48	49	51	51	51
Motor pool	-	-	-	-	-	1	1	1	1	1	45	48	50	50	50
Total	-	-	-	-	-	5	5	5	5	5	201	201	205	205	205

Direct costs (1987 US$ in thousands).

Costs	Current budget		Proposed budget
	Actual 1986	Revised 1987	1988
Personnel	1243	1143	1143
Honoraria, stipends, and allowances	-	-	-
Supplies and services	1271	833	833
Travel	25	26	26
Equipment replacement	476	392	392
Other expenses	298	81	81
Gain in exchange rate	(92)	(200)	(50)
Contingency	-	229	11
Subtotal	3221	2504	2436
Support units[a]	-	-	(866)
Price provision	-	-	228
Total	3221	2504	1798

a. Resources allocated to other programs.

Program Commentary

The Palmira installations consist of about 20 buildings or complexes of buildings, including two laboratory buildings, three office buildings, two field laboratory buildings, seed processing and storage facilities, communications and library buildings, conference facilities, food, housing and recreational facilities, six greenhouses, warehouse, a germplasm store, service building for machinery and vehicle maintenance, laundry facilities, and water treatment. The gross area of buildings is 42,000 m^2 of which about 50% is airconditioned. The entire complex is served by about 37 km of roads, 25,000 m^2 of circulation areas and parking spaces, and is surrounded by about 10,000 m^2 of gardens.

Other than electricity, for which only standby and emergency capacity is maintained, CIAT provides all its own services. The Physical Plant includes resources

to run these services, maintain all buildings and grounds, and provide security.

CIAT operates a fleet of about 260 vehicles which includes buses, trucks, vans, pickups, jeeps, and passenger cars from various manufacturers. The Motor Pool is responsible for servicing, repairing, and maintaining these vehicles and for providing bus services to transport personnel to and from work and regular services during the day and night to Cali and Palmira for employees, training participants, and visitors.

SELF - SUPPORTING AND INCOME - GENERATING ACTIVITIES

CIAT has several self-supporting activities, which are meant to break even, and several other activities which generate income in excess of the extra costs incurred. Activities falling under the two groupings are as follows:

Self-supporting	**Income-generating**
Food and housing	Farm production
Aircraft operation	Cattle herds
Publications fund	Seed marketing
Seed processing and conditioning	Special project support
"PROCIAT" health service	

None of these activities appear separately in this budget document, although in some cases, significant amounts are charged to the core budget. Examples of this are: the food operation, which is partly supported by a subsidy which is charged as a personnel cost; and the aircraft operation, which is funded by charges to the respective individual programs' travel budgets.

CAPITAL REQUIREMENTS

The proposed capital budget of US$1,077,000 includes US$250,000 for the termination of a major construction project initiated in 1987 to upgrade the quality and size of the germplasm storage facilities in the Genetic Research Unit building. An amount of US$200,000 is set aside for the completion of an expanded workspace (offices, clean and dirty laboratories, seed storage space) for the Rice Program. The remainder is for equipment purchases, part of which is to support new activities as summarized in Table IIa (see Annex).

ANNEX

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)
Resource Summary (Core and Special Projects)

Table Ia

	1986 Actual		1987 Plan		1988 Proposal		1989 Forecast	
	Senior Staff Positions	Amount 86$000	Senior Staff Positions	Amount 87$000	Senior Staff Positions	Amount 87$000	Senior Staff Positions	Amount 87$000
1. OPERATIONS PROGRAM								
Research Programs:								
Beans: -Core	16	2,602	18	3,289	18	3,289	18	3,289
-Special	8	1,186	10	1,759	10	2,599	10	2,264
Cassava: -Core	9	2,000	9	2,025	10	2,198	15	3,460
-Special	1	272	1	352	1	493	1	343
Rice: -Core	6	993	7	1,230	7	1,230	7	1,230
-Special	2	183	2	260	2	434	2	483
Tropical Pastures: -Core	17	3,168	18	3,319	18	3,319	19	3,511
-Special	1	55		28		27		
Sub-Total	60	10,459	65	12,262	66	13,589	72	14,580
Research Support:								
Visiting Scientists and Post Doctorals		472		639		639		639
Genetic Resources: -Core	1	323	1	406	1	406	1	406
-Special	1	61	1	97	1	94	1	67
Biotechnology Research: -Core	1	247	2	347	3	530	3	530
-Special		35						
Research Services		308		267		267		267
Station Operations	1	954	1	767	1	767	1	767
Carimagua Station		579		595		595		595
Data Services	1	450	1	519	1	519	1	519
Agroecological Studies	1	150	1	170	1	170	1	170
Seed Unit	2	521	2	487	2	487	2	487
Sub-Total	8	4,100	9	4,294	10	4,474	10	4,447
TOTAL RESEARCH	68	14,559	74	16,556	76	18,063	82	19,027
International Cooperation:								
Training and conferences: -Core	1	1,439	1	1,260	1	1,404	1	1,404
-Special		93		221		227		247
Communication and Information Support:-Core	3	1,369	3	1,422	3	1,422	3	1,422
-Special		99		162		115		
TOTAL INTERNATIONAL COOPERATION	4	3,000	4	3,065	4	3,168	4	3,073
Administration:								
Board of Trustees		174		150		150		150
Director General	2	517	2	524	2	524	2	524
Directors	3	496	3	554	3	554	3	554
Administrative Support: -Core	1	1,402	1	1,473	1	1,473	1	1,473
-Special	1		1		1		1	
TOTAL ADMINISTRATION	7	2,589	7	2,701	7	2,701	7	2,701
General Operating Expenses:								
Physical Plant		1,470		1,090		1,090		1,090
Motor Pool		955		799		799		799
General Expenses		702		386		536		536
TOTAL GENERAL OPERATING EXPENSES		3,127		2,275		2,425		2,425
Other:								
Contingency				229		229		229
Provision for Price Changes						1,018		2,484
TOTAL OTHERS				229		1,247		2,713
TOTAL OPERATIONS	79	23,275	85	24,826	87	27,604	93	29,939
CAPITAL								
Construction: -Core		57		291		200		550
-Special		39		183		45		22
Equipment: -Core		680		651		580		642
-Special		205		335		279		117
CRC Construction & Equipment		29		250		250		-
Provision for Price Changes						47		109
TOTAL CAPITAL		1,010		1,710		1,401		1,440
ADDITIONAL WORKING CAPITAL		11		21		116		231
Total Requirements (1+2+3)		24,296		26,557		29,121		31,610
Less:								
FUNDS ON HAND		552		808				
Funding Requirements		23,744		25,749		29,121		31,610
SOURCES OF FUNDS:								
Core:								
-Restricted		10,377		11,197				
-Capital		73		564				
-Unrestricted		10,327		9,769				
-World Bank		750		1,000				
-Earned Income		574		630		649		680
-Unidentified Sources						24,039		27,110
TOTAL CORE		22,101		23,160		24,688		27,790
SPECIAL PROJECTS								
Capital		244		518		324		139
Others		2,205		2,071		4,109		3,681
TOTAL SPECIAL PROJECTS		2,449		2,589		4,433		3,820
TOTAL		24,550		25,749		29,121		31,610

25 August 1987

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT) — Table 1b

Resource Summary
(Core Only)

	1986 Actual		1987 Plan		1988 Proposal		1989 Forecast	
	Senior Staff Positions	Amount 86$000	Senior Staff Positions	Amount 87$000	Senior Staff Positions	Amount 87$000	Senior Staff Positions	Amount 87$000
1. OPERATIONS PROGRAM								
Research Programs:								
Beans	16	2,602	18	3,289	18	3,289	18	3,289
Cassava	9	2,000	9	2,098	10	2,198	15	3,460
Rice	6	993	7	1,230	7	1,230	7	1,230
Tropical Pastures	17	3,168	18	3,319	18	3,319	19	3,511
Sub-Total	48	8,763	52	9,866	53	10,036	59	11,490
Research Support:								
Visiting Scientists and Post Doctorals		472		639		639		639
Genetic Resources	1	323	1	406	1	406	1	406
Biotechnology Research	1	247	2	347	3	530	3	530
Research Services		308		267		267		267
Station Operations	1	954	1	767	1	767	1	767
Carimagua Station		579		595		595		595
Data Services	1	450	1	519	1	519	1	519
Agroecological Studies	1	150	1	170	1	170	1	170
Seed Unit	2	521	2	487	2	487	2	487
Sub-Total	7	4,004	8	4,197	9	4,380	9	4,380
TOTAL RESEARCH	55	12,767	60	14,060	62	14,416	68	15,870
International Cooperation:								
Training and conferences	1	1,439	1	1,260	1	1,404	1	1,404
Communication and Information Support	3	1,369	3	1,422	3	1,422	3	1,422
TOTAL INTERNATIONAL COOPERATION	4	2,808	4	2,682	4	2,826	4	2,826
Administration:								
Board of Trustees		174		150		150		150
Director General	2	517	2	524	2	524	2	524
Directors	3	496	3	554	3	554	3	554
Administrative Support	1	1,402	1	1,473	1	1,473	1	1,473
TOTAL ADMINISTRATION	6	2,589	6	2,701	6	2,701	6	2,701
General Operating Expenses:								
Physical Plant		1,470		1,090		1,090		1,090
Motor Pool		955		799		799		799
General Expenses		702		386		536		536
TOTAL GENERAL OPERATING EXPENSES		3,127		2,275		2,425		2,425
Other:								
Contingency				229		229		229
Provision for Price Changes				—		898		2,207
TOTAL OTHERS				229		1,127		2,436
TOTAL OPERATIONS	65	86$21,291	70	87$21,942	72	88$23,495	78	89$26,258
2. CAPITAL								
Construction:		57		291		200		550
Equipment & Vehicles		680		651		580		642
CRS Construction & Equipment		29		250*		250		
Provision for Price Changes						47		109
TOTAL CAPITAL		766		1,192		1,077		1,301
3. ADDITIONAL WORKING CAPITAL		11		21		116		231
Total Requirements (1+2+3)		22,068		23,160		24,688		27,790
Less:								
4. FUNDS ON HAND		(33)						
Funding Requirements		22,101		23,160		24,688		27,790
SOURCES OF FUNDS:								
Core:								
-Restricted		10,377		11,197				
-Capital		73		564				
-Unrestricted		10,327		9,769				
-World Bank		750		1,000				
-Earned Income		574		630		649		680
-Unidentified Sources						24,039		27,110
TOTAL		22,101		23,160		24,688		27,790

* In addition, $171,000 unexpended in 1986 and available in 1987.

25 August 1987

1988 Additions
(Core Only)

C$ in Thousand

	Order of Priority	Senior Staff Positions	Operations	Working Capital	Capital Items	Total
1987 Revised Budget		70	21,947	21	1,192	23,160
1. 1988 Price requirements for items not on this review list			878	73	47	998
Reduction on Projected Exchange Rate Gain			150			150
Adjustments in Capital				(21)	(219)	(240)
2. Operations Program						
I. CIAT Cassava Scientist at IITA	1	1	180	15	32	227
II. Virologist for Support of all CIAT Programs but with emphasis in Cassava	2	1	190	16	25	231
III. Additional Resources for Network Conference Events	3		150	12		162
TOTAL ADDITIONS		2	1,548	95	(115)	1,528
1988 PROPOSAL		72	23,495	116	1,077	24,688

25 August 1987

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)

Reduction List
(Core Only)

1988 Proposal

	Senior Staff	Amount	Order of Priority	Description
OPERATIONS PROGRAMS				
Visiting Scientists & Post Doctorals		150	1	Reduction in Visiting Scientists
3 Research Sub-programs		545	2	To be identified
TOTAL REDUCTIONS		695		

25 August 1987

Capital Expenditures
(Core and Special)

	Fiscal Year of Expenditures			
	Total Recommendations /Proposal	Core	Special Project	Total Core & Special
Details				
1. Capital Program				
1986 Capital Program				
Construction		57	39	96
Equipment & Vehicles	463	680	205	885
GRU Constructin & Equipment	250	29		29
TOTAL 1986	713	766	244	1,010
1987 Capital Program				
Construction	153	291	183	474
Equipment & Vehicles	675	651	335	986
GRU Construction & Equipment	250	250		250
TOTAL 1987	1,078	1,192	518	1,710
CIAT'S PROPOSAL				
1988 Capital Program				
Construction	245	200	45	245
Equipment & Vehicles	859	580	279	859
GRU Construction & Equipment	250	250		250
Provision for Price Changes	47	47		47
TOTAL 1988	1,401	1,077	324	1,401
1989 Capital Program				
Construction	572	550	22	572
Equipment & Vehicles	759	642	117	759
Provision for Price changes	109	109		109
TOTAL 1989	1,440	1,301	139	1,440
1990 Capital Program				
Construction	550	550		550
Equipment & Vehicles	642	642		642
Provision for Price Changes	174	174		174
TOTAL 1990	1,366	1,366		1,366
TOTAL 1986-90 CAPITAL PROGRAMS	5,998	5,702	1,225	6,927

25 August 1987

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)

Summary of Authorized Senior Staff Positions
(Core and Special Projects)

	1984	1985	1986	1987	1988
1. OPERATIONS PROGRAM					
Research Programs:					
Beans: -Core	15	16	16	18	18
-Special	5	8	8	10	10
Cassava: -Core	8	9	9	9	10
-Special			1	1	1
Rice: -Core	5	6	6	7	7
-Special	1	1	2	2	2
Tropical Pastures:					
-Core	16	17	17	18	18
-Special	1	1	1	—	—
Sub-Total	51	58	60	65	66
Research Support:					
Genetic Resources:					
-Core	1	1	1	1	1
-Special	1	1	1	1	1
Biotechnology Research:					
-Core		1	1	2	3
-Special					
Station Operations	1	1	1	1	1
Carimagua Station					
Data Services	1	1	1	1	1
Agroecological Studies	1	1	1	1	1
Seed Unit	2	2	2	2	2
Sub-Total	7	8	8	9	10
TOTAL RESEARCH	58	66	68	74	76
International Cooperation:					
Training and Conferences:					
-Core	1	1	1	1	1
-Special					
Communication & Info. Support:					
-Core	3	3	3	3	3
-Special	—	—	—	—	—
TOTAL INTERNATIONAL COOPERATION	4	4	4	4	4
Administration:					
Director General	2	2	2	2	2
Directors	3	3	3	3	3
Administrative Support:					
-Core	1	1	1	1	1
-Special	1	1	1	1	1
TOTAL ADMINISTRATION	7	7	7	7	7
TOTAL OPERATIONS:-Core	60	65	65	70	72
-Special Projects	9	12	14	15	15
	69	77	79	85	87

25 August 1987

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT) Table V

Special Projects
(Summary Only)

	1987 Plan		1988		
	Senior Staff	Amount	Senior Staff	Amount	Description
1. OPERATIONS PROGRAM					
Beans		90		86	Legume Germplasm
	4	675	4	1,129	Bean Improvement for Eastern Africa
	5	704	5	1,192	Bean Improvement for Southern Africa
		134		101	Research on Phaseolus Germplasm
	1	106	1	106	Bilateral Bean Project with Peru
		50		63	Economic Studies of Snap Beans
TOTAL BEANS	10	1,759	10	2,677	
Cassava		32		32	Cassava Program in Panama
		49		57	Agro-industrial Development of Cassava
		144		139	Explorat. & Eval.of Cassava Mite Pred.
	1	127	1	280	Cassava Development in Brazil
TOTAL CASSAVA	1	352	1	508	
Rice		32		32	Rice Program in Panama
	1	110	1	110	Bilateral Rice Project with Peru
	1	118	1	305	Caribbean Rice Research Network
TOTAL RICE	2	260	2	447	
TROPICAL PASTURES		28		28	Farming Systems in the Western Amazonia
Genetic Resources	1	37	1	37	Germplasm Collection (Beans, Cassava & *Tropical Pastures*)
		60		60	In-vitro Active Gene Bank
TOTAL GENETIC RESOURCES	1	97	1	97	
Training & Conferences		121		134	Farmer Participation in Technology Design
		100		100	Various Courses & Training
TOTAL TRAINING & CONF.		221		234	
COMMUNICATION & INFORM.		162		118	Specialized Information Centers
ADMINISTRATION SUPPORT	1		1		Special Projects Officer
TOTAL OPERATIONS	15	2,879	15	4,109	
2. CAPITAL		518		324	
TOTAL SPECIAL PROJECTS	15	3,397	15	4,433	

25 August 1987

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)

1988 Total Budget Request: U.S. Dollar Amounts Allocated to Research and Research Related Activities

ACTIVITIES	Beans	Cassava	Rice	Tropical Pastures	Genetic Resources	Biotech-nology Research	Agroeco-logical Studies	Seed Unit	Training and Confe-rences	Communi-cations and Infor-mation	Total
Water Management	24.9										24.9
Soil Management & Conservation Res.	146.9	57.2	2.5	207.0							413.6
Agroclimatology Research	68.4			10.8			166.7				245.9
Germplasm:											
a) Research on Conservation & Diversity			83.5	151.1	94.6	27.1					356.3
b) Collection		51.3		225.3	81.6	13.9					372.1
c) Conservation, Characterization & Doc.	135.2	295.4	72.9	315.1	281.7	45.2					1,145.5
d) Enhancement	478.9	296.6	9.4	492.2	9.9	13.9					1,300.9
e) Plant Breeding/Improvement	1,198.3	631.5	504.1	172.7		31.3					2,537.9
f) International Trials (distrib.& Exch.)	493.2	248.9	232.5	531.6	11.4	18.1					1,535.7
Seed Production	10.7		76.4	160.4	5.3			34.7			287.5
Crop Systems Research	663.5	301.1	104.4								1,069.0
Livestock				263.2							263.2
Crop-Livestock Systems Research				145.3			44.1				189.4
Plant Protection Research	630.5	470.8	236.5	136.6	36.5	141.7					1,652.6
Plant Nutrition Research	371.2	23.3	25.6	167.3							587.4
Machinery Research & Development			5.7	43.2				11.6			60.5
Livestock Nutrition Research				426.5							426.5
Livestock Reproduction Research				50.2							50.2
Human Resource Enhancement:											
a) Specialized Courses (short term)	532.1	87.7	130.4	265.8	19.6	31.3		86.7	646.8	79.4	1,879.8
b) Individualized Internships	359.5	169.6	61.6	164.2	11.9	42.3		46.2	645.7	38.5	1,539.5
Conferences and Seminars	39.6	48.8	72.1	70.9		31.3		92.4	423.5	7.1	785.7
Documentation and Dissemination	134.5	68.9	48.6	8.3	11.1	32.7	9.8	52.0	19.3	1,033.5	1,418.7
Research on Approaches, Concepts, Methodol. and Procedures	175.6	45.2	25.2	234.0		43.0				5.4	528.4
Counselling and Advising NARS	358.5	130.3	112.3	118.1	14.8	13.2		40.4			787.6
Technical Assistance	97.3	138.3	38.5	95.0	14.8	12.5		80.9	11.7		489.0
Coordination of Networks	719.5	83.3	114.2	279.3		36.1		92.4	28.6	72.9	1,426.3
Economic and Social Analysis at Micro-Level	101.0	166.2	55.4	74.7			24.5	5.8		11.9	439.5
Market Analysis	56.1	60.5	26.6					11.6			154.8
Policy Analysis	56.1	105.7	50.0					11.6			223.4
Nutrition and Consumption Analysis	29.7	49.1	20.9								99.7
Research on Research	8.3										8.3
Exploratory Research	129.7	66.0		116.3		91.8					403.8
Conversion and Utilization Research	115.8	132.3						11.6			259.7
SUB-TOTAL	7,135.0	3,728.0	2,109.3	4,925.1	593.2	625.4	245.1	577.9	1,775.6	1,248.7	22,963.3
Central Support Services/Administration											4,640.7
TOTAL CORE AND SPECIAL PROJECTS											27,604.0

25 August 1987

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)

1988 Total Budget Request: Positions Allocated to Research and Research Related Activities

ACTIVITIES	Beans	Cassava	Rice	Tropical Pastures	Genetic Resources	Biotech-nology Research	Agroeco-logical Studies	Seed Unit	Training and Confe-rences	Communi-cations and Infor-mation	Total
Water Management	0.150										0.2
Soil Management & Conservation Res.	0.555	0.215	0.001	0.870							1.6
Agroclimatology Research	0.250			0.050			0.734				1.0
Germplasm:											
a) Research on Conservation & Diversity			0.276	0.424	0.103	0.100					0.9
b) Collection		0.190		0.433	1.104	0.050					1.8
c) Conservation, Characterization & Doc.	0.141	0.395	0.263	0.542	0.573	0.200					2.1
d) Enhancement	2.020	0.385	0.052	2.310	0.001	0.050					4.8
e) Plant Breeding/Improvement	3.370	1.895	2.411	0.579		0.150					8.4
f) International Trials (distrib.& Exch.)	1.931	1.220	0.861	1.358	0.004	0.100					5.5
Seed Production	0.100		0.325	0.450	0.002			0.124			1.0
Crop Systems Research	2.519	0.515	0.598								3.6
Livestock				0.940							0.9
Crop-Livestock Systems Research				0.770			0.194				1.0
Plant Protection Research	2.850	1.090	0.945	0.820	0.011	0.800					6.5
Plant Nutrition Research	1.653	0.120	0.125	0.950							2.8
Machinery Research & Development			0.050	0.210				0.041			0.3
Livestock Nutrition Research				1.470							1.5
Livestock Reproduction Research				0.210							0.2
Human Resource Enhancement:											
a) Specialized Courses (short term)	2.160	0.400	0.592	1.015	0.032	0.150		0.309	0.245	0.009	4.9
b) Individualized Internships	1.820	0.770	0.330	0.820	0.051	0.200		0.165	0.408	0.005	4.6
Conferences and Seminars	0.220	0.210	0.278	0.180		0.150		0.330	0.326	0.001	1.7
Documentation and Dissemination	0.700	0.300	0.208	0.050	0.050	0.150	0.043	0.185	0.020	2.892	4.6
Research on Approaches, Concepts, Methodol. and Procedures	0.790	0.160	0.108	0.660		0.200				0.001	1.9
Counselling and Advising NARS	1.420	0.520	0.517	0.610	0.061	0.050		0.144			3.3
Technical Assistance	0.500	0.650	0.116	0.430	0.061	0.150		0.288	0.020		2.2
Coordination of Networks	3.260	0.450	0.471	1.490		0.100		0.330		0.192	6.3
Economic and Social Analysis at Micro-Level	0.450	0.580	0.296	0.370			0.108	0.021			1.9
Market Analysis	0.250	0.280	0.158					0.041			0.7
Policy Analysis	0.250	0.440	0.243					0.041			1.0
Nutrition and Consumption Analysis	0.078	0.250	0.108								0.4
Research on Research	0.050										0.1
Exploratory Research	0.396	0.285		0.580		0.400					1.7
Conversion and Utilization Research	0.117	0.450						0.041			0.6
SUB-TOTAL	28.000	11.770	9.330	18.590	2.050	3.000	1.080	2.060	1.020	3.100	80.00
Central Support Services/Administration											7.0
TOTAL SENIOR STAFF POSITIONS											87.00

25 August 1987

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL
SUMMARY OF SOURCES AND APPLICATION OF FUNDS
(C US$ Thousands)

TABLE VIII

	ACTUAL		1987 BUDGET		Proposed Budget	PROJECTIONS
	1985	1986	Approved Budget	Current Estimate	1988	1989
SOURCES OF FUNDS						
Core Operations						
Unrestricted Core:						
Government of Australia	457	440				
Government of Belgium	126			152		
Government of Canada	1,218	1,218		1,295		
Government of China	33	30				
The Ford Foundation	100	100		100		
Government of Germany (Fed. Rep.)	708	626		583		
Government of Italy	348	417		437		
Government of Mexico	111			194		
Government of Norway	339	442		467		
Government of Spain	30	30		60		
Government of Sweden	122	207		214		
Government of Switzerland	439	544		702		
Government of United Kingdom	513	675		745		
Government of the United States	5,540	5,600		4,820		
The World Bank	376	57		372		
Unconfirmed Sources			12,475		11,562	14,409
Balance (deficit) from previous year	(39)	(33)				
Income applied in year	302	563	300	609	533	449
Sub-Total Unrestricted	10,723	10,916	12,775	10,750	12,095	14,858
Restricted Core:						
European Economic Community	1,632	1,857		1,837		
The Ford Foundation	10	48		20		
Government of France	53	104		146		
Interamerican Development Bank	4,043	4,275		4,640		
Intl.Dev.Research Centre (IDRC)	209	114		79		
Intl.Fund for Agr.Develop. (IFAD)	500					
Government of Italy				250		
Government of Japan	1,389	1,758		1,800		
Kellogg Foundation	(2)					
Government of Netherlands	235	329		336		
The Rockefeller Foundation	46	141		166		
Government of Switzerland	673	1,407		1,823		
U.N. Development Programme (UNDP)	384	342		100		
Unconfirmed Sources			10,250		11,400	11,400
Balance from previous year	758					
Sub-Total Restricted	9,930	10,375	10,250	11,197	11,400	11,400
TOTAL CORE OPERATIONS FUNDS	20,653	21,291	23,025	21,947	23,495	26,258
Capital						
Government of Italy				250		
Government of Japan		28		217		
Government of Switzerland		45		97		
World Bank	924	693		628		
Others	271	118				
Unconfirmed Sources			1,253		1,077	1,301
Income Applied in Year		11		21	116	231
Balance of Working Funds	1,245	1,245	1,245	1,374	1,395	1,511
TOTAL CAPITAL FUNDS	2,440	2,140	2,498	2,587	2,588	3,043
Special Projects						
Government of Belgium	80	107				
Canadian Intl.Dev.Agency (CIDA)	253	103		700		
The Ford Foundation	102	108				
Food & Agr.Organiz.of U.S. (FAO)		14				
German Agency for Techn.Coop. (GTZ)	131	23		43		
Interamerican Develop. Bank (IDB)		44				
Intl.Dev.Res. Centre (IDRC)	99	289		162		
Government of Italy	100	104				
Government of Japan		425				
Kellogg Foundation				121		
Government of Netherlands		44		50		
The Rockefeller Foundation		98				
Government of Switzerland	49	491		32		
U.N. Development Programme (UNDP)	163	160		109		
U.S. Agency for Intl.Dev. (AID)	146	59		360		
The World Bank	282	178		180		
Others	25	53		181		
Unidentified Sources			3,790	1,032	4,188	3,720
Balance from previous year	876	609	400	972	545	300
TOTAL SPECIAL PROJECT	2,306	2,909	4,190	3,942	4,733	4,020
Projects at CIAT by Sister Institutes						
Intl.Board for Plant Genetic Resources	22	116		37		
Intl. Fertilizer Dev.Center (IFDC)	49	124		100		
Intl. Institute of Trop.Agr. (IITA)	15			262		
International Maize and Wheat Improvement Center (CIMMYT)	106	101		100		
International Potato Center (CIP)	15					
Intl. Rice Research Institute (IRRI)	192	249		180		
Intsormil	96	44		60		
Intsoy		47		9		
Unconfirmed Sources			153		400	400
Balance from previous year	(38)	(128)		(164)		
TOTAL PROJECTS BY SISTER INST.	457	553	153	584	400	400
TOTAL FUNDS	25,856	26,893	29,866	29,060	31,216	33,721
APPLICATION OF FUNDS						
Core Operation	20,630	21,291	23,025	21,947	23,495	26,258
Capital	1,251	766	1,078	1,192	1,077	1,301
Special Projects	1,748	1,937	3,990	3,397	4,433	3,820
Projects at CIAT by Sister Institutes	534	717	153	584	400	400
Unexpended Balances						
Unrestricted Core (deficit)	(33)					
Working Funds	1,245	1,374	1,420	1,395	1,511	1,742
Special Projects	595	972	200	545	300	200
Projects at CIAT by Sister Institutes	(114)	(164)				
Sub-Total Unexpended Balances	1,693	2,182	1,620	1,940	1,811	1,942
TOTAL APPLICATIONS	25,856	26,893	29,866	29,060	31,216	33,721
Memo :						
1. Total Core Operating Funds Required	20,630	21,291	23,025	21,947	23,495	26,258
Less unexpended balance previous-year	(663)	33				
Less earned income applied	(302)	(563)	(300)	(609)	(533)	(449)
Net Core Operating Funds Required	19,665	20,761	22,725	21,338	22,962	25,809
2. Total Capital Funds Required	2,225	2,140	2,498	2,587	2,588	3,043
Less unexpended balance previous year	(56)					
Less balance working funds	(1,245)	(1,363)	(1,245)	(1,374)	(1,395)	(1,511)
Less earned income applied		(11)		(21)	(116)	(231)
Net Capital Funds Required	924	766	1,253	1,192	1,077	1,301
3. Total Funds Required from Donors	20,589	21,527	23,978	22,530	24,039	27,110
4. Total Earned Income	302	574	300	630	649	680
Applied to Core Operation	(302)	(563)	(300)	(609)	(533)	(449)
Applied to Capital		(11)		(21)	(116)	(231)
Balance	-	-	-	-	-	-

25 August 1987

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL

TABLE IX

SUMMARY FINANCIAL DATA 1985-1988

	Actual 1985	Actual 1986	1987 Budget Approved	1987 Budget Current Estimate	Budget 1988
Current Assets					
Cash and Banks	2,804	5,069	3,500	4,100	4,550
Receivable from Donors	2,735	227	900	300	300
Receivable from Others	1,445	1,291	2,300	1,350	1,400
Inventories	2,329	1,323	454	1,145	1,012
Total Current Assets	9,313	7,910	7,154	6,895	7,262
Long-Term Accounts Receivable and Other Assets	861	790	1,295	800	800
Fixed Assets					
Buildings, Lands & Construction in Progress	8,189	7,935			
Research Equipment	1,462	1,544			
Operation Equipment	4,382	4,698			
Vehicle	3,422	3,904			
Furniture & Office Equip.	2,546	2,859			
Airplane	1,299	1,299			
Total Fixed Assets	21,300	22,239	23,091	23,949	25,350
TOTAL ASSETS	31,474	30,939	31,540	31,644	33,412
Libilities					
Bank Debts & Overdrafts	1,017	146	787	200	200
Accounts Payable & Other Liabilities	3,842	3,570	2,973	2,900	3,000
Accrued Salaries & Benef.	1,237	1,594	1,835	1,800	1,900
Advances Received from Donors	1,994	553	600	500	600
Accounts Payable to Donors	391	655	302	300	250
Total Liabilities	8,481	6,518	6,497	5,700	5,950
Fund Balances					
Capital Fund	21,300	22,239	23,091	23,949	25,350
Capital Development Fund	1,245	1,374	1,752	1,395	1,512
Operating Fund	448	808	200	600	600
Total Fund	22,993	24,421	25,043	25,944	27,462
TOTAL LIABILITIES AND FUND BALANCES	31,474	30,939	31,540	31,644	33,412

25/08/87

ULTURA TROPICAL

MANPOWER

Table X

PORT STAFF									TOTAL STAFF					
CLERICAL			OTHER SUPPORT STAFF											
MAN-YEARS			POSITIONS			MAN-YEARS			POSITIONS			MAN-YEARS		
Act. 86	Rev. 87	Bud. 88	Act. 86	Rev. 87	Bud. 88	Act. 86	Rev. 87	Bud. 88	Act. 86	Rev. 87	Bud. 88	Act. 86	Rev. 87	Bud. 88
8.3	10.0	10.0	128	118	121	123.0	118.0	121.0	188	182	185	182.3	182.0	185.0
7.9	9.0	9.0	103	94	92	98.0	93.0	113.0	141	136	133	136.9	135.0	154.0
5.6	7.0	6.0	63	77	77	55.7	73.0	77.0	85	106	106	77.3	102.0	105.0
12.0	12.0	11.0	152	158	158	149.0	148.0	158.0	216	225	225	213.0	216.0	224.0
33.8	38.0	36.0	446	447	448	425.7	432.0	469.0	630	649	649	609.5	635.0	668.0
1.1	1.0	1.0	25	24	24	24.7	24.0	24.0	31	30	30	30.8	30.0	30.0
1.0	1.0	1.0	9	12	17	9.1	12.0	17.0	15	21	30	15.1	21.0	30.0
			18	19	19	17.6	19.0	19.0	22	23	23	21.6	23.0	23.0
2.0	2.0	2.0	82	80	80	80.8	80.0	80.0	90	88	88	88.8	88.0	88.0
5.8	4.0	5.0	1	2	2	1.5	2.0	2.0	8	10	10	9.4	10.0	11.0
7.9	9.0	10.0	1			1.4			18	20	20	18.6	20.0	19.0
1.0	1.0	1.0	3	3	3	3.0	3.0	3.0	6	8	8	5.7	7.0	8.0
2.8	2.0	2.0	5	9	9	5.0	9.0	9.0	16	19	20	15.6	19.0	20.0
21.6	20.0	22.0	144	149	154	143.1	149.0	154.0	206	219	229	205.6	218.0	229.0
55.4	58.0	58.0	590	596	602	568.8	581.0	623.0	836	868	878	815.1	853.0	897.0
5.8	5.0	5.0	4	4	5	4.0	4.0	5.0	20	21	22	20.2	21.0	22.0
14.8	18.0	16.0	39	34	34	39.2	34.0	36.0	81	81	83	79.7	81.0	83.0
20.6	23.0	21.0	43	38	39	43.2	38.0	41.0	101	102	105	99.9	102.0	105.0
4.1	4.0	4.0	2	2	2	2.0	2.0	2.0	15	15	15	14.4	15.0	15.0
3.9	6.0	6.0	1	1	1	1.0	1.0	1.0	10	14	14	10.2	14.0	14.0
75.1	67.0	67.0	3	3	3	3.1	3.0	3.0	94	94	95	99.4	94.0	95.0
83.1	77.0	77.0	6	6	6	6.1	6.0	6.0	119	123	124	124.0	123.0	124.0
6.0	6.0	6.0	149	146	148	148.3	146.0	148.0	159	156	158	158.3	156.0	158.0
3.8	4.0	4.0	42	45	47	43.3	45.0	47.0	47	50	52	48.1	50.0	52.0
9.8	10.0	10.0	191	191	195	191.6	191.0	195.0	206	206	210	206.4	206.0	210.0
25.0	24.0	25.0	62	60	62	62.0	60.0	62.0	98	94	98	98.0	94.0	98.0
193.9	192.0	191.0	892	891	904	871.7	876.0	927.0	1360	1393	1415	1343.4	1378.0	1434.0

25/ 08/ 87

CENTRO INTERNACIONAL DE A

TABLE OF POSITION

	SENIOR STAFF						SCIENTIFIC AND SUPERVISORY							
	POSITIONS			MAN-YEARS			POSITIONS			MAN-YEARS			POSITI	
	Act. 86	Rev. 87	Bud. 88	Act. 86	Rev. 87	Bud. 88	Act. 86	Rev. 87	Bud. 88	Act. 86	Rev. 87	Bud. 88	Act. 86	Rev. 87
RESEARCH PROGRAMS														
Beans	16	18	18	15.0	18.0	18.0	36	36	36	36.0	36.0	36.0	8	10
Cassava	9	9	10	9.0	9.0	10.0	21	24	22	22.0	24.0	22.0	8	9
Rice	6	7	7	6.0	7.0	7.0	10	15	15	10.0	15.0	15.0	6	7
Tropical Pastures	17	18	18	17.0	18.0	18.0	35	37	37	35.0	38.0	37.0	12	12
SUB-TOTAL	48	52	53	47.0	52.0	53.0	102	112	110	103.0	113.0	110.0	34	38
RESEARCH SUPPORT														
Genetic Resources Unit	1	1	1	1.0	1.0	1.0	4	4	4	4.0	4.0	4.0	1	1
Biotechnology Research	1	2	3	1.0	2.0	3.0	4	6	9	4.0	6.0	9.0	1	1
Research Services							4	4	4	4.0	4.0	4.0		
Station Operations	1	1	1	1.0	1.0	1.0	5	5	5	5.0	5.0	5.0	2	2
Carimagua Station							2	4	4	2.1	4.0	4.0	5	4
Data Services	1	1	1	1.0	1.0	1.0	8	10	10	8.3	10.0	8.0	8	9
Agroecological Studies	1	1	1	1.0	1.0	1.0	1	3	3	0.7	2.0	3.0	1	1
Seeds	2	2	2	2.0	2.0	2.0	6	6	7	5.8	6.0	7.0	3	2
SUB-TOTAL	7	8	9	7.0	8.0	9.0	34	42	46	33.9	41.0	44.0	21	20
TOTAL RESEARCH	55	60	62	54.0	60.0	62.0	136	154	156	136.9	154.0	154.0	55	58
INTERNATIONAL COOPERATION														
Training & Conferences	1	1	1	1.0	1.0	1.0	10	11	11	9.4	11.0	11.0	5	5
Communication & Inform.	3	3	3	3.0	3.0	3.0	24	26	28	22.7	26.0	28.0	15	18
TOTAL INTL. COOP.	4	4	4	4.0	4.0	4.0	34	37	39	32.1	37.0	39.0	20	23
ADMINISTRATION														
Director General	2	2	2	2.0	2.0	2.0	7	7	7	6.3	7.0	7.0	4	4
Directors	3	3	3	3.0	3.0	3.0	3	4	4	2.3	4.0	4.0	3	6
Administrative Support	1	1	1	1.0	1.0	1.0	23	23	24	20.2	23.0	24.0	67	67
TOTAL ADMINISTRATION	6	6	6	6.0	6.0	6.0	33	34	35	28.8	34.0	35.0	74	77
GENERAL OPERATING EXPENSES														
Physical Plant							4	4	4	4.0	4.0	4.0	6	6
Motor Pool							1	1	1	1.0	1.0	1.0	4	4
TOTAL GENERAL OPERATING							5	5	5	5.0	5.0	5.0	10	10
SELF-SUPPORTING & INCOME GENERATING ACTIVITIES	1	1	1	1.0	1.0	1.0	10	9	10	10.0	9.0	10.0	25	24
GRAND TOTAL	66	71	73	65.0	71.0	73.0	218	239	245	212.8	239.0	243.0	184	192

LIST OF ACRONYMS AND ABBREVIATIONS CITED

AEU	Agroecological Studies Unit (CIAT)
AGLINET	Agricultural Libraries Network (United Kingdom and FAO)
AGRINTER	Sistema Interamericano de Información para las Ciencias Agrícolas (also known as Inter-American Information System of Agricultural Sciences)
AGRIS	International Information System for the Agricultural Sciences and Technology (FAO)
ARTES	Asociación Regional de Tecnólogos en Semillas (for Central America, Panama, and the Caribbean region)
BCMV	Bean common mosaic virus
BGMV	Bean golden mosaic virus
BMMV	Bean mild mosaic virus
BNF	Biological nitrogen fixation
BRU	Biotechnology Research Unit (CIAT)
BTI	Boyce Thompson Institute for Plant Research (USA)
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza (for Central America, with headquarters in Costa Rica)
CBB	Common bacterial blight
CCMV	Colombian cassava mosaic virus
CENARGEN	Centro Nacional de Recursos Genéticos (Brazil)
CETREISEM	Centro de Estudos e Treinamento em Tecnologia de Sementes e Mudas (Brazil)
CGIAR	Consultative Group on International Agricultural Research (USA)
CGPRT	ESCAP Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots, and Tuber Crops in the Humid Tropics of Asia and the Pacific (Indonesia)
CIAT	Centro Internacional de Agricultura Tropical (Colombia)

CIBC	Commonwealth Institute of Biological Control (United Kingdom)
CIDA	Canadian International Development Agency (Canada)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (Mexico)
CIP	Centro Internacional de la Papa (Perú)
CISU	Communication and Information Support Unit (CIAT)
CMD	Cassava mosaic disease
CPAC	Centro de Pesquisa Agropecuária dos Cerrados (Brazil)
CPU	Central processing unit
CVL	Central Virology Laboratory (CIAT)
CsXV	Cassava X virus
DNA	Deoxyribonucleic acid
DRI	Programa de Desarrollo Rural Integrado (Colombia)
EEC	European Economic Community (Belgium)
ELISA	Enzyme-linked immunasorbent assay
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazil)
EMPASC	Empresa de Pesquisa Agropecuária de Santa Catarina (Brazil)
EMR	External Management Review (CIAT)
EPR	External Program Review (CIAT)
ESCAP	Economic and Social Commission for Asia and the Pacific (Thailand)
FAO	Food and Agriculture Organization of the United Nations (Italy)
FEDEARROZ	Federación Nacional de Arroceros (Colombia)
FSD	Frogskin disease
GAS	General Administrative Staff (CIAT)
GENSTAT	A General Statistical Program (United Kingdom)
GLIM-3	Generalised Linear Interactive Modelling, Release 3 (United Kingdom)
GRIN	Germplasm Resources Information Network (USA)
GRU	Genetic Resources Unit (CIAT)
IARCs	International agricultural research centers
IBPGR	International Board for Plant Genetic Resources (Italy)
IBYAN	International Bean Yield and Adaptation Nursery (CIAT)
ICA	Instituto Colombiano Agropecuario (Colombia)
ICM	Integrated crop management

ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
ICRO	International Cell Research Organization
ICTA	Instituto de Ciencia y Tecnología Agrícola (Guatemala)
IDB	Inter-American Development Bank (USA)
IDIAP	Instituto de Investigaciones Agropecuarias de Panamá
IDMS/R	Cullinet's Integrated Database Management System/Relational (USA)
IDRC	International Development Research Centre (Canada)
IFDC	International Fertilizer Development Center (USA)
IITA	International Institute of Tropical Agriculture (Nigeria)
ILCA	International Livestock Center for Africa (Ethiopia)
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuárias (Mexico)
INIPA	Instituto Nacional de Investigaciones y Promoción Agraria (Peru)
IPM	Integrated pest management
INTSORMIL	International Sorghum and Millet Program (USA)
IRAT	Institut de Recherches Agronomiques Tropicales et de Cultives Vivriéres (France)
IRRI	International Rice Research Institute (Philippines)
IRTP	International Rice Testing Program (Philippines)
ISIS	Interactive Simulation System (United Kingdom)
IVITA	Instituto Veterinario de Investigaciones Tropicales y de Altura (Perú)
JUNAC	La Junta del Acuerdo de Cartagena (Andean Pact, Colombia)
MINOS	Modular In-core Nonlinear Optimization System (USA)
MIRCEN	UNEP/UNESCO/ICRO Microbiological Resource Centre (Sweden)
MITA	Mayaguez Institute of Tropical Agriculture (Puerto Rico)
NAG	Numerical Algorithms Group (United Kingdom)
NARS	National agricultural research systems
NVRS	National Vegetable Research Station (United Kingdom)
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer (France)
PROCIANDINO	Programa Cooperativo de Investigación Agrícola para la Subregión Andina
RICA	Red Interamericana de Comunicadores Agrícolas (CIAT)
RIEPT	Red Internacional de Evaluación de Pastos Tropicales (CIAT) (Translates as International Tropical Pastures Evaluation Network.)
SADCC	Southern African Development Coordination Conference
SAS	Statistical Analysis System (USA)

SDC	Swiss Development Cooperation
SNICA	Subsistema Nacional de Información en Ciencias Agropecuárias (Colombia)
STAIRS	Storage and Information Retrieval System (USA)
TAC	Technical Advisory Committee of the CGIAR
TDRI	Tropical Development and Research Institute (United Kingdom)
UNDP	United Nations Development Programme (USA)
UNEP	United Nations Environmental Programme
UNESCO	United Nations Education, Scientific and Cultural Organization
USAID	United States Agency for International Development
VM/CMS	Virtual machine/conversational monitor system