Program Plans and Funding Requirements 1989-1993

Centro Internacional de Agricultura Tropical

CIAT PROGRAM AND BUDGET
1989-1993

CONTENTS

ACRONYMS

AID	United States Agency for International Development
ACIAR	Australian Centre for International Agricultural Research
BCMV	Bean common mosaic virus
BRU	Biotechnology Research Unit
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIDA	Canadian International Development Agency
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CNPAF	Centro Nacional de Pesquisas-Arroz e Feijao
CPAC	Centro de Pesquisa Agropecuária dos Cerrados
DNA-RFLP	DNA-Restriction fragment length polymorphism
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária
HCN	Hydrocyanic acid
IARC	International Agricultural Research Center
IBPGR	International Board for Plant Genetic Resources
ICA	Instituto Colombiano Agropecuario
ICARDA	International Center for Agricultural Research in the Dry Areas
IITA	International Institute of Tropical Agriculture
INIAA	Instituto Nacional de Investigación Agraria y Agroindustrial
ILCA	International Livestock Center for Africa
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
IRTP	International Rice Testing Program
IVITA	Instituto Veterinario de Investigaciones Tropicales y de Altura
MAG	Ministerio de Agricultura y Ganadería
ODNRI	Overseas Development Natural Resources Institute
P&B	Program and Budget
PROCICENTRAL	Programa Cooperativo de Investigación Agrícola de América Central y el Caribe
RIEPT	Red Internacional de Evaluación de Pasturas Tropicales (International Pasture Evaluation Network)

SADCC	Southern African Development Co-ordination Conference
TAC	Technical Advisory Committee
UNDP	United Nations Development Programme
WARDA	West Africa Rice Development Association

INTRODUCTION

This document provides a preview of the trends emerging for CIAT in the upcoming decade. Prepared in response to a request by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR), it summarizes some of the progress to date and outlines the plans. An exercise scheduled to begin in late 1988 is expected to culminate in CIAT's strategic plan for the 1990s. The strategic plan should be available for the center's external program review at the end of 1989. This program and budget for 1989-1993, therefore, is an interim plan to be read in conjunction with the results of planning for the long term and with earlier documents, such as **CIAT in the 1980s** and the updated operational plan for 1986-1990.

The strategic plan for the 1990s will be developed as an interactive process, including significant input from CIAT's national program partners with respect to what types of support they need and expect from CIAT. They will also be asked to anticipate how they will change during the next decade and how that is likely to modify the kinds of support required from CIAT. Since this five-year P&B was developed out of phase with CIAT's strategic planning schedule and in a very short period of time, such consultation in its preparation was necessarily limited.

Even without detailed analysis, however, it is clear that the environment in which CIAT will work during the next 5 years is changing rapidly—and the strategy of the center and its programs must be responsive to the changing scene. Three trends are central to these projections: the evolution of national programs, the changing scientific/technological base, and increased concern for sustainability.

CIAT's national program partners represent the most important element in CIAT's environment. Our plans are founded on the assumption that on average the national programs will grow stronger; and this will gradually modify our respective roles.

The scientific foundation on which CIAT's research is built is also changing rapidly; this is particularly true in the area of biotechnology, which offers new tools to solve old problems. The information and communications revolution will also change the way we go about our work.

CIAT associates itself strongly with the growing worldwide concern for the environment and natural resources. The program strategies described in this document reflect a commitment to sustainable production systems.

In its research and in its support to national programs, CIAT is but one element in an increasingly integrated global system. The international centers (IARCs) that form a part of this system are now well established and are developing a mature relationship with their national program partners and with each other.

All the centers have in common the goal of improving the lot of low-income farmers. Within the overall imperative to increase food production, the commodities, policies, resources, systems and technologies being researched are crucial to low-income peoples. CIAT has always been strongly committed to this goal. Each of the commodities receiving research attention has at least one of the following attributes: it is a relatively inexpensive source of calories or protein; it is part of the food budget of low-income consumers; or it is grown largely by low-resource farmers.

CIAT has been given a worldwide mandate for research on beans and cassava and a regional mandate for research on rice. Its work on tropical pastures is aimed chiefly at the vast, underutilized land masses of tropical America; however, technology generated for this ecosystem can benefit similar areas in other continents with marginal additional costs. Thus CIAT is making available promising pasture materials to interested institutions in Africa and Asia.

In the case of those commodities with a global mandate, CIAT strives to make the benefits of its research available to all parts of the Third World where these commodities are important. Where another IARC has regional responsibility for one of these commodities, CIAT works closely with that center, providing scientific and information backup support and ensuring that national programs in the region have access to the genetic diversity available at CIAT. Conversely, where CIAT has regional responsibility for a commodity in which a sister center has a global mandate, CIAT applies its comparative advantage of language facility, familiarity with the conditions, and close working relations with national agricultural research systems in the region to ensure that the germplasm methodology and scientific knowledge generated by the sister center are most effectively utilized in tropical America. CIAT also makes available these regional advantages and its facilities to other centers by hosting their staff at its headquarters.

Within the CGIAR network, CIAT currently has ties in the form of personnel, projects, data, germplasm, etc. with seven of the other IARCs; some initiatives are new and others, long-standing. Electronic links make communications almost as simple as between departments within the center.

The ties among the IARCS have expanded the expertise and resources upon which CIAT can draw to support national agricultural research systems—the main partners in research.

Within the partnerships, CIAT can perform some of the activities along the continuum from basic research to consumption; where it focuses its efforts depends on the capacity and programs of the countries involved. It cooperates with the other participants and attempts to concentrate on areas in which it has a comparative advantage. Its aim is to achieve complementarity.

The program activities and the budget envisaged for 1989-1993 set forth what is essential and what is desirable for CIAT to continue contributing effectively to the network of international and national centers working for productive, sustainable agriculture in the developing world.

CENTERWIDE STRATEGIES AND ALLOCATIONS: 1989-1993

The plan written for CIAT for the 1980s expressed its overall objective as being:

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

No change from this general goal is contemplated at this time. As part of the strategic planning exercise for the 1990s, this statement will be reexamined in the light of the current situation, projected trends and any concomitant changes in the Center's mission.

To reach our goal, we:

- Conduct sharply focused research to generate new knowledge, methods and technology components.
- Provide opportunities to individuals in the national agricultural research and development systems for enhancing their capability to complement CIAT in the generation and transfer of appropriate technologies.
- Organize and promote international and regional seminars, workshops and conferences as part of the activities to strengthen networks and to share knowledge and methods.
- Assist institutions involved in the generation and transfer of improved technology for commodities with which we have expertise.
- Contribute where possible to dialogue between research institutions in developed and developing countries; between national research institutions within regions; and between various research and development institutions within countries.
- Preserve and make available germplasm.
- Provide continuity when research efforts are likely to be abandoned because of the poor fortune of the executing institution.

The major program divisions in our center are by commodity—bean, cassava, rice, and tropical pastures—with support coming from the training and communications program and research units in agroecology, biotechnology, virology, genetic resources, and seed production and testing.

Center staff all seek technological innovations that are not dependent on high levels of purchased inputs and that use efficiently whatever inputs are applied—in line with the center's concerns for equity and the environment. Genetic resistance to insects and diseases and development of integrated est management technology help to reduce environmental pollution. Biological nitrogen fixation, selection of plants that inherently use nutrients more efficiently and that are more tolerant of adverse soil conditions are aimed at increasing production without excessively depleting natural resources. These ensure access to the benefits of CIAT technology by farmers whose lack of resources seriously limit the amounts of inputs they can purchase. Work on *Pennisetum* stakes grown on erosion control terraces for use as supports for climbing beans in Central Africa and work on crop combinations and cultivation practices to prevent erosion in cassava production in Latin America and Asia are examples of efforts to preserve the natural resource base.

New techniques and inputs are tested on farms in a series of trials that systematically diminish researchers' involvement in management while stepping up farmers' participation. The approach ensures that inputs are kept within the means of smallholders, and the center has been experimenting with methods to expand the input by farmers in the design of improved technologies. This "farmer participation research" has been regarded as highly desirable as a means to incorporate farmers' experience at an early stage in the technology-generation process. The results should put the center in a better position to assist national centers to get reliable information from farmers—what they need as well as what they do when and how. One senior staff position is set aside for this temporary activity and is paid for by a special project.

Probably the best example of low-input/high-output technology is improved germplasm. All of CIAT's programs have produced—and continue to produce in response to changing conditions—lines with increased yield potential, resistance to insects and diseases, and tolerance to environmental stresses. The combination of characters reduces risk and the need for the applications of insecticides, fungicides and other chemicals. Farmers all over Latin America and the Caribbean grow varieties from lines that were originally developed or distributed by CIAT. In addition, the germplasm banks assembled at the center represent a source of genetic diversity and security for scientists around the world.

The underlying philosophy is that the research must be relevant; the quality must be excellent; and the work must be founded on trust and responsibility. From this philosophy has grown the "CIAT culture." It represents commitment:

- To our **beneficiaries**, the poor—producers and consumers—to improve their welfare.
- To our national program **partners**, to provide the elements they need to develop and disseminate improved production technology.
- To our **donors**, to manage efficiently the resources they provide.
- To our **employees**, to create an atmosphere conducive for them to make a maximum contribution to the center's mission and to reward them appropriately.

- To society, to contribute to economic development in a manner that improves human welfare and dignity.

The center's research and international cooperation program has evolved over the years in response to continuous and rigorous analysis of the strategies, activities and resources required to meet its objectives; the relative strengths and capacities of the national program partners; the contributions from collaborating institutes throughout the world; and resource constraints.

Allocation of Resources

A look at CIAT's allocation of resources over the next 5 years (Table 1) demonstrates the directions in which the center is moving. For purposes of clarity and simplicity, the activities of the programs and support units have been aggregated into three categories: research, institution building and networking, and management and administration. The list of "Candidate Activities" approved by TAC for use in allocation of resources fits easily into these three major groups (Table 2). It should be mentioned that one senior staff position is allocated for the temporary activity on "farmers' participation research" and is paid for by a special project. As this is a centerwide activity it is currently shown as a "desirable" position within the research services component of the budget.

In the overall projections, the costs for centralized administrative services and management remain fairly constant while the programs' activities grow. This results in a decrease in the percentage devoted to "management and administration" and an increase in "research," with the percentage devoted to "institution building/ networking" changing little.

The projected increase in the proportion of research activities is caused primarily by an expansion in specialized research to support national programs. Strong national programs now take on some responsibilities previously carried out by CIAT and other IARCs—a trend frequently referred to as devolution. Most countries, for example, do much of the breeding of the crops and production training. Similarly, national programs are becoming the leaders in setting policies and deciding methods for networking activities.

In looking to the future, we believe the trend will continue and that national programs will gain recognition and, hence, greater support from policymakers. The more skills that national scientists have, the higher the level of research backstopping that will be expected from CIAT; and the greater its role in linking groups for mutual benefit and overall savings.

At the same time, the national programs will be under increasing pressure to show an impact. The IARCs need to be in a position to assist national programs in building bridges between research and technology transfer institutions and in developing national commodity plans. In other words, on-farm trials, support for trainers, utilization, marketing, etc. will receive increased attention. CIAT has begun to upgrade its capacity to provide support in these areas.

In sum, the national centers are assuming more of the "midstream" functions (i.e., development of tech-

Table 1

Summary: Resource Utilization by Activities for the Years 1988, 1989 and 1993

ACTIVITIES	1988	1989	1993	1988	1989	1993
	% of Total CIAT			% of Category		
RESEARCH						
Natural Resources	3.7%	3.9%	4.4%	7.7%	8.0%	8.8%
Genetic Resources	5.4%	5.5%	4.8%	11.3%	11.3%	9.6%
Crop Improvement	15.3%	15.0%	13.3%	31.9%	30.8%	26.6%
Crop Production	7.2%	7.3%	7.0%	15.0%	15.0%	14.0%
Crop Protection	6.2%	6.1%	6.0%	12.9%	12.5%	12.0%
Livestock Production	3.1%	3.2%	3.9%	6.5%	6.6%	7.8%
Analysis	2.6%	2.6%	3.1%	5.4%	5.4%	6.2%
Utilization	0.5%	0.6%	1.0%	1.0%	1.2%	2.0%
Exploratory Res. & Method. Develop.	3.7%	4.2%	5.9%	7.7%	8.6%	11.8%
Analysis of Impact	0.3%	0.3%	0.6%	0.6%	0.6%	1.2%
TOTAL RESEARCH	48.0%	48.7%	50.0%	100.0%	100.0%	100.0%
INSTITUTION BUILDING & NETWORKING						
Training	12.0%	11.9%	12.0%	37.4%	36.8%	37.4%
Conferences and Seminars	3.0%	3.1%	3.3%	9.4%	9.6%	10.3%
Documentation & Information	5.2%	5.3%	5.2%	16.3%	16.4%	16.3%
Counseling/Advising NARS	5.3%	5.3%	4.5%	16.6%	16.4%	14.1%
Technical Assistance	1.8%	2.0%	2.1%	5.6%	6.2%	6.6%
Network Coordination	4.7%	4.7%	4.9%	14.7%	14.6%	15.3%
TOTAL INSTIT. BUILD. & NETWORKING	32.0%	32.3%	32.0%	100.0%	100.0%	100.0%
MANAGEMENT AND ADMINISTRATION	20.0%	19.0%	18.0%			
TOTALS	100.0%	100.0%	100.0%			

Table 2

Relation of Activities as Presented in this Document to List of "Candidate Activities"

Activities as Presented by CIAT	Activities Approved by TAC
RESEARCH	
Natural Resources	1. Water Management Research
	2. Soil Management & Conservation Research
	3. Agroclimatology Research
Genetic Resources	4. Germplasm
	a. Research on conservation & diversity
	b. Collection
	c. Conservation, characterization & documentation
Crop Improvement	4. d. Enhancement
	e. Plant breeding/improvement
	f. International trials
Crop Production	5. Seed Production
	6. Crop Systems Research
	10. Plant Nutrition Research
	11. Machinery Research and Development
Crop Protection	9. Plant Protection Research
Livestock Production	7. Livestock Systems Research
	8. Crop-Livestock Systems Research
	12. Livestock Nutrition Research
Analysis	22. Economic & Social Analysis at Micro-Level
	23. Market Analysis
	24. Policy Analysis
	25. Nutrition & Consumption Anal.
Utilization	28. Conversion & Utilization Res.
Exploratory Research & Methodology Development	18. Research on Approaches, Concepts, Methods & Procedures
	27. Exploratory Research
Analysis of Impact	26. Research on Research
INSTITUTION BUILDING AND NETWORKING	
Training	15. Human Resources Enhancement
	a. Specialized courses
	b. Individual internships
	c. Degree-related
Conferences and Seminars	16. Conferences & Seminars
Documentation & Information	17. Documentation & Dissemination
Counseling/Advising NARS	19. Counseling and Advising NARS
Technical Assistance	20. Technical Assistance
Network Coordination	21. Coordination of Networks

NOTE: Not included in above listing are Activity #14, Livestock Disease Research, and Activity #13, Livestock Reproduction Research, as CIAT does not engage in these activities.

Table 3

Summary: Comparison beetwen Commodity Research Programs in terms of resource utilization by activities for the years 1988, 1989 and 1993

(Percent of resources spent by Commodity Research Programs, plus resources spent by Research Support Programs on behalf of Cornmodity Research Programs)

	1 9 8 8					1 9 8 9					1 9 9 3				
	BEANS	CASSAVA	RICE	TROPICAL PASTURES	TOTAL	BEANS	CASSAVA	RICE	TROPICAL PASTURES	TOTAL	BEANS	CASSAVA	RICE	TROPICAL PASTURES	TOTAL
RESEARCH	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Natural Resources	1.4%	0.7%	0.5%	1.1%	3.7%	1.4%	0.8%	0.6%	1.2%	3.9%	1.5%	1.1%	0.7%	1.2%	4.6%
Genetic Resources	2.0%	1.0%	0.7%	1.7%	5.4%	1.9%	1.1%	0.8%	1.7%	5.5%	1.6%	1.2%	0.5%	1.5%	4.8%
Crop Improvement	5.7%	2.9%	2.0%	4.7%	15.3%	5.3%	3.0%	2.3%	4.5%	15.0%	4.4%	3.2%	1.5%	4.3%	13.3%
Crop Production	2.7%	1.4%	0.9%	2.2%	7.2%	2.6%	1.5%	1.1%	2.2%	7.3%	2.3%	1.7%	0.8%	2.2%	7.0%
Crop Protection	2.3%	1.2%	0.8%	1.9%	6.2%	2.1%	1.2%	0.9%	1.8%	6.1%	2.0%	1.4%	0.9%	1.7%	6.0%
Livestock Production	0.0%	-0.0%	0.0%	3.1%	3.1%	0.0%	0.0%	-0.0%	3.2%	3.2%	0.0%	-0.0%	-0.0%	3.9%	3.9%
Analysis	1.0%	0.5%	0.3%	0.8%	2.6%	0.9%	0.5%	0.4%	0.8%	2.6%	1.0%	0.7%	0.5%	0.8%	3.1%
Utilization	-0.0%	0.6%	-0.0%	-0.0%	0.5%	0.0%	0.6%	-0.0%	-0.0%	0.6%	0.0%	1.0%	-0.0%	-0.0%	1.0%
Exploratory & Methodology Development	1.4%	0.7%	0.5%	1.1%	3.7%	1.5%	0.8%	0.6%	1.3%	4.2%	2.1%	1.4%	0.6%	1.7%	5.9%
Analysis of Impact	0.1%	0.1%	0.0%	0.1%	0.3%	0.1%	0.1%	0.0%	0.1%	0.3%	0.2%	0.1%	0.1%	0.2%	0.6%
TOTAL RESEARCH	16.5%	9.0%	5.7%	16.8%	48.0%	15.7%	9.6%	6.7%	16.6%	48.7%	15.1%	11.8%	5.6%	17.5%	50.0%
INSTITUTION BUILDING & NETWORKING															
Training	4.4%	2.3%	1.6%	3.7%	12.0%	4.2%	2.4%	1.8%	3.6%	11.9%	4.3%	2.9%	1.3%	3.5%	12.0%
Conferences and Seminars	1.1%	0.6%	0.4%	0.9%	3.0%	1.1%	0.6%	0.5%	0.9%	3.1%	1.3%	0.8%	0.4%	0.9%	3.3%
Documentation & Information	1.9%	1.0%	0.7%	1.6%	5.2%	1.9%	1.1%	0.8%	1.6%	5.3%	1.8%	1.2%	0.6%	1.6%	5.2%
Counseling/Advising NARS	2.0%	1.0%	0.7%	1.6%	5.3%	1.9%	1.1%	0.8%	1.6%	5.3%	1.5%	1.1%	0.5%	1.4%	4.5%
Technical Assistance	0.7%	0.3%	0.2%	0.6%	1.8%	0.7%	0.4%	0.3%	0.6%	2.0%	0.7%	0.5%	0.3%	0.6%	2.1%
Network Coordination	1.7%	0.9%	0.6%	1.5%	4.7%	1.6%	0.9%	0.7%	1.4%	4.7%	1.9%	1.2%	0.5%	1.3%	4.9%
TOTAL INSTIT. BUILD. & NETWORKING	11.8%	6.1%	4.2%	9.9%	32.0%	11.3%	6.5%	4.8%	9.7%	32.3%	11.5%	7.7%	3.6%	9.2%	32.0%
MANAGEMENT AND ADMINISTRATION	7.4%	3.8%	2.6%	6.2%	20.0%	6.6%	3.8%	2.8%	5.7%	19.0%	5.9%	4.3%	2.0%	5.8%	18.0%
T O T A L S -	35.7%	18.9%	12.5%	32.9%	100.0%	33.7%	19.9%	14.4%	32.0%	100.0%	32.5%	23.8%	11.2%	32.5%	100.0%

nology components), so CIAT will simultaneously increase its activities at both ends of the spectrum. In fact, many current staff are gradually moving upstream by the nature of their work; and additional staff—for example, two senior staff for the Biotechnology Research Unit, a second breeder for the Cassava Program, a utilization specialist in the Cassava Program, and a senior person in the Training and Communications program—represent either increased sophistication in research or increased strength in reaching the intended beneficiaries.

During the next 5 years, the investment in research on natural resources—agroclimatology and soil and water management—will rise (Table 3); and the real increase is greater than the figures indicate for several reasons. For example, the Cassava Program has incorporated in its budget a position that was funded in 1988 by a temporary special project. The position is dedicated to work on soil erosion and maintenance of soil fertility in Asia and represents a new commitment not reflected in comparisons between 1988 and later years (since it is included in the 1988 aggregate data).

Sustainability concerns are reflected in the increase in the category "natural resources," but only to a very partial extent. CIAT is committed to the challenge of increasing food production in a manner that does not rob future generations of the resources to attain a high quality of life. This means that all scientists—breeders, agronomists, systems specialists alike—are expected to conduct their research with a sustainability perspective. Much of this will be done in the "crop improvement" and "crop production" activities. Thus trends to increase this emphasis will be seen more **within** rather than **between** categories of activities.

Through work on cropping systems, erosion control, minimal tillage, nutrient recycling and soil fertility, CIAT programs are striving to combat soil degradation and environmental pollution. We are convinced that more needs to be done in the future. A number of the additions to senior staff fall into this category; e.g., the land systems geographer in the Agroecological Studies Unit; the agronomist in the Cassava Program for Asia; the production systems specialists for the savanna and for the humid tropics in the Tropical Pastures Program; and the integrated pest management specialist in the Rice Program.

A modest decline is expected in allocations to research on "genetic resources" and is a reflection of reduced efforts in collection of germplasm for tropical pastures, following 10 years of a concerted search. The decline masks increases in collection of wild species planned for the Bean Program and increased efforts in collection and evaluation projected for the Cassava Program (Table 3).

Total allocations to research on crop improvement also show a slight decline although the drop has been largely offset by the Cassava Program's increased activities to support crop improvement in Africa (Table 3); plans are to place one breeder in an Africa-like ecosystem in Brazil and another at IITA in Ibadan, Nigeria.

The set of activities related to utilization is slated to increase modestly, owing chiefly to the considerable growth in utilization work projected for the Cassava Program.

A slight upward trend in counseling and technical assistance for national agricultural centers reflects the continuing decentralization of all the programs, particularly Rice and Cassava.

The Bean Program is shown to devote much more of its resources to institution building/networking than do the other programs (Table 3), essentially as a result of what it has been investing, and will continue to invest, in large, regional programs that work with national programs in Africa.

Cost Assumptions and Financial Requirements

Essential and Desirable Activities, and Considerations of Scale

Throughout the text and accompanying tables, this document makes reference to "essential" and "desirable" activities. As proposed by TAC in 1986, essential activities are the minimum necessary for the Center to carry out its mandate and meet its objectives in research and international cooperation. Desirable activities enhance and complement essential activities; they have high priority and high payoff potential but are not strictly required.

Two important issues arise from these considerations: how to distinguish between essential and desirable; and the scale of activities projected. These are interrelated, especially in relation to senior staff positions. It is not difficult to recognize certain activities or disciplines as essential components of a multidisciplinary program. What is harder to define is how many senior staff in a given discipline are needed to form a critical mass. That must be answered by defining the task to be accomplished. In CIAT's commodity programs, the **essential scale** of activities chiefly relates to the geographic areas and/or ecosystems that are essential in relation to TAC priorities and the centerwide strategy. CIAT has defined essential positions as those required to make up a critical mass to cover the highest-priority regions for CIAT's mandate commodities. A narrowing of the geographic/ecosystem coverage would reduce the scale and vice versa. Some of the positions listed as desirable would permit CIAT to broaden its coverage to areas where the commodity is important enough that such involvement would be a good investment but are less important than those covered by essential positions. Other desirable positions are more of the type to speed up the research or technology transfer process.

The issue of level of support given to each senior staff member has to do more with productivity and cost effectiveness than area covered. The most appropriate pyramid of support and the amounts of supplies/services required vary from research program to research program, depending on the nature of the crop; and the amounts assigned for local and international travel vary with the research locations and geographic coverage of the programs. CIAT is confident that the levels of these types of support now allocated to each program are near optimum, as they have evolved over many years of experience and intense budget scrutiny, especially in particularly lean years when CIAT chose to reduce the number of senior staff (and thus cut out entire subprograms) rather than reduce the level of support below that at which the valuable and expensive resource represented by international staff is fully utilized.

Basic Unit for Scale and Budget Indications

Over the years, CIAT—as well as the CGIAR System—has found that, at least for research and related support activities, the most pertinent budgetary unit is the **senior staff position**. They are typically synonymous with research sections, each devoted to a disciplinary speciality and each consisting of a full complement of professional and other support staff, as well as operational resources. Essentially, CIAT adds to, subtracts from, or modifies its research program by the addition, elimination, or transfer of discrete research sections, each headed by a senior staff. Thus a budget presentation largely based on senior staff positions/research sections allows for ready comparison across programs as well as over time. It also has the advantage of pointing to the basic program components that underlie the management of the Center.

The Budget Request

Table 4 presents the budget request for 1989-1993 in terms of the proposed senior staffing pattern. (Table 4A shows a summary of all support staff positions associated with **essential** senior staff positions; Table 4B does the same for **desirable** senior staff positions.) Table 5 shows the proposed annual budgets for 1989 to 1993 in current U.S. dollars.

As there are existing donor commitments for selected aspects of the proposed budget, and as CIAT expects to generate a modest income from the sale of agricultural products and other services it provides, the actual amounts requested of the donors is less than the totals shown in the overall budget. Table 6 provides a reconciliation between the budgeted amounts and the amounts requested of the donor community.

Capital Outlays

Under "Capital," CIAT has included projected needs for the **replacement** of existing equipment/machinery and the existing plant, as well as projected needs for **additional** research equipment/machinery and modest expansions in infrastructure.

As is done in the area of operations, the budget request for capital outlays is presented along the lines of essential and desirable components.

Essential Resources for Capital

Capital replacement: equipment/machinery. Instead of following a capital depreciation practice, CIAT is budgeting the cost for replacing existing research equipment, machinery, and other nonbuilding related items with replacement value on an annual basis. In late 1988 the total value of such items amounted to some US$13.5 million. Based on CIAT's experience showing that the average useful life of such items is ten years, after which time some 20 percent of the original cost of the equipment can be recovered, the yearly cost for equipment/machinery replacement is budgeted at US$1.08 million.

Capital replacement: major plant maintenance. The total value of the building infrastructure at CIAT headquarters is approximately US$20 million. Some two-thirds of that infrastructure is 15 years old, with the remainder rather evenly distributed between one and 15 years. Over the years, CIAT has continually attempted to keep its infrastructure in very good condition to prevent sudden and large expenses for the upkeep of its infras-

Approved Senior Staff Positions for 1988, and Projected Essential and Desirable Positions for 1989-1993

Table 4

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable
COMMODITY RESEARCH PROGRAMS												
BEANS												
At Headquarters	12	-	12	-	12	-	12	-	12	-	12	-
Decentralized	6	11	11	8	11	8	10	9	10	9	10	9
CASSAVA												
At Headquarters	8	-	8	-	10	-	10	-	10	-	10	-
Decentralized	2	3	4	3	4	3	5	3	5	3	5	3
RICE												
At Headquarters	7	-	8	-	8	-	8	-	8	-	8	-
Decentralized	-	-	-	2	-	2	-	2	-	2	-	2
TROPICAL PASTURES												
At Headquarters	13	-	13	-	13	-	13	-	13	-	13	-
Decentralized	5	-	5	-	5	1	6	2	6	2	6	2
TOTAL COMMODITY RESEARCH PROGRAMS												
At Headquarters	40	-	41	-	43	-	43	-	43	-	43	-
Decentralized	13	14	20	13	20	14	21	16	21	16	21	16
Total Research Programs	53	14	61	13	63	14	64	16	64	16	64	16
RESEARCH SUPPORT												
GENETIC RESOURCES												
Botanist, Head	1	-	1	-	1	-	1	-	1	-	1	-
BIOTECHNOLOGY RESEARCH												
Tissue Culture Specialist	1	-	1	-	1	-	1	-	1	-	1	-
Biochemist/Molec.Biologist			1	-	1	-	1	-	1	-	1	-
Cytogeneticist							1	-	1	-	1	-
VIROLOGY RESEARCH												
Virologist(s)	2	-	2	-	2	-	2	-	2	-	2	-
STATION OPERATIONS												
Superintendent	1	-	1	-	1	-	1	-	1	-	1	-
DATA SERVICES												
Head	1	-	1	-	1	-	1	-	1	-	1	-
AGROECOLOGICAL STUDIES												
Agroecologist	1	-	1	-	1	-	1	-	1	-	1	-
Agric. Geographer			1	-	1	-	1	-	1	-	1	-
SEEDS												
Head (Seed Systems Mgt. Spec.)	1	-	1	-	1	-	1	-	1	-	1	-
Seed Specialist (Production, Planning & Organization)	1	-	1	-	1	-	1	-	1	-	1	-
FARMER PARTICIPATION RESEARCH	-	1	-	1	-	1	-	1	-	1	-	1
Total Research Support	9	1	11	1	11	1	12	1	12	1	12	1
TRAINING AND COMMUNICATION												
Leader	1	-	1	-	1	-	1	-	1	-	1	-
Head, Training & Conferences					1	-	1	-	1	-	1	-
Head, Information	1	-	1	-	1	-	1	-	1	-	1	-
Head, Publications	1	-	1	-	1	-	1	-	1	-	1	-
Head, Public Information	1	-	1	-	1	-	1	-	1	-	1	-
Total Training and Communication	4	0	4	0	5	0	5	0	5	0	5	0
ADMINISTRATION												
OFFICE OF DIRECTOR GENERAL												
Director General	1	-	1	-	1	-	1	-	1	-	1	-

Approved Positions for 1988, and Projected Essential Positions for 1989-1993

Table 4.A

	SENIOR STAFF						SUPPORT STAFF																		TOTAL STAFF					
							SCIENTIFIC AND SUPERVISORY						CLERICAL						OTHER SUPPORT STAFF											
	ACT.	BUDGET					ACT.	BUDGET					ACT.	BUDGET					ACT.	BUDGET					ACT.	BUDGET				
	88	89	90	91	92	93	88	89	90	91	92	93	88	89	90	91	92	93	88	89	90	91	92	93	88	89	90	91	92	93
COMMODITY RESEARCH PROGRAMS																														
Beans	23	23	23	22	22	22	45	45	45	43	43	43	17	17	17	16	16	16	153	153	153	153	153	153	238	238	238	234	234	234
Cassava	11	12	14	15	15	15	23	25	29	31	31	31	11	12	13	14	14	14	98	100	114	116	116	116	143	149	170	176	176	176
Rice	7	8	8	8	8	8	17	18	18	18	16	16	8	9	9	9	7	7	79	83	83	83	75	75	111	118	118	118	106	106
Tropical Pastures	18	18	18	19	19	19	38	38	38	40	40	40	12	12	12	13	13	13	161	161	161	167	167	167	229	229	229	239	239	239
Subtotal Research Programs	59	61	63	64	64	64	123	126	130	132	130	130	48	50	51	52	50	50	491	497	511	519	511	511	721	734	755	767	755	755
RESEARCH SUPPORT																														
Genetic Resources	1	1	1	1	1	1	4	4	4	4	4	4	2	2	2	2	2	2	26	26	27	28	28	28	33	33	34	35	35	35
Biotechnology Research	1	2	2	3	3	3	4	7	7	10	10	10	1	2	2	2	2	2	7	12	12	17	17	17	13	23	23	32	32	32
Virology Research	2	2	2	2	2	2	5	5	5	5	5	5	1	1	1	1	1	1	7	7	7	7	7	7	15	15	15	15	15	15
Research Services	-	-	-	-	-	-	4	4	4	4	4	4	1	1	1	1	1	1	21	21	22	22	22	22	26	26	27	27	27	27
Station Operations	1	1	1	1	1	1	5	5	5	5	5	5	3	3	3	3	3	3	82	84	87	87	87	87	91	93	96	96	96	96
Carimagua Station	-	-	-	-	-	-	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	11	11	11	11	11	11
Data Services	1	1	1	1	1	1	10	10	10	11	11	11	8	8	8	9	9	9	2	2	2	2	2	2	21	21	21	23	23	23
Agroecological Studies	1	2	2	2	2	2	3	6	6	6	6	6	1	1	1	1	1	1	4	8	8	8	8	8	9	17	17	17	17	17
Seeds	2	2	2	2	2	2	7	7	7	7	7	7	2	2	2	2	2	2	9	9	9	9	9	9	20	20	20	20	20	20
Subtotal Research Support	9	11	11	12	12	12	46	52	52	56	56	56	23	24	24	25	25	25	161	172	177	183	183	183	239	259	264	276	276	276
Total Research	68	72	74	76	76	76	169	178	182	188	186	186	71	74	75	77	75	75	652	669	688	702	694	694	960	993	1,019	1,043	1,031	1,031
TRAINING & COMMUNICATION																														
Training & Conferences	-	-	1	1	1	1	12	12	13	13	13	13	5	5	6	6	6	6	4	4	5	5	5	5	21	21	25	25	25	25
Communication & Information	4	4	4	4	4	4	27	27	27	27	27	27	18	18	18	19	19	19	35	35	35	35	35	35	84	84	84	85	85	85
Total Training and Communic.	4	4	5	5	5	5	39	39	40	40	40	40	23	23	24	25	25	25	39	39	40	40	40	40	105	105	109	110	110	110
ADMINISTRATION																														
Office of Director General	2	2	2	2	2	2	6	6	6	6	6	6	4	4	4	4	4	4	2	2	2	2	2	2	14	14	14	14	14	14
Directors	3	3	3	3	3	3	4	4	4	4	4	4	7	7	7	7	7	7	1	1	1	1	1	1	15	15	15	15	15	15
Administrative Support	2	2	2	2	2	2	28	29	29	30	30	30	73	75	77	79	79	79	5	5	5	5	5	5	108	111	113	116	116	116
Total Administration	7	7	7	7	7	7	38	39	39	40	40	40	84	86	88	90	90	90	8	8	8	8	8	8	137	140	142	145	145	145
GENERAL OPERATING EXPENSES																														
Physical Plant	-	-	-	-	-	-	6	6	6	6	6	6	11	11	11	11	11	11	151	152	153	155	155	155	168	169	170	172	172	172
Motor Pool	-	-	-	-	-	-	1	1	1	1	1	1	4	4	4	4	4	4	46	47	48	48	48	48	51	52	53	53	53	53
Total General Operating Exp.	0	0	0	0	0	0	7	7	7	7	7	7	15	15	15	15	15	15	197	199	201	203	203	203	219	221	223	225	225	225
SELF-SUPPORTING & INCOME-GENERATING ACTIVITIES	-	-	-	-	-	-	15	15	15	15	15	15	19	19	19	19	19	19	60	60	60	60	60	60	94	94	94	94	94	94
T O T A L	79	83	86	88	88	88	268	278	283	290	288	288	212	217	221	226	224	224	956	975	997	1013	1005	1005	1515	1553	1587	1617	1605	1605

Table 4.B

Projected Desirable Positions for 1989-1993

	SENIOR STAFF					SUPPORT STAFF															TOTAL STAFF				
						SCIENTIFIC AND SUPERVISORY					CLERICAL					OTHER SUPPORT STAFF									
	BUDGET					BUDGET					BUDGET					BUDGET					BUDGET				
	89	90	91	92	93	89	90	91	92	93	89	90	91	92	93	89	90	91	92	93	89	90	91	92	93
COMMODITY RESEARCH PROGRAMS																									
Beans	8	8	9	9	9	5	5	7	7	7	3	3	4	4	4	11	11	11	11	11	27	27	31	31	31
Cassava	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	-	-	-	-	-	7	7	7	7	7
Rice	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	10	10	10	10	10
Tropical Pastures	-	1	2	2	2	-	1	4	4	4	-	1	3	3	3	-	1	3	3	3	0	4	12	12	12
Total Research Programs	13	14	16	16	16	10	11	16	16	16	6	7	10	10	10	15	16	18	18	18	44	48	60	60	60
RESEARCH SUPPORT																									
Farmer Participation Research	1	1	1	1	1	4	4	4	4	4	1	1	1	1	1	3	3	3	3	3	9	9	9	9	9
TOTAL RESEARCH	14	15	17	17	17	14	15	20	20	20	7	8	11	11	11	18	19	21	21	21	53	57	69	69	69

Approved Budget for 1988, and Projected Budgets for Essential and Desirable Activities for 1989-1993 (Constant 1988 US$)

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable
COMMODITY RESEARCH												
BEAN PROGRAM	3,221,610	2,791,480	4,497,870	1,813,850	4,501,437	1,765,875	4,369,907	1,927,023	4,369,907	1,927,023	4,369,907	1,927,023
CASSAVA PROGRAM	2,143,923	384,000	2,608,923	199,000	3,092,923	199,000	3,207,923	199,000	3,207,923	199,000	3,207,923	199,000
RICE PROGRAM	1,279,720	491,645	1,952,760	400,000	1,848,945	400,000	1,539,953	400,000	1,419,720	400,000	1,419,720	400,000
TROPICAL PASTURES PROGRAM	3,453,675	-	3,453,675	-	3,453,675	200,000	3,653,675	400,000	3,653,675	400,000	3,653,675	400,000
Total Research Programs	10,098,928	3,667,125	12,513,228	2,412,850	12,896,980	2,564,875	12,771,458	2,926,023	12,651,225	2,926,023	12,651,225	2,926,023
RESEARCH SUPPORT												
VISITING SCIENTISTS AND PDFs	670,688	-	670,688	-	670,688	-	670,688	-	670,688	-	670,688	-
GENETIC RESOURCES	403,651	-	403,651	-	403,651	-	403,651	-	403,651	-	403,651	-
BIOTECHNOLOGY RESEARCH												
Tissue Culture Specialist	235,229	-	235,229	-	235,229	-	235,229	-	235,229	-	235,229	-
Biochemist/Molec.Biologist	-	-	242,000	-	242,000	-	242,000	-	242,000	-	242,000	-
Cytogeneticist	-	-	-	-	-	-	242,000	-	242,000	-	242,000	-
VIROLOGY RESEARCH	278,322	-	278,322	-	278,322	-	278,322	-	278,322	-	278,322	-
RESEARCH SERVICES	320,372	-	320,372	-	320,372	-	320,372	-	320,372	-	320,372	-
STATION OPERATIONS	783,977	-	783,977	-	783,977	-	783,977	-	783,977	-	783,977	-
CARIMAGUA STATION	615,509	-	615,509	-	615,509	-	615,509	-	615,509	-	615,509	-
DATA SERVICES	522,518	-	522,518	-	522,518	-	522,518	-	522,518	-	522,518	-
AGROECOLOGICAL STUDIES												
Agroecologist	177,565	-	177,565	-	177,565	-	177,565	-	177,565	-	177,565	-
Agric. Geographer	-	-	190,000	-	190,000	-	190,000	-	190,000	-	190,000	-
SEEDS	550,522	-	550,522	-	550,522	-	550,522	-	550,522	-	550,522	-
RESEARCH CONTRACTS	-	-	100,000	-	140,000	-	180,000	-	220,000	-	260,000	-
FARMER PARTICIPATION RESEARCH	-	148,550	-	167,350	-	167,350	-	167,350	-	167,350	-	167,350
Total Research Support	4,558,351	148,550	5,090,351	167,350	5,130,351	167,350	5,412,351	167,350	5,452,351	167,350	5,492,351	167,350
TRAINING AND COMMUNICATION												
Leader	135,176	-	135,176	-	135,176	-	135,176	-	135,176	-	135,176	-
Head, Training & Conferences	1,269,594	-	1,269,594	-	1,409,594	-	1,409,594	-	1,409,594	-	1,409,594	-
Head, Information	517,395	-	517,395	-	517,395	-	517,395	-	517,395	-	517,395	-
Head, Publication	361,301	-	361,301	-	361,301	-	361,301	-	361,301	-	361,301	-
Head, Public Information	136,586	-	136,586	-	136,586	-	136,586	-	136,586	-	136,586	-
Training Materials	99,784	-	99,784	-	99,784	-	99,784	-	99,784	-	99,784	-
Graphic Arts	363,045	-	363,045	-	363,045	-	363,045	-	363,045	-	363,045	-
Total Training and Communication	2,882,881	0	2,882,881	0	3,022,881	0	3,022,881	0	3,022,881	0	3,022,881	0
MANAGEMENT AND ADMINISTRATION												
BOARD OF TRUSTEES	175,636	-	175,636	-	175,636	-	175,636	-	175,636	-	175,636	
OFFICE OF DIRECTOR GENERAL												
Director General	517,514	-	517,514	-	517,514	-	517,514	-	517,514	-	517,514	-
Deputy Directors General	413,795	-	413,795	-	413,795	-	413,795	-	413,795	-	413,795	-
Director of Finance & Admin.	227,168	-	227,168	-	227,168	-	227,168	-	227,168	-	227,168	-
PROJECTS OFFICE (*)	-	-	-	-	-	-	-	-	-	-	-	-
ADMINISTRATIVE SUPPORT												
Executive Officer	357,051	-	357,051	-	357,051	-	357,051	-	357,051	-	357,051	-
Controller's Office	401,777	-	401,777	-	401,777	-	401,777	-	401,777	-	401,777	-
Human Resources	230,600	-	230,600	-	230,600	-	230,600	-	230,600	-	230,600	-
Administrative Systems	231,240	-	231,240	-	231,240	-	231,240	-	231,240	-	231,240	-
Supplies	287,987	-	287,987	-	287,987	-	287,987	-	287,987	-	287,987	-
Total Mgt.and Administration	2,842,767	0	2,842,767	0	2,842,767	0	2,842,767	0	2,842,767	0	2,842,767	0
GENERAL OPERATING EXPENSES												
Physical Plant	1,143,882	-	1,143,882	-	1,143,882	-	1,143,882	-	1,143,882	-	1,143,882	-
Motor Pool	521,650	-	521,650	-	521,650	-	521,650	-	521,650	-	521,650	-
General Expenses	817,452	-	817,452	-	817,452	-	817,452	-	817,452	-	817,452	-
Total General Operating Exp.	2,482,984	0	2,482,984	0	2,482,984	0	2,482,984	0	2,482,984	0	2,482,984	0

Projected Resources Required for 1989-1993

Breakdown by existing commitments, self-generated income, and new requests to donors

	1989				1990				1991				1992				1993			
	Essential		Desirable		Essential		Desirable		Essential		Desirable		Essential		Desirable		Essential		Desirable	
	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount	Senior Staff Posit.	Amount
CATEGORIES OF EXPENSES																				
Personnel		16,450,846		1,383,898		16,913,244		1,528,322		17,192,919		1,794,622		17,162,544		1,794,622		17,162,544		1,794,622
Training		2,021,807		223,648		2,038,807		223,648		1,944,607		223,648		1,923,107		223,648		1,923,107		223,648
Supplies and Services		4,516,665		384,259		4,586,665		398,598		4,632,905		420,828		4,595,035		420,828		4,595,035		420,828
Travel		1,915,992		180,424		1,955,792		200,372		1,895,792		223,372		1,895,192		223,372		1,895,192		223,372
Other Expenses		827,455		353,918		881,455		327,299		804,692		376,917		826,839		376,917		916,330		376,917
Equipment Replacement		1,300,000		250,000		1,300,000		250,000		1,300,000		250,000		1,300,000		250,000		1,300,000		250,000
Capital		550,000		500,000		730,000		500,000		550,000		500,000		730,000		500,000		550,000		500,000
Contingency		356,068		87,355		284,060		88,808		345,350		92,420		334,313		92,420		283,422		92,420
Working Capital Adjust.		262,386		285,898		63,851		13,051		-		31,005		8,565		-		-		-
Provision for Price Changes		1,410,061		182,470		2,947,272		361,835		4,318,520		616,757		6,201,321		836,554		7,908,734		1,072,472
TOTAL	83	29,611,280	14	3,831,870	86	31,701,146	15	3,891,933	88	33,184,785	17	4,529,569	88	34,976,916	17	4,718,361	88	36,534,364	17	4,954,279
SOURCES OF FUNDS																				
Existing Commitments from Donors	6	2,568,516	7	1,581,200	5	2,278,268	6	1,365,875	-	-	5	1,381,845	-	-	-	-	-	-	-	-
CIAT Self-generated Income	1	649,000	-	-	1	681,450	-	-	1	715,523	-	-	1	751,299	-	-	1	788,864	-	-
	7	3,217,516	7	1,581,200	6	2,959,718	6	1,365,875	1	715,523	5	1,381,845	1	751,299	0	0	1	788,864	0	0
Outside Funding Requested	76	26,393,764	7	2,250,670	80	28,741,428	9	2,526,058	87	32,469,262	12	3,147,724	87	34,225,617	17	4,718,361	87	35,745,500	17	4,954,279
Total Needed from Donors		$33,443,150				$35,593,079				$37,714,354				$39,695,277				$41,488,643		

tructure. To continue this practice, CIAT has budgeted an annual amount of US$220,000 for this item.

New capital: research equipment and machinery. CIAT's experience shows that—within the context of trying to strike a reasonable balance between very sizable requests for additional, new laboratory/research equipment and other nonbuilding related capital items on the one hand, and limited resource availability on the other hand—a minimum of US$550,000 per annum is needed for this item. With the advent of ever more sophisticated research equipment and the consequent pressure on CIAT to remain at least somewhat competitive with other advanced research institutions, this amount is the minimum of the requirements.

New capital: infrastructure development. CIAT has reached a size at headquarters that permits the Center to plan for only minor expansions, mostly only to accommodate additional visiting and permanent staff. For the period 1989-1993, only the completion of a laboratory/office space complex is proposed (i.e., two additional modules in a site prepared to contain a total of three modules—of which one module is already built). The cost per module is about US$180,000. One is proposed for 1990, with the second module to follow in 1992.

Desirable Resources for Capital

Additional needs for resources for capital are in the following areas:

a. Advanced Research Equipment: CIAT estimates that if it is to equip itself with the research/laboratory equipment that will keep it at the forefront of applied biotechnology research, the Center can cost-effectively invest in advanced research equipment on the order of US$400,000 per year beyond the required minimum.

b. Scientific and Administrative Computing: CIAT is working with two mainframe computers: an IBM 4361 for scientific computing and data bases to support the research process; and an IBM S/36 for administrative computing. Compared to other institutions with the size and type of mandate as CIAT's, these are quite modest installations. Both systems are rapidly approaching the time when they need replacement. Thus US$1.25 million to meet the extra hardware requirements of the Center is desirable.

c. Infrastructure Development in Carimagua: The complex operation at the Carimagua Research Center in the savannas requires an adequate infrastructure in this remote area. The station is in need of additional housing for staff and training participants. Also, the harsh physical environment in the region puts a heavy strain on the existing building infrastructure with consequent needs for major maintenance. CIAT proposes that for the five-year period under consideration, a yearly allocation of US$100,000 each for building maintenance and infrastructure development is desirable.

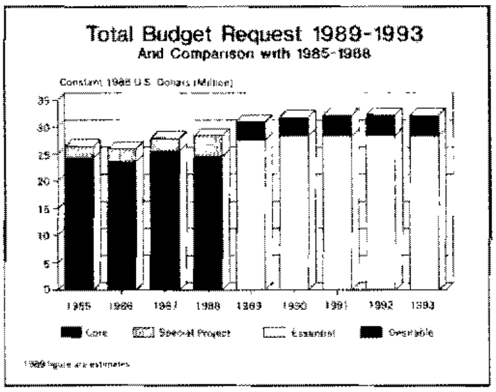
Adjustment for Inflation

All budgetary information in this document is in current U.S. dollars.

The budgeted amounts for 1989 to 1993 assume an annual rate of inflation of five percent.

The Budget Request in Perspective

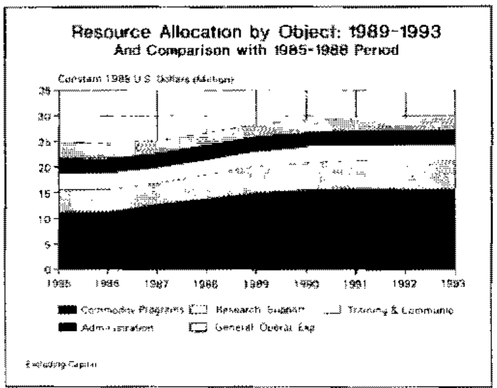
The graphic below shows the budget request for 1989-1993 (essential and desirable activities) and compares this request to the approved budget for 1988, and comparable historical data for 1985-1987. To facilitate comparison, all figures are in constant 1988 U.S. dollars.



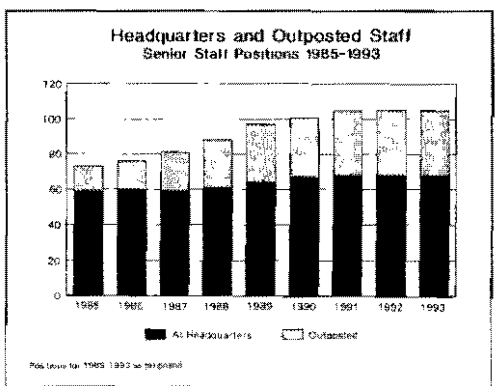
The increase from the total set of operations in 1988 (i.e., core and special project resources) to the proposed program in 1989 (essential and desirable activities) amounts to US$2.57 million,or 9 percent. The total proposed subsequent real growth during the period 1990-1993 is below 4 percent.

The essential component of the proposed 1989 activities incorporates the core activities of 1988, a sizeable (US$2.22 million) portion of the activities labeled as special projects in 1988, plus selected new, high priority activities. [The proposed **essential** program for 1989 is 13 percent higher, in real terms, than the core program in 1988, but one percent below the total set of operations in 1988.]

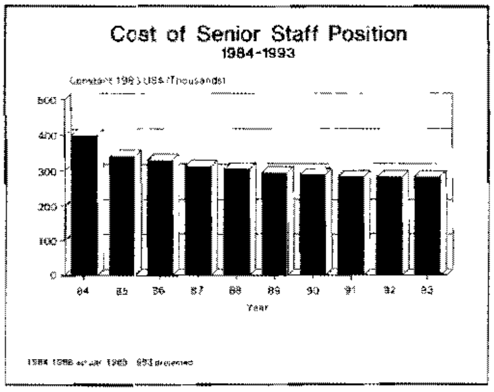
The graphic below presents an area graph of the proposed resource allocation by object for the period 1989-1993, and compares this data with actual resource allocation patterns in 1985-1988. Particularly noteworthy is the fact that the modest growth in the overall program is restricted to the research and international cooperation activities, with administration and general operating costs being kept level.



The graph below shows that, in recent years, most of the growth in the number of senior staff positions has been away from headquarters (i.e., outside of Colombia). As demonstrated, this trend is projected to continue.



With the projected slight growth in senior staff positions, and a less than proportional expansion in administrative and other support services, the cost per senior staff position is declining gradually. As the graph below shows, this trend has been in effect in the past, too. While in 1984 the cost per senior staff was close to US$400, 000, this cost was reduced by 25 percent in 1988, and is projected to diminish further during the 1989-1993 period.



COMMODITY RESEARCH PROGRAMS

Bean Program

Beans are the most important food legume for over 300 million people in Latin America and the highlands of eastern and southern Africa. Beans are the leading source of protein for over 100 million of the poorest of the poor whose diets otherwise consist principally of low protein starchy staples (e.g., cassava, yams and plantains).

Despite the nutritional importance of beans, growth rates in production have been declining throughout Africa, Brazil and the Andean region; and population growth is outstripping bean production growth in all these regions, with associated dire implications for the nutritional status of the poor. Moreover, the slow increase in bean production that has been achieved has been due almost entirely to area expansion, which can not be long sustained, especially in Africa. Consequently, productivity-increasing technology is urgently needed.

Beans are generally produced without irrigation on poor soils by semi-subsistance farmers, many of whom lack the resources to use fertilizer or crop protection chemicals. To generate technology appropriate for these poor farmers, the Bean Program's research strategy focuses on improved disease and pest resistance as well as adaptation to acid and low phosphorus soils. The program also conducts research to improve beans' contribution to soil fertility through increased nitrogen fixation.

This strategy of emphasizing genetic improvement without requiring additional inputs, both keeps new technology well within the reach of poor farmers and leads to more sustainable systems due to the avoidance of ecologically disturbing agrochemicals.

New bean technology has to be targeted to fit highly varied cropping systems that are adapted to local conditions, as well as meet strong local consumer preferences for particular grain types. Only strong national programs are able to respond to farmers' needs for such location-specific technology. Consequently, training and networking are crucial Bean Program activities that strengthen national program capacity to insure that new technologies reach poor farmers as quickly as possible.

Program Activities

Program activities are oriented to maximize complementarity with other institutions. While national agricultural research systems have a comparative advantage in location-specific adaptation research and developed country research institutes have a comparative advantage in basic research, the Bean Program concentrates on applied research of broad applicability and undertakes basic or adaptative research primarily to fill in gaps not covered by others. The major Program activities are research, training and networking.

Genetic improvement is the principle research activity of the Program. Priority is placed on improving disease and insect resistance, as well as on tolerance of drought, low phosphorus and acid soils, improved nitrogen fixation, early maturity and yield potential.

Sources of these desired characters are obtained from the CIAT germplasm bank, which with 40,000 accessions is the world's largest collection of *Phaseolus vulgris*, and also includes related species and wild ancestors.

Genetic improvement is organized first around 22 projects to improve characters such as resistance to anthracnose or drought or ability to fix nitrogen. Breeders work closely with disciplinary specialists (for example, pathology, physiology, microbiology) in each of these projects. Multiple characters from these projects are combined for eight distinct grain classes and are made available to national programs as fixed lines or segregating populations through international and regional nurseries.

Improved management practices are developed to accompany new germplasm or to solve problems not amenable to genetic solutions. This research, which is carried out largely in collaboration with national programs, is mainly conducted on farm. This has led to the development of technologies like the combination of zero tillage with tolerant varieties to reduce losses from web blight in Central America.

Information and research skills are transferred to national programs both through collaborative research projects and through formal training. Emphasis is placed on strengthening the skills of mid-career professionals through workshops, short courses and internships. Training in on-farm research is now receiving major attention to improve research planning and technology evaluation. Much training is conducted through in-country or regional courses where participants develop work plans for future activities as part of the training experience.

The program promotes regional research networks formed around common problems, with each network member specializing in a specific problem. For example, in the Great Lakes Network, Burundi specializes in halo blight, Rwanda in anthracnose, and Zaire in angular leaf spot. The best materials from each country are shared through regional nurseries. Individual national programs often lack the resources to solve all the problems that their farmers face; but by pooling efforts across countries, all problems can be effectively researched.

Networks have been formed in Central America, the Andes, East Africa, Southern Africa and the African Great Lakes, as well as in Brazil and the Southern Cone. Most networks have annual meetings to exchange results, regional nurseries to distribute germplasm, and a steering committee to coordinate activities of mutual interest. Exchanges at the continental and world level are maintained through periodic workshops, international nurseries and publications.

The Bean Program has formed a critical mass of scientists at headquarters to operate as a tightly knit multidisciplinary research team. Outposted staff both in Africa and Latin America complement headquarters research by supporting national programs in their adaptive research. Training and network coordination are as important as research for outposted staff. Headquarters staff are involved in training and networking, but they give priority attention to research.

Currently, three breeders at headquarters have responsibility for 22 projects in character improvement, representing 8 separate grain classes and corresponding to regions where the characters are particularly relevant.

A pathologist and scientists from the Virology Research Unit at headquarters conduct research on diseases such as bean common mosaic virus (BCMV), rust, anthracnose, angular leaf spot and common bacterial blight, which are distributed worldwide. Pathologists stationed in Rwanda and Tanzania support African nationals and assist in germplasm evaluation.

The headquarters-based entomologist works on pest problems of worldwide significance (such as leaf hoppers, bruchids and whitefly), as well as on the ones purely in Latin America, such as bean pod weevil. The Africa-based entomologist is primarily concerned with control of the beanfly, the worst pest of beans in Africa.

Increased biological fixation of nitrogen is a low-input, sustainable technology that can contribute substantially to nitrogen availability. A headquarters-based microbiologist is identifying characteristics that can be used in bean breeding, as well as working closely with breeders in developing methods of screening for improved nitrogen fixation. Rhizobia strains are also being screened for effectiveness and competitiveness. The results of this research are being tested in Africa and Latin America by forming a network in which previously isolated microbiologists are encouraged to work closely with plant breeders and agronomists.

Strategic research on yield physiology, earliness and drought mechanisms is undertaken to guide breeders seeking genetic improvement for these characteristics. Priority is given to identifying traits that can be useful to breeders selecting for yield or drought. This research is carried out by the headquarters-based physiologist.

A high proportion of beans, both in Africa and Latin America, are produced on heavily weathered acid soils with low phosphorus availability and high levels of aluminum. Continued strengthening of physiology work, by temporary, postdoctoral or visiting scientist staff, will be required for a few years to identify traits useful in breeding superior bean genotypes in order to optimize sustainable bean productivity in these low-fertility soils. This research will integrate whole-plant nutritional physiology with soil fertility and chemistry, and will be closely coordinated with research on rhizobial symbiosis.

In agronomy, the major emphasis is the on-farm testing of new lines for adaptation to farmers' current cropping systems. Research is also carried out on improved cultural practices and intensified cropping systems. Because the research is location-specific, agronomic staff must be decentralized to be effective in providing feedback to CIAT and in training national personnel. Agronomists for the Bean Program are posted in Brazil, Ethiopia, Guatemala, Tanzania and Uganda, while two headquarters-based agronomists are responsible for efforts in South America and for coordinating international yield trials.

Studies of farmers' production systems, resources, problems and objectives are critical as are studies of consumer preferences for new grain types. Socioeconomists participate with agronomists in on-farm evaluation of new technologies and are responsible for generating feedback on the adoption of new technology. A headquarters-based economist works with national programs to monitor adoption of improved technology and provides input to the setting of research priorities in Latin America; an economist and an anthropologist have been posted to Africa to support farm-level evaluation of technological alternatives.

Resource Requirements

No change in numbers of senior staff is envisaged at headquarters during 1989-1993, but outposted staff now being funded in special projects are classified as essential. (Tables 7 and 8).

Currently four positions in East Africa (funded until December 1990) and five positions in Southern Africa (funded till August 1991) are supported by the Canadian International Development Agency (CIDA) and the US Agency for International Development (AID). These positions have been instrumental in setting up the operations in Africa.

African operations are organized into three regional networks that typify agroecological conditions, production problems, institutions and language. The Great Lakes network focuses on the Central African highlands, where plantain/bean systems predominate in Francophone countries. The East African network focuses on the area north of Lake Victoria, where both plantain/beans and maize/beans are widely grown. The Southern Africa network comprises the countries of the Southern African Development Coordination Conference (SADCC), where maize/bean systems predominate.

Research, training and networking are coordinated on a continental basis by an all-Africa coordinator. Staffing is also planned on a continental basis with, for example, one entomologist working across the three networks. Because of agroecological and production system differences among the regions, each has been assigned a breeder and a cropping systems agronomist.

A significant commitment of scientists is essential in Africa in the short term to build the program's knowledge of African bean production; to stimulate bean research in national programs; and to provide support during advanced training of national personnel. In the longer term (i.e., 1994 and onward), the Bean Program envisions that the three regional networks will each comprise a breeder/germplasm specialist, a cropping systems specialist (agronomist or socioeconomist), with two additional specialized disciplines (e.g., pathology, entomology) to serve all of Africa located with one of the three programs as appropriate. This framework would provide both effective support for each of the agroecologically distinct regional networks and a fully integrated multidisciplinary team at the continental level.

The positions for on-farm agronomists in the Andean Zone and Central America will be shifted from essential to desirable by 1993, since by

Table 7

Bean Program: Approved Senior Staff Positions for 1988, and Projected Essential and Desirable Positions for 1989-1993

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable
HEADQUARTERS												
Leader	1	-	1	-	1	-	1	-	1	-	1	-
Breeder (Andean Zone)	1	-	1	-	1	-	1	-	1	-	1	-
Breeder (Brazil/Southern Cone)	1	-	1	-	1	-	1	-	1	-	1	-
Breeder (Central America)	1	-	1	-	1	-	1	-	1	-	1	-
Pathologist	1	-	1	-	1	-	1	-	1	-	1	-
Entomologist	1	-	1	-	1	-	1	-	1	-	1	-
Microbiologist	1	-	1	-	1	-	1	-	1	-	1	-
Soil/Plant Nutritionist	1	-	1	-	1	-	1	-	1	-	1	-
Physiologist	1	-	1	-	1	-	1	-	1	-	1	-
Agronomist	1	-	1	-	1	-	1	-	1	-	1	-
Agronomist (Int. Trials)	1	-	1	-	1	-	1	-	1	-	1	-
Economist	1	-	1	-	1	-	1	-	1	-	1	-
CENTRAL AFRICA (Rwanda, Burundi, Zaire)												
Breeder	1	-										
Pathologist	1	-										
Farming Systems Specialist	1	-										
EASTERN AFRICA (Kenya, Uganda, Ethiopia, Somalia, Sudan)												
Breeder	-	1 F										
Agronomist (OFR)	-	1 F										
Bean Specialist (Africa-wide	-	1 F										
Coordinator)			7 F	5 F	7 F	5 F	7	5	7	5	7	5
Economist	-	1 F										
SOUTHERN AFRICA (SADCC Countries)												
Breeder	-	1 F										
Pathologist	-	1 F										
Entomologist	-	1 F										
Agronomist (OFR)	-	1 F										
Breeder/Agronomist	-	1 F										
CENTRAL AMERICA & CARIBBEAN												
Breeder (Coordinator)	1	-	1	-	1	-	1	-	1	-	1	-
Agronomist (OFR)	1	-	1	-	1	-	-	1	-	1	-	1
BRAZIL & SOUTHERN CONE												
Bean Specialist (Coordinator)	1	-	1	-	1	-	1	-	1	-	1	-
ANDEAN REGION (Peru, Ecuador, Bolivia)												
Bean Specialist (Coordinator)	-	1	1 F	-	1 F	-	1	-	1	-	1	-
On-Farm Research Specialist	-	1	-	1 F	-	1 F	-	1	-	1	-	1
WEST ASIA AND NORTH AFRICA												
Breeder (Coordinator)	-	-	-	1	-	1	-	1	-	1	-	1
Agronomist	-	-	-	1	-	1	-	1	-	1	-	1
Total Headquarters-based	12	0	12	0	12	0	12	0	12	0	12	0
Total Decentralized	6	10	11	8	11	8	10	9	10	9	10	9
GRAND TOTAL	18	10	23	8	23	8	22	9	22	9	22	9

F = Funding from extra CG resources

BEAN PROGRAM

Table 8

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable
HEADQUARTERS												
Leader	227,545	-	227,545	-	227,545	-	227,545	-	227,545	-	227,545	-
Breeder (Andean Zone)	204,702	-	204,702	-	204,702	-	204,702	-	204,702	-	204,702	-
Breeder (Brazil/Southern Cone)	237,267	-	237,267	-	237,267	-	237,267	-	237,267	-	237,267	-
Breeder (Central America)	181,409	-	181,409	-	181,409	-	181,409	-	181,409	-	181,409	-
Pathologist	225,117	-	225,117	-	225,117	-	225,117	-	225,117	-	225,117	-
Entomologist	147,097	-	147,097	-	147,097	-	147,097	-	147,097	-	147,097	-
Microbiologist	123,883	-	123,883	-	123,883	-	123,883	-	123,883	-	123,883	-
Soil/Plant Nutrition Specialist	130,905	-	130,905	-	130,905	-	130,905	-	130,905	-	130,905	-
Physiologist	164,723	-	164,723	-	164,723	-	164,723	-	164,723	-	164,723	-
Agronomist	161,610	-	161,610	-	161,610	-	161,610	-	161,610	-	161,610	-
Agronomist (Int. Trials)	217,255	-	217,255	-	217,255	-	217,255	-	217,255	-	217,255	-
Economist	135,256	-	135,256	-	135,256	-	135,256	-	135,256	-	135,256	-
CENTRAL AFRICA (Rwanda, Burundi, Zaire)	494,216	-										
EASTERN AFRICA (Kenya, Uganda, Ethiopia, Somalia, Sudan)	-	1,090,040	1,516,916 F	1,278,376 F	1,516,916 F	1,231,994 F	1,516,916 F	1,261,612 F	1,516,916	1,261,612	1,516,916	1,261,612
SOUTHERN AFRICA (SADCC Countries)	-	1,296,230										
CENTRAL AMERICA & CARIBBEAN	405,530	-	405,530	-	405,530	-	274,000	131,530	274,000	131,530	274,000	131,530
BRAZIL & SOUTHERN CONE												
Bean Specialist (Coordinator)	165,096	-	165,096	-	165,096	-	165,096	-	165,096	-	165,096	-
ANDEAN REGION (Peru, Ecuador, Bolivia)	-	405,210	253,560 F	135,474 F	257,127 F	133,881 F	257,127	133,881	257,127	133,881	257,127	133,881
WEST ASIA AND NORTH AFRICA	-	-	-	400,000	-	400,000	-	400,000	-	400,000	-	400,000
Total Colombian-based	2,156,768	0	2,156,768	0	2,156,768	0	2,156,768	0	2,156,768	0	2,156,768	0
Total Decentralized	1,064,842	2,791,480	2,341,102	1,813,850	2,344,669	1,765,875	2,213,139	1,927,023	2,213,139	1,927,023	2,213,139	1,927,023
GRAND TOTAL	3,221,610	2,791,480	4,497,870	1,813,850	4,501,437	1,765,875	4,369,907	1,927,023	4,369,907	1,927,023	4,369,907	1,927,023

F = Funding from extra CG resources

that date major production problems in principal systems in these regions should have been identified, and national programs should be capable of assuming responsibility for these activities. The changes will mean a significant drop in crop systems research (Table 9), with remaining activities in this area for Latin America being handled by a single headquarters-based cropping systems agronomist.

Resource utilization by activities is expected to change due to increases in national program capacity, especially in Latin America (Table 9). CIAT varietal development efforts will decline, freeing up additional resources for exploratory application of new genetic manipulation techniques emerging from the CIAT biotechnology unit.

Greater emphasis will be placed on specialized advanced training, but there will be a gradual reduction both in training courses and in advisory services to national programs as these activities become less needed by the most developed national programs in Latin America.

While activities in institution building, cropping systems research and breeding are projected to decline because of the increased strength of the national programs in some countries of Latin America, increased attention will be devoted to several areas. More efforts will go into exploratory upstream research. Greater attention will also be paid to natural resource issues, especially the maintenance of soil fertility in intensively cropped small farm hill systems, both in Africa and Latin America.

Expanded efforts will be made to tap the potential of the wild progenitors and ancestors of the common bean being collected by the CIAT Germplasm Resources Unit. With progress in the development of improved disease resistant germplasm, plant protection research will focus increasingly on integrated disease and pest management strategies. Studies monitoring the impact of new bean production technologies are also expected to increase over time.

As work on character improvement of dry beans diminishes, breeders may intensify efforts on the improvement of snap beans (edible pods). Preliminary socioeconomic assessment suggests that this crop is increasing dramatically in the tropics, leading to both improved nutrition for consumers and income-earning opportunities for farmers.

To date, program activities have been modest in West Asia and North Africa; but an expansion in coverage of this ecologic area is considered desirable as Turkey (162,000 t/year), Iran (98,000 t) and Pakistan (60,000 t) are relatively large producers during the warm season. Production figures do not include snap beans, and consumption in this form is common. The scientists would be stationed at the Grain Legume Program of ICARDA, which conducts research on winter legumes—chickpeas, lentils and broad beans—in the region.

Expected Benefits

The diffusion and impact of new bean technologies are routinely monitored by economic studies conducted in cooperation with national researchers in Latin America and Africa. Based on these data and on published secondary sources, total benefits (i.e., the value of the increased production brought

Table 9

BEANS
Resource utilization by activities for the years 1988, 1989 and 1993

	1983	1989	1993
RESEARCH	%	%	%
Natural Resources	1.3	1.5	2.3
Genetic Resources	2.1	2.3	3.5
Genetic Improvement	22.1	21.6	18.8
Crop Protection	11.2	11.4	12.2
Plant Nutrition	6.1	6.1	6.1
Cropping Systems	12.5	12.3	9.8
Economics, Marketing & Policy	3.3	3.3	3.6
Analysis of Impact	0.8	0.9	1.7
Exploratory Research	3.1	3.5	7.3
TOTAL RESEARCH	62.5	62.9	65.3
INSTITUTION BUILDING & NETWORKING			
Training	13.2	13.2	12.7
Conferences and Seminars	2.3	2.2	2.2
Documentation & Information	2.2	2.2	2.2
Counseling/advising NARS	11.2	11.0	9.6
Technical Assistance	1.5	1.4	1.0
Network Coordination	7.1	7.1	7.0
TOTAL INST. BUILD.& NETWORKING	37.5	37.1	34.7
T O T A L S	100.0	100.0	100.0

about by new varieties) amounted to US$41 million in 1987. If only half of these benefits derived from CIAT's efforts, the benefit/cost ratio to CIAT investment in bean research was 2.8 in 1987. In Latin America CIAT bean research had a benefit/cost ratio of 6.0, while in Africa, where activities started only in 1983, the ratio was 0.4.

Projections based on new varieties already in seed multiplication and on the rate of adoption of previously released new varieties (58%) suggest that total benefits from the CIAT network bean research will reach US$68 million in 1993, with a benefit/cost ratio of 6.8 in Latin America and 1.4 in Africa.

Cassava Program

The Cassava Program at CIAT is part of a global network dedicated to improving the welfare of producers and consumers of the fourth most important source of carbohydrates produced within the tropics. The program has recently gained impetus from demand studies that were accelerated on the recommendation of the TAC.

The studies were launched because of uncertainty about the role of cassava in the development process in the Third World in the upcoming decades. World production of cassava is 130 million t, the vast majority of which comes from small farmers' fields in Africa (41%), Asia (37%) and Latin America (21%); but changing economic circumstances in the Third World, particularly the tendency toward urbanization, have caused reductions in per-person consumption. In many developing countries, the potential of cassava to generate employment and income in the rural sector has not been recognized, and government policies have either favored imported grains or subsidized local grain production.

The demand studies demonstrated that cassava can successfully compete in many different markets. Furthermore, the studies clearly showed the particular role that cassava can play in the marginal agroclimatic zones that were left largely untouched by the Green Revolution. In these areas, it is one of the few alternatives available to resource-poor farmers and one of a limited number of crops for which research strategies can be directed to benefit the poor. Because of the low resource base of the producers and the poor infrastructure in these areas, the production and processing systems that are developed must be simple, low cost and self-sustaining. In other words, they must incorporate post-harvest handling technology and production systems based on improved varieties, biological control, erosion control, appropriate fertilization and artisanal seed production.

The fact that cassava is unique to the tropics has had—and continues to have—a profound effect on the organization and structure of cassava research. In developed countries, the amount of research done on cassava is very modest, and most of it is the result of collaborative projects developed with IARCs. Basic research on the crop is very recent in comparison with grain crops and mostly dates from the inception of the IARCs. Basic research is essential for sound applied research, and the centers working on cassava will continue to ensure the existence of research that increases knowledge on the crop. Analysis of various cassava-based development projects indicates that success depends on integration of production, processing and marketing. Hence, the research strategy must also deal with the complete system for the commodity.

Within this context, CIAT's Cassava Program is well positioned to have the global mandate for the crop. It is located in the center of origin of cassava and of the pests and diseases that have coevolved with it. It can collect and distribute germplasm, evaluate potential end uses, screen for resistance in its collection, and search for biological control agents that can be used worldwide, realizing economies of scale not possible elsewhere.

Objectives

The Cassava Program pursues several objectives:

- To develop basic components of production technology for sustainable cassava-based cropping systems with low costs per unit output.
- To investigate practices that enable cassava to be grown and sustained on underexploited lands.
- To develop techniques for processing cassava into a low-cost, high-quality convenient food.
- To combine technologies that are cost-competitive in production and processing and that improve the growers' incomes while generating employment for others.
- To reduce the share of costs attributable to marketing.
- To stimulate the growth of markets that provide a stable price for the raw material.
- To assist in the development of novel uses of cassava.
- To increase the percentage of produce that is finally consumed.
- To encourage other agencies to contribute to cassava research and development.
- To support national programs carrying out cassava projects.

Global Research

Under the program leader at CIAT, the researchers at headquarters undertake basic and applied investigations that are not location specific. The areas of endeavor addressed by the interdisciplinary team include:

- Assembly of a basic body of knowledge on the crop. An example is the recent discovery at CIAT that cassava possesses an intermediate C3/C4 pathway. This opens up possibilities for manipulating variation to obtain varieties with enhanced productivity and water use efficiency suitable, for example, in drought-prone areas of the Sahel in Africa.
- Genetic conservation and improvement. Over the last decade, CIAT collected and evaluated more than 3000 germplasm accessions and tens of thousands of different genotypes of cassava. These have been used to build gene pools adapted to each of the different ecosystems. The progeny from crosses made at CIAT are tested by more than 20 countries and the best of the lines have been selected and released as varieties. This effort will continue in the next 5 years. Over the longer term, the program will look at improved breeding methods based on new techniques. Anther culture, for example, could lead to the planting of cassava from true seed rather than vegetative materials.
- Integrated disease and pest management. Screening methods for bacterial blight and super-elongation disease are now routinely used by breeders. In the

future, the team will focus on methods to screen for resistance to more elusive diseases that reduce early vigor and germination and cause root rots. Screening techniques for mites were developed in the last 5 years; however, routine methods to screen for mealybugs do not exist and are being investigated. Host plant resistance will be complemented by biological control and management practices of the crop.

- Appropriate cassava production systems. Past efforts concentrated on the components of production systems, such as quality of planting material, pest management and control of root rots. This approach proved successful in countries committed to increasing cassava production on a large scale. For example, Cuba applied the components in a package called the Colombian system and has quadrupled production while reducing costs. Present and future efforts are to fit the components into sustainable cropping systems, which are inherently location specific. Erosion and declining soil fertility affect all areas where cassava is grown under marginal conditions and thus are particular focuses of this effort.

- Improved root quality. Quality characteristics of the roots differ for the many end uses of cassava. For example, cooking quality has restricted the use of new high-yielding varieties for food consumption in Latin America and southern India, and high contents of dry matter are essential for the expanding animal feed and starch markets in Southeast Asia and Latin America. Little is known about the nature of differences in quality. This makes screening and selection not only slow but also haphazard. Screening must be made systematic and must be based on CIAT's world germplasm collection. In the next 5 years, this research will be carried out in conjunction with agencies such as ODNRI (Overseas Development Natural Resources Institute) that have expertise in this field.

- New products and alternative markets. People's habits, lifestyles and the products they purchase are changing in the developing world; and new markets are continually emerging. The Cassava Program identifies likely markets for cassava-based products and uses the information in development of new varieties and processing. Past studies, for example, indicated the market for cassava as food in urban areas could be rejuvenated if the perishability of fresh roots were reduced. Present efforts are concentrated on the market for high-quality flours.

- Improved preservation and processing. Asian drying techniques adapted by CIAT to Latin American conditions are now being used on a commercial scale in Mexico, Panama, Cuba, Colombia, Ecuador and Brazil. In Colombia at least 50 commercial plants—mostly owned by smallholders' associations—have brought benefits to more than 4000 small farmers. A recently developed technology converts fresh roots into a convenience food and is now being used commercially in Colombia and Ecuador. In future, emphasis will be on refining the techniques for conserving fresh cassava and on developing the technology for producing high-quality flours.

- The policy environment for cassava. CIAT can assist national programs in analyzing the possible effects of policy decisions on cassava; the information it collects can be used by national policymakers to facilitate their assessments of benefits and disadvantages of options.

The results of these and other activities are integrated into ongoing collaborative research in the regions of Latin America and the Caribbean, Africa and Asia.

Regional Programs

In Latin America, the demand for cassava still relies chiefly on food markets, and the price has masked incentives to invest in processing cassava for other uses, especially for animal feed. To overcome this constraint to expansion of cassava markets, CIAT has encouraged the formation of integrated projects.

Such projects are now in motion in Colombia, Ecuador, Mexico, Panama and Brazil. The projects are run and managed by the national programs. CIAT's role is to assist and give technical advice. The work is paid for by bilateral funds or, as in the case of Colombia, by the government.

The integrated projects include study of possible markets, potential production sites, identification of appropriate processing technology, and the setting up of pilot projects to evaluate the feasibility of the integrated systems. The approach is proving successful in creating a demand for cassava products, which in turn stimulates the demand for new production techniques. In Mexico, cassava farmers who produce for the animal feed industry use, almost exclusively, CIAT varieties and production packages passed to the national program for adaptation to local conditions. In Colombia, the clone Manihoica P12 tested by CIAT and ICA has now been released and is spreading rapidly along the North Coast. The farmers who are adopting accompanying management practices are members of the drying cooperatives who have a guaranteed outlet for their produce. Most countries producing cassava in Latin America are requesting similar assistance.

CIAT's strategy in Africa is to complement cassava research being undertaken by the IITA, which has regional responsibility for the crop. The area planted to cassava in Africa has increased during the last 20 years—from 5.7 million ha in 1961-1965 to 7.5 million ha in 1984-1986. IITA is seeking to develop stable, intensive production systems in the humid tropics where demographic pressures are increasing and the fallow periods for the regeneration of the land are becoming short. In the drier areas, cassava is being grown increasingly because of its stable yields under sporadic, uncertain rainfall. CIAT will be expanding its capability to provide input from Latin America and will be increasing its efforts within Africa in full collaboration with IITA.

The utility of the research base in

Latin America has already been demonstrated: It has proved critical to efforts by IITA to establish biological control of the mealybug and to broaden the genetic base of their breeding program. Similar experience is expected in the development of gene pools for particular ecosystems in Africa. For example, most African materials were originally introduced from the wet littoral zones of the Americas to the humid coastal areas of Africa; hence germplasm well adapted to drier areas is probably underrepresented.

One source of input that has not been tapped sufficiently is Brazil, which not only is the largest cassava producer in the world but also possesses the greatest genetic variability in numerous production systems and diverse ecologies. The genetic materials selected by farmers over hundreds of years in the semiarid northeast offer potential as the basis for developing lines suitable for the drier areas of Africa. Similarities in the climate are clear: rainfall is sporadic, often lasting for fewer than 4 months in the year and totaling less than 700 mm. CIAT's role is to increase the flow of such germplasm to Africa, where it can be tested and adapted locally.

In addition, IITA and CIAT are working with the national agricultural research systems in Africa and are developing an agroeconomic study on which to build a coherent research strategy for the continent. The first step is to obtain data on present production, processing and marketing systems. Then it should be possible to assess the potential for producing cassava in new areas and the changes in demand as well as postharvest aspects such as the use of cassava leaves. The studies are expected to take 3 years. The results will serve as a basis for a coordinated plan for the IARCs and will be passed to national policymakers and planners.

Similar studies have been completed by CIAT in Asia as well as in Latin America. The initial phase focused on the potential demand. Findings were that cassava is increasingly being planted in dry or sparsely populated areas such as the outer islands of Indonesia and the dry areas of northeast Thailand and tropical India. It is being replaced by more lucrative alternatives under better conditions in South India, Malaysia and Java. The overall trend, however, is a demand-led increase. A multiple market structure for cassava has already developed in most of the region, and these markets can absorb large increases in production. If prices can be lowered, new markets are poised to come on line. Hence CIAT's efforts are directed toward establishing an effective cassava production research network. The structure of that network was discussed at a workshop held in June 1984 (see **Cassava in Asia, Its Potential and Research Development Needs**) and is considered a means to incorporate cassava into the development of upland areas in the region.

In Asia, the macro-level demand studies can now branch into the microeconomic scale: an evaluation of how new technology will fit into the intricate cropping patterns of the region and an identification of constraints to the adoption of new technology, including methods to process the fresh roots. At present the available processing technology is relatively efficient and is not seen as an immediate constraint. Any new methods developed at headquarters will be transferred to Asian national programs through training and conferences.

The Global Network

The Cassava Program's activities include informing a global network of individuals in national agencies working on cassava; 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 large and amorphous group is held together by the cassava newsletters, the information/documentation service on cassava, workshops and conferences, and frequent, nonsystematic contacts between and among members.

Special networks have been organized around problems and by specialty. One example is germplasm testing and evaluation. At present, sexual seed, originating from elite germplasm pools in Colombia, is distributed according to agroclimatic zone. To facilitate exchanges, CIAT is working with national cassava programs in Asia to establish similar gene pools and is planning them in Brazil, where many varieties have been selected for high and stable yields in dry areas.

Another example is research on processing, which, particularly in Asia, is often conducted in specialized centers outside national cassava programs. Under these circumstances, CIAT can assist by facilitating information sharing. The same is true in Latin America, where it links groups undertaking integrated projects on cassava.

While the Cassava Program seeks to be instrumental in the efficient functioning of these networks, it also seeks horizontal exchange of ideas, germplasm and technologies so that it does not necessarily become the focal point of the network.

Resource Requirements

This approach to the network permits the program to maintain a relatively small but effective team at headquarters (Tables 10 and 11). Resource restrictions have limited outposted core staff, and the positions being requested are principally to strengthen regional programs.

A look at how many senior staff are dedicated to work on cassava and what they are doing clarifies the projections.

At present, the program has one breeder at headquarters who has responsibility for developing germplasm resources for the humid and subhumid lowland areas of Latin America and Asia. Another breeder is working in Asia. At headquarters, an additional breeder is needed to apply new techniques that the Biotechnology Research Unit is developing for cassava improvement and to collaborate on activities at IITA. Also, this scientist is expected to concentrate on the intermediate-altitude tropical highlands and the subtropical ecologies, which are not well represented in the CGIAR system. The position is regarded as essential because an estimated 15-20% of the world's cassava is produced in the subtropics and 18% of African cassava is planted in the intermediate-altitude highlands. A breeder is also regarded as essential in Brazil to capitalize on the rich local germplasm and to develop pools for transfer to the dry, lowland areas of Africa.

Table 10

Cassava Program: Approved Senior Staff Positions for 1988, and Projected Essential and Desirable Positions for 1989-1993

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able
HEADQUARTERS (Colombia)												
Leader	1	-	1	-	1	-	1	-	1	-	1	-
Physiologist	1	-	1	-	1	-	1	-	1	-	1	-
Pathologist	1	-	1	-	1	-	1	-	1	-	1	-
Entomologist	1	-	1	-	1	-	1	-	1	-	1	-
Breeder(s)	1	-	1	-	2	-	2	-	2	-	2	-
Economist	1	-	1	-	1	-	1	-	1	-	1	-
Agronomist	1	-	1	-	1	-	1	-	1	-	1	-
Utilization Specialist(s)	1	-	1	-	2	-	2	-	2	-	2	-
AFRICA												
CIAT Cassava Specialist at IITA	1	-	1	-	1	-	1	-	1	-	1	-
ASIA												
Breeder	1	-	1	-	1	-	1	-	1	-	1	-
Agronomist	-	1	1	- F	1	-	1	-	1	-	1	-
Economist	-	-					1	-	1	-	1	-
LATIN AMERICA												
Agronomist/Breeder (Brazil)	-	-	1	-	1	-	1	-	1	-	1	-
Integrated Projects	-	2	-	3	-	3	-	3	-	3	-	3
Total Colombian-Based	8	0	8	0	10	0	10	0	10	0	10	0
Total Decentralized	2	3	4	3	4	3	5	3	5	3	5	3
GRAND TOTAL	10	3	12	3	14	3	15	3	15	3	15	3

F = Funding from extra CG resources

Table 11

Cassava Program: Approved Budget for 1988, and Projected Budgets for Essential and Desirable Activities for 1989-1993

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable
HEADQUARTERS												
Leader	331,888	-	331,888	-	331,888	-	331,888	-	331,888	-	331,888	-
Physiologist	188,878	-	188,878	-	188,878	-	188,878	-	188,878	-	188,878	-
Pathologist	202,035	-	202,035	-	202,035	-	202,035	-	202,035	-	202,035	-
Entomologist	217,252	-	217,252	-	217,252	-	217,252	-	217,252	-	217,252	-
Breeder(s)	262,984	-	262,984	-	504,984	-	504,984	-	504,984	-	504,984	-
Economist	209,481	-	209,481	-	209,481	-	209,481	-	209,481	-	209,481	-
Agronomist	214,762	-	214,762	-	214,762	-	214,762	-	214,762	-	214,762	-
Utilization Specialist(s)	205,200	-	205,200	-	447,200	-	447,200	-	447,200	-	447,200	-
AFRICA												
CIAT Cassava Specialist at IITA	150,000		150,000	-	150,000	-	150,000	-	150,000	-	150,000	-
Agroeconomic Study of Cassava		75,000	75,000 F		75,000 F	-	-	-	-	-	-	-
ASIA												
Breeder	161,443	-	161,443	-	161,443	-	161,443	-	161,443	-	161,443	-
Agronomist	-	190,000	190,000 F	-	190,000	-	190,000	-	190,000	-	190,000	-
Economist							190,000	-	190,000	-	190,000	-
LATIN AMERICA												
Agronomist/Breeder (Brazil)	-	-	200,000	-	200,000	-	200,000	-	200,000	-	200,000	-
Integrated Projects	-	119,000	-	199,000	-	199,000	-	199,000	-	199,000	-	199,000
GRAND TOTAL	2,143,923	384,000	2,608,923	199,000	3,092,923	199,000	3,207,923	199,000	3,207,923	199,000	3,207,923	199,000

F = Funding from extra CG resources

To carry out their tasks effectively, breeders work closely with a physiologist at headquarters who is studying the C3-C4 intermediates, the mechanisms responsible for reactions to water stress and low fertility, and the potential for variation in photosynthetic capacity as a means to improve productivity of the crop.

A pathologist at headquarters is studying bacterial and fungal diseases of the crop, the design of integrated disease control methods, and means for the safe and efficient international transfer of germplasm.

An entomologist at headquarters assists the intercenter effort to identify, rear and distribute insects for biological—and hence sustainable, low-cost—control of cassava pests. In addition, attention focuses on germplasm evaluation for pest resistance and tolerance as a basic input into germplasm improvement.

Three other headquarters-based staff—an economist, cropping system specialist and utilization specialist—now share responsibility for assisting and linking integrated projects in Latin America and the Caribbean. While the procedure is straightforward, its execution is complex and the number of integrated projects is expected to increase in coming years.

The CIAT "integrated projects team" will provide continuity and will stimulate national agencies to develop their own such projects. The agronomy input on this team is geared to assisting national programs in developing sustainable cassava-based cropping systems.

Special attention is given to ensuring that crop management practices such as erosion control, biological control and production of high-quality planting material are incorporated into these systems. The aim is to ensure stability of production over time without degrading the natural resource base for production.

The staff will be able to devote attention to these expanding projects because of plans for additional staff in each of their specialties. The economist currently at headquarters, besides being part of the "integrated projects team," will be closely associated with the IITA-CIAT agroeconomic studies planned for Africa and will liaise with the team of four economists employed by IITA for the 3-year project. A regional economist will be sought for responsibilities in Asia—someone who is familiar with the intricate cropping and processing systems there and who can coordinate the microeconomic studies. A regional agronomist, already funded on a special project, is projected as essential in Asia to assist national programs in their search for measures to control soil erosion and nutrient depletion, which are major concerns in the intensive cropping systems of Asia.

A new utilization specialist is expected to join the one at headquarters, who will continue to focus on the engineering and logistical aspects of cassava processing and two will collaborate with IITA to adapt or develop methods for use in Africa. The new utilization specialist is projected for work on quality characters of cassava roots for various end uses. Collaborating with breeders, this scientist will establish guidelines for techniques to measure root quality rapidly. The techniques will then become a routine part of the breeding program.

The two utilization specialists will also work with CIAT scientists pursuing improved methods of conserving fresh cassava; other responsibilities are to facilitate commercial testing of low-cost technology to produce high-quality flours.

Scientists in the Virology Research Unit are undertaking collaborative research with European institutions to identify viruses and develop effective indexing methods. They are also routinely "cleaning" clonal materials to ensure that they are free of viruses before shipment.

A breeder is also to be located at IITA in Ibadan; besides being responsible for putting CIAT-developed technology into the hands of researchers there, this scientist will form an integral part of the IITA cassava effort and carry out an active research program.

Given the staffing levels, the allocation of resources will change over the next 5 years (Table 12), and the changes will reflect increased emphasis on integrated technology development; postharvest utilization and market development; development of methods to improve income distribution; breeding to help national agricultural research systems to produce finished varieties; and decentralization of agronomy and on-farm research in close collaboration with the national programs.

Expected Benefits

In Latin America, benefits from the longest functioning integrated projects—drying cassava for use in animal feed in Colombia and Ecuador—have been skewed toward small producers, with 95% of the beneficiaries having fewer than 20 ha. In the next 5-10 years, cassava dried for animal feed is expected to reach 100,000-2,000,000 t/year, depending on policy, market and institutional variables. Based on benefits of the integrated projects, this would be equivalent to an increase of US$3-60 million/year annually in gross incomes of small farmers in Northeast Brazil, the Yucatan peninsula in Mexico, the Atlantic coast of Colombia and the Pacific coast of Ecuador. In addition the new industry would create employment opportunities on the order of 2500-50,000 person-years/year, as well as savings in foreign exchange.

The technology to conserve fresh cassava is only now moving from pilot project to adoption; however, based on demand studies, potential annual benefits to producers are US$50 million and consumer savings, up to US$100 million.

In Asia, new varieties resulting from work by the Cassava Program are now being released in several countries—China, Thailand, Philippines and Indonesia—and are being multiplied by farmers. Even if these varieties contribute no more than a 5% increase in yield, with no increase in costs, then the net benefits to farmers would be US$20-30 million/year in Thailand alone.

In Africa, the benefits from CIAT's efforts are difficult to separate from those brought about by IITA; however, over the past 10 years, CIAT germplasm has been incorporated into the IITA breeding program, and exchange will increase in the coming years. If the diversity from CIAT germplasm increased cassava yields by 1%, benefits would be US$50-100 million annually.

Table 12

CASSAVA
Resource utilization by activities for the years 1988, 1989 and 1993

	1988	1989	1993
RESEARCH	%	%	%
Natural Resources	14.8	13.8	11.6
Genetic Resources	5.3	8.1	7.9
Crop Improvement	23.3	23.4	21.3
Crop Production	5.5	5.2	5.2
Crop Protection	13.3	12.5	10.5
Analysis	5.0	4.7	7.8
Utilization	4.6	4.3	6.7
Exploratory & Methodology Development	5.0	4.7	4.3
TOTAL RESEARCH	76.8	76.7	75.3
INSTITUTION BUILDING & NETWORKING			
Training	7.9	7.4	7.8
Conferences and Seminars	1.3	1.3	1.5
Documentation & Information	1.7	1.6	1.6
Counseling/Advising NARS	2.3	2.1	1.8
Technical Assistance	4.3	5.6	6.1
Network Coordination	5.7	5.3	5.9
TOTAL INST. BUILD.& NETWORKING	23.2	23.3	24.7
T O T A L S	100.0	100.0	100.0

The release in Africa of parasites imported from Latin America to control mealybugs has already given benefits that have been estimated, by an independent evaluator, to be hundreds of millions of US dollars a year. In the coming years, the release and spread of mite predators captured in Latin America and sent to Africa, coupled with mite resistance incorporated from CIAT germplasm, are expected to give benefits of a similar order of magnitude.

Rice Program

The Rice Program at CIAT will maintain its strong commitment to improving germplasm for the irrigated system. In addition, three new themes will be addressed during the coming 5 years: environmentally safe methods to cut costs in production, particularly in the control of pests and weeds; expanded testing of improved germplasm adapted to acid soils; and transfer of methods to national programs. These focuses are in line with the program's overall aim to improve efficiency and output of rice production and to do so in a way that protects the environment and benefits the 40% of Latin Americans who are calorie deficient.

Over the past 30 years, per capita consumption has doubled from 14 to 28 kg paddy, and the growth has been uniform across economic strata. At present the region is almost self-sufficient in rice production, but even conservative projections of demand point to serious deficits in the near future. By the year 2000, Brazil is expected to have a 5 million t deficit even if rice consumption increases by only 2.5% each year. Colombia and Peru will have deficits of almost 1 million t.

As elsewhere in the developing world, rice in Latin America and the Caribbean is produced in distinct systems: irrigated, rainfed, favored upland, and unfavored upland. Irrigated rice, which accounts for only 32% of the production area, provides 61% of the 16 million t total production, while favored upland contributes about 10%. The unfavored upland system predominates in area (55%), primarily in Brazil (4.5 million ha), but production is low (only 4.3 million t) because of variable precipitation, poor soils and low-yielding varieties. Rainfed and subsistence rice production accounts for less than 3% of the total.

During the last 20 years, trends have been disturbing. Although aggregate rates of yield growth were positive and tended to increase in tropical South America, the rate of increase has dropped sharply. In the Caribbean, it has remained constant. In 1976, 11 countries were not self-sufficient in rice production; by 1985 the number had increased to 16. Self-sufficient countries represented only 23% of the production in the region; and, of this amount, Colombia accounted for half.

Price and transport subsidies are common throughout the region; and although they encourage rice consumption, they discourage efficient production and postharvest practices. Under such circumstances, rice can become a drag upon the economy rather than food for development.

Modern varieties with improved plant type and response to nitrogen fertilizer ar grown primarily in the irrigated and favored upland systems. Some progress has been made by the national rice program CNPAF and the Instituto Agropecuária do Campinas, Brazil, in developing varieties for unfavored upland and rainfed systems. Efforts are still needed to incorporate disease and insect resistance, tolerance to common soil stresses, tolerance to low temperatures, and earliness.

In some areas, crop protection against weeds, pests and diseases accounts for 20% or more of production costs. Crop establishment also contributes substantially to high costs in some countries. Yet, these components are particularly amenable to technological solutions, making rice-growing more attractive. To assist countries in the region to find and implement solutions the Rice Program at CIAT is working to:

- Diversify the genetic base of rice in Latin America and the Caribbean.
- Develop and improve screening methods for evaluating germplasm and assist national scientists in acquiring the expertise in evaluating, selecting and advancing early-generation breeding lines.
- Develop high-yielding germplasm that is adapted to irrigated/favored upland and to savanna conditions; that satisfies cropping system requirements; that incorporates tolerance and/or resistance to biotic and abiotic stresses specific to the particular system; and that meets consumer and milling requirements.
- Develop crop management components suitable for incorporation into an integrated system (including practices to control diseases, insects and weeds; to maintain soil fertility and to prepare the land for rice cultivation), giving particualar attention to small- and medium-sized rice producers in tropical areas.
- Assess the alternatives in mechanization available to Latin American and Caribbean rice production systems.
- Assist national programs to set priorities for research and extension.
- Develop an economic data base on rice production and marketing for the region.
- Develop a data base of rice germplasm for the region, available to collaborators.
- Offer appropriate training to national programs.

Germplasm Distribution and Development

The CIAT Rice Program addresses four distinct subregions: the Caribbean; Central America and Mexico; tropical South America; and the Southern Cone. The breeders within the program specialize by production system:

- One breeder is responsable for programming crosses and managing breeding populations for the irrigated systems of the tropical Andean zone and central Brazil. Specific characters for this area include resistance to fungal diseases and hoja blanca virus, iron tolerance, leaf miner tolerance, earliness and excellent grain quality. This individual also manages the rice research at the Santa Roca experimental station, coordinates activities with ICA, La Libertad, and oversees training in the Llanos (including workshops in which national breeders visit Santa Rosa to select materials directly for their programs). Other responsibilities include maintaining close contacts with agencies in Colombia, Peru, Ecuador and Brazil, which have tropical irrigated rice programs.

- For favored upland/subtropical areas, a second breeder programs crosses and manages segregating populations with resistance to fungal diseases and hoja blanca virus, tolerance to iron and cold temperatures, excellent grain quality and earliness. This individual also manages the daily activities at headquarters, the anther culture laboratory and the grain-quality lab, each of which includes research and training components as well as routine germplasm evaluation. Regional responsibilities include liaising with agencies in Central America and the Southern Cone and overseeing two breeding sites maintained in Panama and Guatemala.

- The other breeder is developing germplasm for the vast savanna upland systems of Latin America. In addition, this individual manages the iron tolerance and hoja blanca virus screening nurseries, the crossing program for all breeders, the germplasm bank, and the design and implementation of a population improvement scheme based upon cytoplasmic male sterility. Other responsibilities are diversification of germplasm and support for national efforts to improve production from the savannas in Brazil, Bolivia, Colombia and Venezuela.

The distribution of genetic material within Latin America and the Caribbean is conducted primarily within the International Rice Testing Program (IRTP), a UNDP-funded special project administered by IRRI. This global program ensures that Latin America has access to diverse germplasm from Africa and Asia. Similarly it enables distribution and testing of CIAT-improved varieties. Germplasm with resistance to blast is considered essential for all environments. Other characters such as resistance or tolerance to hoja blanca virus, the Sogata plant hopper, and acid soils are targeted specifically to the various regions.

A few national breeding programs within CIAT's mandate region are beginning to screen early-generation materials supplied by the center; they have either developed their own methods or adopted the methods developed within the network of IARCs. Some have begun to program crosses for their areas and to conduct fully integrated breeding programs, depending on CIAT only for parental material. During the next 5 years, the Rice Program will be working closely with staff in countries such as Brazil, Colombia and Cuba to transfer the capability to evaluate early-generation materials for grain quality, resistance/tolerance to Sogata, stemborers, rice blast and grain discoloration.

The program will also be seeking means to increase diversity in the germplasm it provides to the countries and to improve the efficiency of crosses between Asian and Latin American germplasm. The activities include evaluation of advanced tissue culture and nonsexual gene transfer methods in collaboration with the Biotechnology Research Unit. Techniques using monoclonal antibodies specific to single proteins may be a key to rapid screening for some characters.

The program provides basic breeding support to areas previously neglected. For example, recent breakthroughs in the northern savanna breeding program promise to overcome constraints to rice production in Brazil, particularly in parts of the Cerrado with adequate rainfall. Lines emerging from the project are deep rooted, providing some degree of drought avoidance, are tolerant to soils of pH 5.0 or less with over 80% aluminum saturation, resistant to the blast fungus, and have relatively good yield potential. In spite of these adverse soil conditions, some areas have traditionally given fairly stable, low yields of around 1.5 t/ha and are considered as "moderately favored" for upland rice given their high (about 2000 mm) and reasonably dependable rainfall. This is in contrast to the less-favored upland systems where undependable rainfall is added to the soil problems. The program now projects increased involvement in this production system/ecosystem by providing adapted germplasm.

Newly developed lines have promise for other rice-growing regions as well, and CIAT will be working with IRRI and WARDA to facilitate testing on unfavorable uplands in Asia and in the savanna areas of Africa, respectively. Also, the global network for testing will include CIAT-developed rice lines tolerant to cold during the seedling stage; these should have applications outside the primary target regions of the Southern Cone and Caribbean. For example, around the Mediterranean low temperatures during seeding limit stands, and cold throughout the growing season limits production in the highlands of Central Africa and Madagascar.

Crop Management

As the potential of adapted germplasm can be expressed only under appropriate management practices, an agronomist and a pathologist in the Rice Program seek to refine techniques in crop establishment, weed control (particularly for the noxious weed, red rice), disease management, and harvesting. Feeding into this work is applied original research on pathogens causing, for example, blast and grain rot; on biological control of insect pests; and on nonchemical means of weed control.

The addition of an integrated pest management (IPM) specialist to work with the program is considered essential for 1989 to continue development of the concept of IPM, which is in its infancy in Latin America. IPM is critical to the success of programs to expand rice culture into the savanna, as well as to reduce production costs in irrigated systems. The potential is clear as a postdoctoral fellow with the program was able to make some progress in efforts to reduce inappropriate spraying of pesticides by designing a simplified technique for monitoring pests. The procedure includes a decision tree, based on the levels of insect damage and presence of beneficial insects in the field, which enables farmers to spray only when infestation warrants it.

Among other tasks, program staff, in conjunction with the Seed Unit, work to strengthen the ability of national agencies to produce quality seed of improved lines and to extend the activity so that good-quality seed reaches the farm level.

The agronomist will also evaluate rice cultivars and management practices to identify components that improve the economic feasibility of double cropping with beans and other legumes. The aim will be to capture the residual moisture after irrigated rice. This practice could enable farmers who invest in development of lands (drainage and leveling) for rice cultivation to recover the costs in a relatively short time. For example, costs of government-sponsored development of the poorly drained bottom lands known as varzeas in Brazil are about $1000/ha, and a crop of rice followed by beans could increase the income enough to make the schemes attractive and bring under cultivation millions of hectares (1.3 million ha in Minas Gerais and Santa Catarina alone). Staff from CIAT's Bean Program will provide input.

An economist contributes to the assessment of costs and oversees studies of consumption, demand and marketing. Part of this work is devoted to improving techniques for small irrigated family farms. The studies will enable staff to determine priorities for the program's approach in different countries and to guide activities toward low-income peoples. They will also provide input into the development, feasibility and adoption of crop management and mechanization alternatives, including small machinery available from Brazil and Asia.

The findings of the studies will also aid CIAT staff working with national scientists to develop interdisciplinary diagnoses of limitations in the rice sector and to design plans to address them. Such joint work plans cross institutional boundaries and bring together research and extension groups. They are one form of training that will be a focus of activities over the next 5 years.

Training and Information Sharing

Entry-level scientists will continue to be welcome in the general production course of the program, but emphasis will be given to in-service training for senior scientists seeking advancement in specialized fields, such as IPM and advanced germplasm evaluation. National scientists will receive special publications on methods developed by the program and will have on-line access to the data base on germplasm, provided they have appropriate hardware.

Resource Requirements

Currently, the senior staff positions in the Rice Program are all in Colombia; proposed increases over the next 5 years are for two decentralized staff and one headquarters-based IPM specialist (Table 13) and are reflected in changing budgetary requirements (Table 14).

Resource allocations (Table 15) to research will decline somewhat during the next 5 years in favor of institution building and networking, primarily training and technical assistance. A small increase is expected in research on natural resources and the percentage of allocations to research on crop production will double, while research on genetic resources and crop improvement is expected to drop markedly. One reason for the reduction is the diminishing emphasis on diversifying the genetic base—a major focus over the first several years. At the

Rice Program: Approved Senior Staff Positions for 1988, and Projected Essential and Desirable Positions for 1989-1993

Table 13

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able
HEADQUARTERS												
Leader	1		1	-	1	-	1	-	1	-	1	-
Varietal Improvement												
Breeder, Irrig.Rice (Tropics)	1		1	-	1	-	1	-	1	-	1	-
Breeder, Irrig.Rice (Subtropics), and Favored Upland Rice	1		1	-	1	-	1	-	1	-	1	-
Breeder, Savanna Ecosystem	1		1	-	1	-	1	-	1	-	1	-
Crop Management/Protection												
Agronomist	1		1	-	1	-	1	-	1	-	1	-
Pathologist/IDM	1		1	-	1	-	1	-	1	-	1	-
Entomologist/IPM	-		1	-	1	-	1	-	1	-	1	-
Socioeconomics												
Economist	1		1	-	1	-	1	-	1	-	1	-
CARIBBEAN NETWORK												
Coordinator	-	(1) *F	(1)	- *F	(1)	- *F	(1)	- *F	-	-	-	-
CENTRAL AMERICA NETWORK												
Coordinator	-		-	1	-	1	-	1	-	1	-	1
SOUTHERN CONE NETWORK												
Breeder/Agronomist	-		-	1	-	1	-	1	-	1	-	1
Total Colombian-Based	7	-	8	-	8	-	8	-	8	-	8	-
Total Decentralized	-	-	-	2	-	2	-	2	-	2	-	2
GRAND TOTAL	7	0	8	2	8	2	8	2	8	2	8	2

F = Funding from extra CG resources

* = Senior Staff position provided by IRTP

Rice Program: Approved Budget for 1988, and Projected Budgets for Essential and Desirable Activities for 1989-1993

Table 14

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable
HEADQUARTERS												
Leader	178,146	-	178,146	-	178,146	-	178,146	-	178,146	-	178,146	-
Varietal Improvement												
Breeder, Irrig. Rice (Tropics)	261,405	-	261,405	-	261,405	-	261,405	-	261,405	-	261,405	-
Breeder, Irrig.Rice (Subtropics), and Favored Upland Rice	170,069	-	170,069	-	170,069	-	170,069	-	170,069	-	170,069	-
Breeder (Savanna Ecosystem)	156,689	-	156,689	-	156,689	-	156,689	-	156,689	-	156,689	-
Crop Management/Protection												
Agronomist	180,424	-	180,424	-	180,424	-	180,424	-	180,424	-	180,424	-
Pathologist/IDM	173,932	-	173,932	-	173,932	-	173,932	-	173,932	-	173,932	-
Entomologist/IPM	42,939	-	182,939	-	182,939	-	182,939	-	182,939	-	182,939	-
Socioeconomics												
Economist	116,115	-	116,115	-	116,115	-	116,115	-	116,115	-	116,115	-
CARIBBEAN NETWORK												
Coordinator	-	491,645 *F	533,040 *F	-	429,225 *F	-	120,233 *F	-	-	-	-	-
CENTRAL AMERICA NETWORK												
Coordinator	-	-	-	200,000	-	200,000	-	200,000	-	200,000	-	200,000
SOUTHERN CONE NETWORK												
Breeder/Agronomist	-	-	-	200,000	-	200,000	-	200,000	-	200,000	-	200,000
GRAND TOTAL	1,279,720	491,645	1,952,760	400,000	1,848,945	400,000	1,539,953	400,000	1,419,720	400,000	1,419,720	400,000

F = Funding from extra CG resources

* = Senior staff position provided by IRTP; Operational resources provided by CIDA

Table 15

RICE
Resource utilization by activities for the years 1988, 1989 and 1993

	1988	1989	1993
RESEARCH	%	%	%
Natural Resources	0.2	0.4	0.6
Genetic Resources	8.5	6.0	3.5
Crop Improvement	32.0	27.2	22.0
Crop Production	8.2	11.7	16.7
Crop Protection	13.7	13.0	12.5
Analysis	9.1	9.0	8.0
Exploratory & Methodology Development	1.5	1.5	1.5
TOTAL RESEARCH	73.2	68.8	64.8
INSTITUTION BUILDING & NETWORKING			
Training	8.6	10.1	13.6
Conferences and Seminars	2.1	2.1	2.1
Documentation & Information	2.0	2.5	2.5
Counseling/Advising NARS	6.8	9.1	9.6
Technical Assistance	2.3	3.0	3.0
Network Coordination	5.0	4.4	4.4
TOTAL INST. BUILD.& NETWORKING	26.8	31.2	35.2
TOTALS	100.0	100.0	100.0

same time, the resources allocated to varietal improvement will decrease, as the program moves from providing fixed lines to providing early-generation material, specifically targeted and characterized for the different systems addressed by national programs.

In close collaboration with IRRI, the program has initiated the Caribbean Rice Improvement Network with headquarters in the Dominican Republic. A senior staff position for coordinating the network has been funded by IRRI; and a system is now in place for distributing germplasm, with material dispatched according to the recipients' requirements. This network coordination is being served by short-term postdoctoral-level staff employed by CIAT, using special project funds. The funds also finance network activities such as workshops and training.

The question now being addressed is how the Rice Program can best serve the needs of Mexico and Central America; one possibility is to integrate activities with the Programa Cooperativo de Investigación Agrícola de América Central y el Caribe (PROCICENTRAL). Having a senior scientist posted to the region is desirable and could take significant pressure off headquarters-based staff, possibly freeing up one breeder to be posted to Brazil to serve the Southern Cone. This scenario would bring the total senior staff in the program to nine. A regional effort based in Brazil is needed, given the environmental differences from CIAT headquarters, the size of the region, and the similarities to the African savanna. The breeder in Brazil would handle germplasm exchange, as well as assist in the coordination of joint agronomic investigations by CIAT, the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) within the savanna and the varzeas, and the other countries of the Southern Cone.

The program plans to strengthen its agronomic evaluation of cropping systems, particularly for the savanna/Cerrado systems and the Brazilian varzeas; it will gain from cooperative research with the Tropical Pastures and Bean programs.

Expected Benefits

Emphasis will now gradually shift towards integrated crop management which can substantially reduce production costs of tropical rice. For example, in Colombia alone, reductions in pesticide use on rice could save about US$16 million annually and provide employment in pest monitoring for agricultural technicians. In an isolated area (6000 ha) of eastern Colombia, farmers have stopped applying insecticides by using the CIAT-developed technique for monitoring pests. Similarly, savings in herbicides can be achieved by good land preparation and timely applications, and the amount of rice seed being planted (up to 300 kg/ha) can be cut in half.

Furthermore, the germplasm adapted to acid soil savannas could open vast areas for rice production (50,000 ha in Colombia alone), and dwarf lines with relatively high yield potential could increase productivity to 3 t/ha on about 2 million ha of Cerrados.

The CIAT Rice Program and national partners periodically monitor technology adoption. A recent study estimated that in 1984 the additional annual production of rice attributable to CIAT-developed technologies was US$545 million. As research on rice is linked with the global operation coordinated by IRRI, a cost/benefit ratio for the CIAT Rice Program is not strictly fair. Yet if one assumed CIAT efforts were responsible for half that value, benefits would be 225 times the costs of research. The new varieties for the Cerrados and improved crop management practices could net similar returns.

The cattle industry and, hence, pastures in poor acid soil of the savannas, the rain forests and Central American ecosystems are growing in Latin America; and the practices currently employed in such environments have low outputs and limited sustainability. The program is focusing on methods to increase the productivity of these lands and to halt the progressive depletion of the soils. The different ecosystems differ markedly as do the production systems being set up on them.

The tropical savannas (about 250 million ha) have great agricultural potential because of abundant solar radiation, adequate rainfall and temperatures favoring extended growing seasons. Parts (100-150 million ha) of the forest also have high agricultural potential but are at high environmental risk because of traditional practices in opening up and exploiting the land. The risk is augmented by the heavy influx of people attempting to escape poverty elsewhere in these countries (population growths of, for example, 8.6% annually in Rondonia, Brazil, and 7.9% in Ucayali, Peru, compared with national averages of 2.7%).

In the tropical savannas, pasture is the most practical way to use the land profitably until the infrastructure develops adequately to support other uses. At present, cattle can graze the savannas at little or no opportunity cost, but existing vegetation will support only 0.1-0.2 animal/ha. The cattle ranches have been pushed to these marginal agricultural areas as prime lands have been developed for crop production. For example, cattle populations in the developed southern Brazilian states of Rio Grande do Sul and Santa Catarina constituted 23.8% of the national herd in 1940, but only 12.7% by 1985. During the period, cattle in the Cerrados states of Goiás and Mato Grosso (with predominantly acid and poorer soils) had increased from a minor proportion of 15.3% of the national herd to nearly one-third of the Brazilian cattle population. Similarly, the Valle del Cauca, where CIAT headquarters is located, accounted for 7.4% of the Colombian herd in 1950 and only 2.2% by 1985, with the predominantly poor acid soils of Meta (Llanos) carrying a much-increased proportion of the cattle population—6.1% in 1985 compared with 0.6% in 1950.

The herds have also grown in what was once forested regions. In the humid tropics of Caquetá, Colombia, for example, the cattle population increased from 1.4% to 5.5% of the national herd between 1950 and 1985.

In the savanna, native grasslands are burned and then grazed; the new growth serves as quality forage for a few weeks. As the grass matures, it becomes unpalatable to the grazing animals. The forage that accumulates thus is sparingly grazed and is essentially left as fuel for the next burning (1-2 years later). In the Cerrados alone, close to 30 million ha of traditional grass pastures are subject to progressive degradation.

In the humid tropics, livestock producers clear forested land and burn it for cultivation and pasture. The land can initially support more than 2 animals/ha; but it deteriorates within

3-4 years and becomes seriously degraded in a few more years. The production systems include, besides pastures for beef and dual-purpose cattle, various annual and perennial crops. Trees for timber, shade and forage as components of silvopastoral systems, are still a minor and relatively unknown component.

Tropical America has an estimated 250 million head of cattle, about 20% of the world total. Beef and milk are traditional staples in the region, and beef consumption per person is 16 kg/year (range 7-38 kg), significantly higher than in tropical Africa and Asia and about two-thirds that in Europe. During the last two decades, consistent increases in beef production have been recorded in most of the region; but with few exceptions, supplies have lagged behind demand. As a result, beef prices have increased in real terms in most countries. The implications are serious because the proportion of family income spent on beef is high. Among low-income consumers, these commodities make up 12-26% of total household expenditures. Data on income elasticities indicate that increased supplies of the commodities would particularly benefit the low- and middle-income families in both urban and rural areas.

The opportunity to increase supplies of these traditional staples in urban and rural areas is one of the promises of improved technologies for pastures. On the one hand, increased and sustainable production on the large cattle ranches in the tropical savannas would increase the supply—and hence reduce the price—of beef and dairy products in urban areas. On the other hand, improved, ecologically sound systems for the humid tropics would increase income for small farms operated by the poor.

To ignore the urban poor in Latin America is unacceptable, as this group—mainly landless rural dwellers seeking work—is expanding rapidly and is demanding attention. Urbanization has increased an average 20% throughout tropical America during the past 25 years. In tropical South America and Mexico, urbanization increased, on the average, from 46% in 1960 to 67% in 1985; in Central American countries, the increase was from 39.5% to almost 59%, growing much faster than the food supply.

At present, the major constraint to increasing—perhaps doubling—production of beef and milk is the quality and availability of forage and feed. Diseases and pests are less of a problem for cattle in tropical America than they are in Central Africa, and the breeds are well adapted to the region.

The countries are devoting personnel, infrastructure and funds toward improving the picture for the cattle industry. Since 1979, they have been working with CIAT in the Tropical Pasture Evaluation Network (RIEPT) to test forage and systems that can increase production without damaging the environment.

CIAT possesses the world's largest collection of germplasm of forages (grasses and legumes) suited to infertile acid soils. Assembling it has been one major focus of the Tropical Pastures Program. The collection is the foundation for the program's effort to improve productivity in the region.

The program currently has a multidisciplinary staff of 17 senior scientists (Table 16). They constitute three

Table 16

Tropical Pastures Program: Approved Senior Staff Positions for 1988, and Projected Essential and Desirable Positions for 1989-1993

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able	Essen-tial	Desir-able
HEADQUARTERS (Palmira, Carimagua, Quilichao)												
Leader	1	-	1	-	1	-	1	-	1	-	1	-
Germplasm Exch./Collection Spec.	1	-	1	-	1	-	-	- *	-	-	-	-
Plant Breeder	1	-	1	-	1	-	1	-	1	-	1	-
Plant Pathologist	1	-	1	-	1	-	1	-	1	-	1	-
Plant Entomologist	1	-	1	-	1	-	1	-	1	-	1	-
Microbiologist	1	-	1	-	1	-	1	-	1	-	1	-
Soil/Nutrient Recycling Spec.	1	-	1	-	1	-	1	-	1	-	1	-
Ecophysiologist	1	-	1	-	1	-	1	-	1	-	1	-
Animal Nutritionist/Mgt. Spec.	1	-	1	-	1	-	1	-	1	-	1	-
Seed Production Specialist	1	-	1	-	1	-	1	-	1	-	1	-
Grazing Systems Specialist	1	-	1	-	1	-	1	-	1	-	1	-
Economist	1	-	1	-	1	-	1	-	1	-	1	-
ISOHYPERTHERMIC SAVANNAS (Palmira, Carimagua, Llanos)												
Agronomist/RIEPT	1	-	1	-	1	-	1	-	1	-	1	-
Production Sys. Specialist					-	-	1	- **	1	-	1	-
ISOTHERMIC SAVANNAS (CPAC, Cerrados)												
Agronomist/RIEPT	1	-	1	-	1	-	1	-	1	-	1	-
Pasture Establishment/ Reclamation Specialist	1	-	1	-	1	-	1	-	1	-	1	-
HUMID TROPICS (Pucallpa, Amazon Region)												
Agronomist/RIEPT	1	-	1	-	1	-	1	-	1	-	1	-
Pasture Reclamation Specialist	1	-	1	-	1	-	1	-	1	-	1	-
Production Systems Specialist	-	-					1	-	1	-	1	-
Socioeconomist	-	-					-	1	-	1	-	1
CENTRAL AMERICA & THE CARIBBEAN (Costa Rica, C.A. & Carib. Region)												
Agronomist/RIEPT	1	-	1	-	1	-	1	-	1	-	1	-
AFRICA (Subhumid Lowlands)												
Agronomist/RIEPT--ILCA	-	-	-	-	-	1	-	1	-	1	-	1
Total Colombian-based	13	-	13	-	13	-	13	-	13	-	13	-
Total Decentralized	5	-	5	-	5	1	6	2	6	2	6	2
GRAND TOTAL	18	0	18	0	18	1	19	2	19	2	19	2

F = Funding from extra CG resources
* = Transfer to Production Systems Specialist in Isohyperthermic Savannas
** = Transfer from position for Germplasm Exch./Collection Specialist

research groups. The groups are collaborating with national and other international scientists (Table 17) to strengthen pasture research and development of acid soils in the region. The activities are to:

- Broaden the genetic base and screen for adaptation of forage grasses and herbaceous and tree legumes for incorporation in low-input pastures.
- Develop a low-input, low-risk pasture technology for increasing beef and milk production, thereby contributing to the sustainability and rehabilitation of production systems in the savannas and rain forests.

  Fit the pasture-based technology into the predominant farming systems of the region.

Broadening and Testing the Genetic Base

Collecting grasses and legumes adapted to acid soils has produced high payoffs. Several have promise for reclaiming degraded grass pastures in the savannas and humid tropics if introduced together with appropriate techniques for grazing management.

More than 20,000 entries are now available in the germplasm bank at CIAT and are essential to the other efforts in the Tropical Pastures Program and to the regionwide program of testing and evaluation. Future activities will be to increase the variability of the key grass and legume species including leguminous shrubs, tolerant to acid soils with high levels of aluminum. Selected components will be used primarily for systems designed to minimize erosion and to contribute to the sustainability of production in both the savanna and the humid tropics. This effort is complemented by a breeding program to recombine positive characteristics of highly promising accessions.

Preselection of germplasm is currently done in cooperation with ICA in Carimagua, Colombia, which represents the isohyperthermic savannas; the Centro de Pesquisa Agropecuária dos Cerrados (CPAC-EMBRAPA) in Planaltina, Brazil, representing the isothermic savannas; the Instituto Nacional de Investigación Agraria y Agroindustrial (INIAA) and the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA) in Pucallpa, Peru, which represents the humid tropics; and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) and the Ministerio de Agricultura y Ganadería (MAG), in three sites of Costa Rica, representing the major climatic zones of Central America with acid soils.

Discussions are being held with both ILCA and CIRAD (France) to establish a pasture screening and evaluation network in West Africa.

The pasture technologies for acid soils may also prove useful in Asian farming systems. Germplasm is already being exchanged in cooperation with the national agricultural programs and a pasture network financed by the Australian Centre for International Agricultural Research (ACIAR).

The preselections go to national programs (more than 200 sites) participating in the RIEPT, which serves to catalyze pasture-applied research and promote development. Training and coordination of regional subnetworks

Table 17

Essential Senior Scientist Positions Required and their Focus and Contributions to the Tropical Pastures Program's Strategies

	Research						Networking
	Applied					Basic	
Staff Positions	1 Germplasm	2 Adapta-bility	3 Low input pastures	4 Pasture systems	5 Methods	6	7
Headquarters (Palmira, Carimagua, Quilichao)							
Leader	+	+	+	+	+	+	+
Germplasm collector*	+++	++			+		+
Breeding	+++	+			++		+
Plant pathology		+++			+	+	++
Plant entomology		+++			++		++
Microbiology	++		+++			+	+
Soils/nutrient recycling			++		++	+++	
Ecophysiology			++		++	+++	
Animal nutrition/mgement				+	+	++	+++
Seed production		+		+++			+++
Grazing systems				+++		++	++
Economics			+	+++	++		+
Isohyperthermic savanna (Palmira, Carimagua, Llanos)							
Agronomy/RIEPT*		+++			+		+++
Production systems**				+++	++	+	+
Isothermic savanna (CPAC & Cerrados)							
Agronomy/RIEPT		+++			+		+++
Pasture establishment/reclamation			+++	++	++		
Humid tropics (Pucallpa & the Amazon)							
Agronomy/RIEPT		+++			+		+++
Pasture reclamation			+++	+	+	+	+
Production systems**				+++	++	+	+
Socioeconomics**				+++	++	+	+
Central America & Caribbean (Costa Rica & the region)							
Agronomy/RIEPT		+++			+		+++
Africa (Subhumid lowland)							
Agronomy/RIEPT - ILCA***	+	+++					+++

Level of contributions: + = moderate; ++ = high; +++ = very high (maximum of 7+/SS)

* Senior scientist positions to be merged during the period 1989-1993.
** New (essential) senior scientist position for the period 1989-1993.
*** New (desirable) senior scientist position for the period 1990-1993.

are part of CIAT's contribution to the RIEPT. Leaders of national programs and CIAT participate on RIEPT's advisory committee. Given the network's continued growth, the advisory committee decided to decentralize activities, creating four subnetworks: the humid tropics, Llanos, Cerrados and Central America, coordinated by the program's four pasture agronomists in Pucallpa, Palmira, Brasilia and San José, respectively (Fig. 1).

Besides the agronomists, CIAT scientists devoted to germplasm development include a specialist in germplasm collection and exchange, a breeder, a plant pathologist and an entomologist. In 1990, the position for the germplasm specialist at headquarters will be eliminated, and the responsibilities for collection and initial characterization will be shared by the Genetic Resources Unit and the agronomist at Palmira (focusing on germplasm development for the Llanos). At that time, the program will be joined by a production systems specialist for the Llanos.

Over the last few years, the breeder has developed lines of *Stylosanthes guianensis*, which are now being exposed to the RIEPT's screening scheme. New breeding projects—such as interspecific crossing of *Centrosema* spp. to obtain new materials that combine the characters of resistance to *Rhizoctonia* and high seed production—are being initiated. The plant pathologist and entomologist will continue providing input to basic research at headquarters and Carimagua, and will increase support to the main screening sites of the RIEPT.

The results from the work of germplasm development feed into work on pasture development, production and management practices, and farming systems. These activities are all part of the program's commitment to devising technologies for low-input, high-output pastures, alone or as part of a cropping/production system.

Low-Input, High-Output Pastures

The technologies include:

- Adapted grass-legume associations. Legumes that contribute directly to the animal's intake of protein and energy (particularly during the dry season) and that enhance the nitrogen available to grasses are essential.
- Techniques that improve pasture establishment. Risks or costs during pasture establishment are a major deterrent to adoption by farmers. Crop-pasture interactions open up the possibility of reducing costs, as the grasses and legumes could benefit from the residual effects of fertilizers and other amendments applied to crops.
- Appropriate management. Maintenance, fertilizer application, intensity and frequency of grazing—among other practices—must be relevant to farmers' possibilities and needs; thus the grass-legume associations must be able to tolerate a range of management strategies.
- Farmers' perspective. The role of pastures is extremely variable, depending on the land use potential and its use by the farmer. Some pasture-based farming systems require soil cover that has a high carrying capacity for cow-

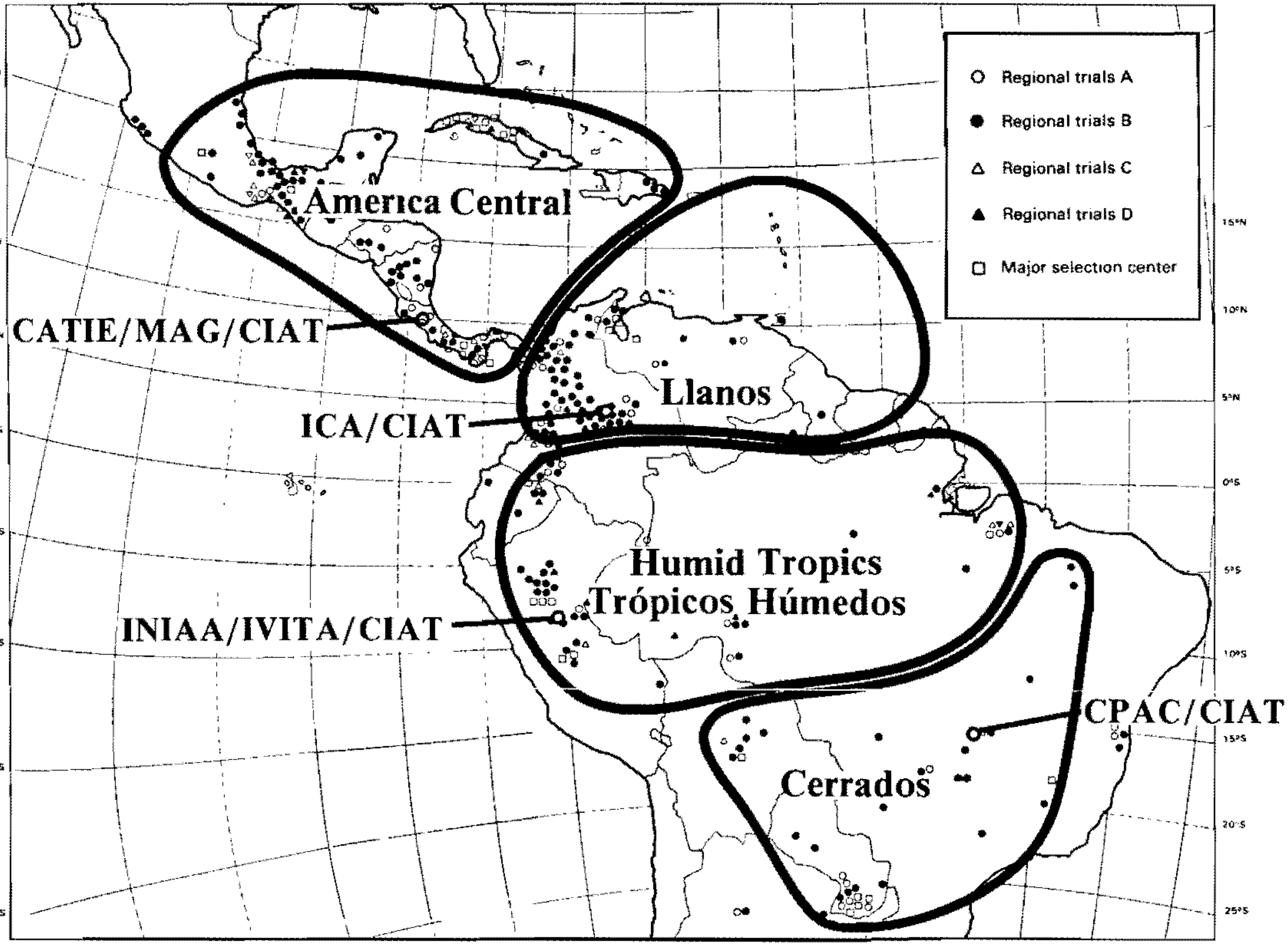


Figure 1. International Tropical Pastures Evaluation Network (RIEPT) 1987.

calf production on erodible slopes or to supplement poor native grass-lands seasonally. Others require a pasture with year-round production of good-quality dry matter to feed milk cows. The species or management practices differ, so researchers work with farmers as early as possible during design of tests.

Given these essential components, the technology is expected to contribute to the sustainability of production systems through the work of specialists in nutrient cycling and ecophysiology, as related to pasture development. These efforts at headquarters are complemented by two specialists on pasture establishment and reclamation based at CPAC (isothermic savannas) and at Pucallpa (humid tropics). These scientists study interactions of biological components of the systems (environment/germplasm, plant/plant, plant/animal/management and pasture/crop); screen for effective rhizobia; and model the behavior of nutrients (nitrogen fixed by the legumes and lost through volatilization, the fate of phosphorus applied at establishment, and potassium, magnesium and sulfur available in the soil). Selections for qualities contributing to the nutrition of the grazing animal are also studied. Research on pasture reclamation is giving priority to testing legumes introduced into degraded weedy areas. In the Cerrados, the focus is on establishing and grazing legumes already deemed suitable. In the humid tropics, reclamation of existing, degraded pastures has priority.

Pasture-Based Farming Systems

Production and management practices within the farming systems of the region are the focus of a seed production specialist, a specialist in grazing systems, and an economist at headquarters. They will work with two production systems specialists—one for the isohyperthermic savannas and one for the humid tropics. The aim is to lay the groundwork for adoption of new techniques.

The specialists in production systems will act as coordinators for activities in their ecosystems, sharing information with members of CIAT's other programs and with the land use specialist from the Agroecological Studies Unit.

A desirable activity would be a systems approach to the humid tropics, incorporating not only the production systems specialist but also a socioeconomist. CIAT considers it important that pasture work be done as part of a larger systems effort integrating research involving perennial plants, such as pastures and trees. This would be a longterm effort incorporating expertise of other international organizations whose staff have experience with crop-tree associations and appropriate management. A collaborative effort would enable CIAT staff to gain from research conducted in the humid tropics of Africa and would be an opportunity for scientists from the other organizations to learn about pasture technologies developed at CIAT.

Resource Requirements

CIAT staff collaborate closely and share responsibilities for applied and basic research as well as training and networking in the program (Table 17). The proposed increases in senior staff and in the corresponding budgets (Tables 16 and 18) are for decentralized positions so that increased emphasis can be placed on networking and institution building in national systems.

In the past, emphasis was given to methods of germplasm screening and pasture evaluation under grazing. During the last 3 years, on-farm evaluation of pastures has been initiated in contrasting ecosystems and farming systems as a basis for more reliable methods of studying the role of pastures and of incorporating farmers' perspectives. These experiences and methods are passed to the RIEPT for advance and application in its research on farmers' fields.

Pilot studies of pasture systems are a new activity of the Tropical Pastures Program. They will be devoted, first, to crop-livestock options for isohyperthermic savannas, expanding later to agro-silvo-pastoral systems for the humid tropics, in cooperation with other institutions.

The program will reduce efforts to broaden variability in the germplasm collection, and increased attention will be given to the evaluation of shrub and tree legumes for both the subhumid and the humid tropical environments within the program's target area (Table 19). More basic and methodological research will be undertaken to define the relationships at the soil/plant/animal interface. Also, projects on integrated pasture-based systems are to be initiated.

Concurrently, downstream research including on-farm testing of improved pastures and large-scale demonstration of new technology will be done as case studies.

The program proposes a reduction in technology development for the isohyperthermic savannas so that it can increase efforts in the humid tropics and Central America. It also plans an initial involvement in Africa.

One of the essential staff changes during the next 5 years will be met by the discontinuation of the position for the germplasm collection specialist; thus only one of the two essential new positions—the production systems specialists for the isohyperthermic savannas and the humid tropics—will be additional staff. Two additions are desirable. One is an agronomist/RIEPT Africa, enabling the program to expand its coverage to support work in Africa; and one is a socioeconomist to support the integration of silvo-pastoral systems in the humid tropics.

Expected Benefits

The program has led to the adoption of improved varieties in several of the countries participating in the RIEPT. Large areas (350,000 ha) of the continent have been sown with *Andropogon gayanus*, one of the improved grasses; and *S. capitata*, a forage legume, is now being planted in the Colombian Llanos (5000 ha in 1986-1987). Availability of seed has been a constraint to adoption of the legume. **CIAT in the 1980s** estimated a benefit/cost ratio of 31:1 for pasture research at CIAT, and the calculations are regarded as valid today.

The program is gradually moving into regions with smaller farms where the potential is to integrate new pasture technologies into mixed farming systems in areas of active colonization. The challenge is to demonstrate the

Table 18

Tropical Pastures Program: Approved Budget for 1988, and Projected Budgets for Essential and Desirable Activities for 1989-1993

	1988		1989		1990		1991		1992		1993	
	Core	Special Project	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable	Essential	Desirable
HEADQUARTERS (Colombia: Palmira, Carimagua, Quilichao)												
Leader	331,628	-	331,628	-	331,628	-	331,628	-	331,628	-	331,628	-
Germplasm Exch./Collection Sp.	206,096	-	206,096	-	206,096	-	-	- *	-	-	-	-
Plant Breeder	166,304	-	166,304	-	166,304	-	166,304	-	166,304	-	166,304	-
Plant Pathologist	179,841	-	179,841	-	179,841	-	179,841	-	179,841	-	179,841	-
Plant Entomologist	162,675	-	162,675	-	162,675	-	162,675	-	162,675	-	162,675	-
Microbiologist	160,383	-	160,383	-	160,383	-	160,383	-	160,383	-	160,383	-
Soil/Nutrient Recycling Spec.	168,107	-	168,107	-	168,107	-	168,107	-	168,107	-	168,107	-
Ecophysiologist	181,995	-	181,995	-	181,995	-	181,995	-	181,995	-	181,995	-
Animal Nutritionist/Mgt. Sp.	232,053	-	232,053	-	232,053	-	232,053	-	232,053	-	232,053	-
Seed Production Specialist	235,706	-	235,706	-	235,706	-	235,706	-	235,706	-	235,706	-
Grazing Systems Specialist	225,153	-	225,153	-	225,153	-	225,153	-	225,153	-	225,153	-
Economist	192,773	-	192,773	-	192,773	-	192,773	-	192,773	-	192,773	-
ISOHYPERTHERMIC SAVANNAS (Palmira, Carimagua, Llanos)												
Agronomist/RIEPT	332,577	-	332,577	-	332,577	-	332,577	-	332,577	-	332,577	-
Production Systems Specialist						-	206,096	- **	206,096	-	206,096	-
ISOTHERMIC SAVANNAS (CPAC, Cerrados)												
Agronomist/RIEPT	134,109	-	134,109	-	134,109	-	134,109	-	134,109	-	134,109	-
Pasture Establishment/ Reclamation Specialist	121,057	-	121,057	-	121,057	-	121,057	-	121,057	-	121,057	-
HUMID TROPICS (Pucallpa, Amazon Region)												
Agronomist/RIEPT	118,284	-	118,284	-	118,284	-	118,284	-	118,284		118,284	-
Pasture Reclamation Specialist	148,966	-	148,966	-	148,966	-	148,966	-	168,966		148,966	-
Production Systems Specialist	-	-	-	-	-	-	200,000	-	200,000	-	200,000	-
Socioeconomist	-	-	-	-	-	-	-	200,000	-	200,000	-	200,000
CENTRAL AMERICA & THE CARIBBEAN (Costa Rica, CA & Carib. Region)												
Agronomist/RIEPT	155,967	-	155,967	-	155,967	-	155,967	-	155,967	-	155,967	-
AFRICA (Subhumid Lowlands)												
Agronomist/RIEPT-ILCA	-	-	-	-	-	200,000	-	200,000	-	200,000	-	200,000
Total Colombian-based	2,775,292	-	2,775,292	-	2,775,292	-	2,775,292	-	2,775,292	-	2,775,292	-
Total Decentralized	678,382	-	678,382		678,382	200,000	878,382	400,000	878,382	400,000	878,382	400,000
GRAND TOTAL	3,453,675	0	3,453,675	0	3,453,675	200,000	3,653,675	400,000	3,653,675	400,000	3,653,675	400,000

* = Transfer to Position for Production Systems Specialist in Isohyperthermic Savannas

** = Transfer from position for Germplasm Exch./Collection Specialist

Table 19

TROPICAL PASTURES
Resource utilization by activities for the years 1988, 1989 and 1993

	1988	1989	1993
RESEARCH	%	%	%
Natural Resources	5.9	5.9	7.5
Genetic Resources	10.2	9.3	4.8
Germplasm Improvement	22.0	22.0	20.2
Pasture Production	6.9	6.9	7.2
Pasture Protection	3.4	3.4	3.1
Livestock Production*	16.1	16.1	20.0
Analysis	1.7	1.7	2.0
Exploratory & Methodology Development	8.2	9.1	9.2
Analysis of Impact	0.7	0.7	1.1
TOTAL RESEARCH	75.1	75.1	75.1
INSTITUTION BUILDING & NETWORKING			
Training	9.6	9.6	9.6
Conferences and Seminars	2.0	2.0	2.0
Counseling/Advising NARS	4.3	4.3	4.3
Technical Assistance	2.2	2.2	2.2
Network Coordination	6.8	6.8	6.8
TOTAL INST. BUILD.& NETWORKING	24.9	24.9	24.9
T O T A L S	100.	100.0	100.0

* This activity includes research on pasture management and utilization to increase animal productivity.

benefits of legume-based pastures in animal output and conservation of resources in relevant farming systems. Over the long term pasture-based integrated systems on marginal acid soils will contribute to economic growth and sustainability in these areas.

The impact of the new pasture technology will be directly measurable in terms of total area planted to the improved pastures; increased productivity (beef and milk) per animal and per ha; and reduced production costs. Other benefits are improved conservation of natural resources in fragile environments and better nutrition of rural and urban peoples. These last benefits are difficult to measure; therefore, the program will work closely with national scientists to develop a method for monitoring and assessment. There is no doubt that this strong ongoing national and international commitment to the development of a revolutionary pasture technology can achieve impact in the development of rural marginal lands and the overall social welfare of the continent.

TRAINING AND COMMUNICATIONS SUPPORT PROGRAM

The Training and Communications Support Program is new, bringing together under one leader all the activities in training and conferences, publications and information. Its goal is to strengthen the capabilities of national partner institutions and to promote complementarity among all the participants in national and international research on agriculture. This includes encouraging development of regional and national training activities as well as global information services to inform not only scientists but also policymakers and donors. Given these objectives, the program will continue and expand the training and communications that have been under way throughout the 1980s.

As in the past, the activities will be flexible, tailored to particular national agricultural programs, according to their requirements and resources for training and communications.

Central to the training to date has been a commodity-specific package made up of a 1-2 month intensive course introducing production and research plus individualized training (2-5 months) in a discipline or subject, under the direct supervision of one of CIAT's scientists.

A range of other group events (from 1-2 weeks to 1.5-2.5 months) and individualized training opportunities are available. For example, CIAT's Seed Unit focuses on short intensive courses providing the knowledge and skills to produce and distribute seed (genetic and basic seed production; seed certification; multiplication; distribution and marketing).

Also, in-country courses (about 2 weeks each) have been increasing. The total conducted between 1980 and 1987 was 95, with commodity programs offering 1-2 in 1980 and 5-7 by 1987. These events are designed mainly for professionals involved in technology transfer (e.g., extension, technical advice, agricultural credit supervision) and in the articulation of research and technology transfer programs within their countries and with CIAT. Often the events are linked to the release of improved varieties; increasingly, they are devoted to on-farm research and are carried out in several consecutive phases covering at least one whole production cycle. They involve two kinds of support: technical input from subject specialists and organizational skills in conducting the courses.

The individualized training takes place both at CIAT headquarters and in decentralized locations where outposted staff operate. It ranges from short technical skills development through in-service disciplinary training (2-8 months) to MSc or PhD thesis research. In-depth individualized training in CIAT commodities is also provided for technology transfer specialists, particularly for professionals who act as trainers in their home countries.

A total of 1409 persons were trained at CIAT between 1980 and 1987. Of this group, only about 6% were involved in work on their master's or doctoral degrees. In future, greater emphasis will be placed on higher degree training and on training trainers in national agricultural systems. These two activities will upgrade national capacities for exacting and sophisticated research, on the one hand, and will bring about multiplier effects in technology transfer, on the other.

The opportunities in higher education are principally for graduates from developing countries. The academic phase will be carried out with funds from extra-CIAT sources, while the research component will be completed with funding from CIAT. Universities such as Vicosa and Pelotas (Brazil), La Molina (Peru), Universidad Nacional (Colombia) and CATIE—as an equivalent institution—are CIAT's academic partners within the region; and initiatives with North American and European universities will continue.

Training for trainers will focus on how to diagnose production problems; what solutions are available, including improved crop varieties; and how to draw on and provide input to researchers for the generation of new technologies. Those who complete the courses will be assembled into regional trainers' networks, and CIAT will keep them up to date on CIAT-developed technologies.

Complementing the courses are audiotutorial materials and training manuals; these have proved effective not only as teaching aids but also as tools for technology transfer and dissemination of research results.

Conferences, workshops, symposia and seminars are means by which the center develops and consolidates partnerships among and with national research institutions. The information generated by and for such events is disseminated in books, reports and periodic publications put out by the center.

CIAT's serial publications include the annual reports and **CIAT International**, a newsletter to inform donors, policymakers and others about CIAT's work. Newsletters or bulletins are also published regularly for each of the commodities and the Seed Unit. Mailing lists differ by publication; but, overall, the tropical Americas constitute 63% of the distribution; North America 16%; Europe and Africa 7% each; Asia 5% and Oceania 2%.

CIAT's library and commodity-specific information centers constitute a superb bank of information. New acquisitions are regularly announced in a current awareness service, which includes journal circulation for internal users; monthly copies of the contents pages from journals; and quarterly abstract journals for cassava, beans and tropical pastures. Upon request, the specialized information centers perform bibliographic searches (lists or annotated bibliographies); and if the subject matter warrants it, the resulting bibliographies are published.

Staff collaborate closely with the commodity programs in planning, programming and implementing activities so that the education and information offered complement and advance at the same time as the research and follow the same strategies. The plan is to focus training and communication on the problems being researched jointly by CIAT and national partners.

Within this framework, the Training and Communications Support Program

- Coordinates training activities, once objectives, methods and responsibilities for input have been agreed with commodity programs;
- Designs methods and assembles data to assess the training and communications needs of national commodity programs;
- Assists national partners to set up training schemes that fit their needs and resources;
- Organizes workshops, seminars and conferences, both for disseminating knowledge and methods and for stimulating cooperation;
- Organizes library services, including acquisitions of books, preparation of microfiches, provision of reference and bibliographic research services;
- Produces specialized information, seeking to disseminate information generated at the center, be it spoken, written or visual, and other support materials; and
- Publishes scientific/technical documents (including monographs, texts and conference proceedings, as well as audiovisual materials) and network support documents (e.g., commodity-specific newsletters, manuals on technology).

The program comprises four units: The Training and Conferences Unit is responsible for all activities related to the training modules—including the preparation of training materials—as well as organizing workshops, seminars and conferences. The Publication Unit is responsible for the public dissemination of information generated at the center. The Information Unit is concerned with the collection, classification, storage, retrieval, packaging and dissemination of knowledge relevant to CIAT's activities but generated by others. The Support Services Unit deals with graphic design, photographs and illustrations; the printing of CIAT publications and other materials; and other ancillary services.

The units report to the leader of the program, who is directly responsible for assuring in-house complementarity and for spearheading collaboration with national partners, particularly the assessments of institutional needs.

Resource Requirements

At present, four senior staff positions (Table 4) and a corresponding budget (Table 5) are set aside for the program; but given the number of lines reporting to the program leader, a head for each unit is essential. A senior-level individual with a strong background in human resource development and educational technology has been projected as an essential addition for Training and Conferences in 1989.

As the activities of CIAT's research programs move toward basic, upstream research, the training and communications support will change accordingly. New joint ventures with national partners will demand new skills and will prompt a reevaluation of the methods, networks and backup information.

The level of training will change. If the national agricultural systems take over research and production activities formerly done jointly, the demand for higher degree level training will grow at the expense of the demand for general researchers. More opportunities for MSc or PhD thesis research will therefore have to be offered by CIAT. The basic human resource development activities for less-advanced partners could be taken on by other national systems, with some assistance by CIAT to develop the capacity.

The production of communication materials will shift toward quicker and cheaper media (available through improved technology) on the one hand and toward greater participation by national scientists, particularly in the commodity newsletters and networking publications, on the other.

Despite the shifts in emphasis, the overall allocation of resources within the program will remain fairly constant during the next 5 years (Table 20).

TRAINING & COMMUNICATIONS
Resource utilization by activities for the years 1988, 1989 and 1993

Table 20

	1988	1989	1993
INSTITUTION BUILDING & NETWORKING	%	%	%
Training:			
Specialized courses	16.9	14.4	11.2
Individual internship	19.0	16.8	14.8
Degree related	6.3	8.8	14.0
Conferences and Seminars	11.0	13.0	15.0
Documentation & Information	35.0	36.0	36.0
Counseling/Advising NARS	6.8	5.5	3.5
Technical Assistance	0.5	0.5	0.5
Network Coordination	4.5	5.0	5.0
TOTAL INST. BUILD.& NETWORKING	100.0	100.0	100.0
T O T A L S	100.0	100.0	100.0

RESEARCH SUPPORT

Agroecological Studies

CIAT's Agroecological Studies Unit is charged with the collection, management and analysis of data on environment, cultural practices and socioeconomic conditions in areas served by the commodity programs. The activities contribute to the setting of research priorities and to the application of technologies in new areas.

The unit employs a computer-based information system, designed for the needs of the four ecologically distinct commodities. The method of data collection and storage, developed by the unit, is flexible enough to provide an appropriate degree of detail and scale and is now being applied to information for the cassava, beans and tropical pastures programs.

Assembling the Pieces: From Climate to Household

Data on climate and soil are common to all the commodities and are relatively easy to retrieve. Coverage of long-term climate data for the whole tropical world is now being realized, and data from more than 12,000 meteorological stations are already on hand. Data on soils are being stored on the basis of land system. Coverage for the lowland tropics of South America is available and will soon be extended to Central America. The method for defining cropping microregions has now been decided for the storage of information on crop system, culture, economy and society. Continentwide distributions of areas where cassava and beans are grown have been produced, and staff in the Cassava Program have drawn on the unit's detailed information on microregions.

At the request of the commodity programs, the unit provides environmental analyses and undertakes field surveys using techniques that detail rapidly the elements necessary for the implementation of new technology—such as the integrated cassava-drying projects—in a given area.

Expanding and maintaining the data base as well as related services to CIAT management and staff are constant activities of the unit, and the level of staffing depends on the demand for and utility of the services. At present, demand far exceeds the unit's capabilities.

In the coming 5 years, the major efforts will be completing the data base for broad-scale (continental and regional) crop geography so that the unit's staff can focus on microregions and expand the crop and socioeconomic data base. The other immediate priority, which will phase out in 2-3 years, is the design of programs that analyze data quickly and easily for users.

A further medium-term activity will be to identify and classify the ranges of adaptability present in the CIAT germplasm. This will enable the unit to give CIAT breeders, scientists and management a clear idea of how many agroecological niches they need to work for and where these niches exist.

In developing a sustainability perspective, commodity programs are increasingly interested in the implications of cropping systems for the environment. To this end, a better understanding of the potential effect of land use practices on land systems is required. The Unit will be serving commodity programs in this field, by contributing to the analysis of the consequences of alternative management systems on the conservation of natural resources.

Resource Requirements

The unit will be well served through 1989 by postdoctoral fellows working on the crop geography of cassava, rice and tropical pastures. The resources available include some extra support staff for these temporary positions; however, for 1990 and beyond, a second senior staff position is essential (Table 4) to expand activities into the land-use field and will mean an increase in the unit's budget (Table 5).

During the next 5 years, the unit staff expect to become more involved in specific projects, both interpreting existing data and conducting detailed rural surveys to supplement them. An increase in demand is expected for agroclimatic studies, assistance with siting projects, analysis and interpretation of regional trials, assessment of sustainability of technologies, and support to projects on integrated farming systems.

As the unit has laid the groundwork for data collection and retrieval, the resources allocated to research in exploratory and methodology development will decline markedly, and the research on natural resources—primarily in the form of surveys to provide a microecologic perspective for commodity programs—will increase (Table 21).

AGROECOLOGICAL STUDIES **Table 21**
Resource utilization by activities for the years 1988, 1989 and 1993

	1988	1989	1993
RESEARCH	%	%	%
Natural Resources	53.0	71.0	73.0
Livestock Production	18.0	7.5	13.0
Exploratory & Methodology Development	25.0	17.5	10.0
TOTAL RESEARCH	96.0	96.0	96.0
INSTITUTION BUILDING & NETWORKING			
Documentation & Information	4.0	4.0	4.0
TOTAL INST. BUILD.& NETWORKING	4.0	4.0	4.0
T O T A L S	100.0	100.0	100.0

CIAT created the Biotechnology Research Unit (BRU) in 1985. It had anticipated the move in its long-term plan in 1981; and in 1984 the second External Program Review recommended the creation of an interdisciplinary research structure for the application of emerging biotechnologies to intractable problems affecting commodities within CIAT's mandate.

Advances over the past decade have resulted in the development of new techniques that make it possible to address plant improvement at the cellular and molecular levels. Through the unit, some of the new techniques, based on the ability to regenerate plants from cells in culture, are offering a shortcut in selection and breeding at CIAT.

Because research on CIAT's crops, especially *Manihot* and *Phaseolus*, is minimal in advanced institutions, the unit has a role not only in bringing the techniques within the grasp of national research programs in the tropics but also in stimulating the interest of institutions in both developed and developing countries to conduct coordinated and efficient research on biotechnological issues related to these crops. It can assist in establishing priority targets; preventing wasteful duplication; identifying problems that warrant a biotechnological approach; conducting research in areas that are likely to have a quick technological payoff; and providing a mechanism for transferring the technologies to developing countries. The unit's access to the largest germplasm collections for these two crops worldwide and a wide range of environmental conditions and biological constraints gives it a comparative advantage in selected areas of basic research that will enable more effective collaboration with other institutions.

General Unit Goals

The BRU will serve as a research linkage between CIAT commodity programs and basic research institutions for the application of emerging technologies to CIAT commodities. The BRU will keep abreast of new advances in plant biotechnology to advise the commodity programs on potential applications and will serve as a bridge to the national agricultural research systems for the application of biotechnology.

Operational Strategies

1. **Networking**. The BRU will stimulate the interest of scientists in advanced institutions in developed and developing countries to carry out research projects based on specific research constraints identified by CIAT commodity programs. Networking of collaborative research will mainly involve cellular and molecular genetics research, with special reference to *Phaseolus* and *Manihot*.

2. **Research backstopping**. The BRU will strengthen its scientific and technical capabilities in those areas where CIAT has a comparative advantage, particularly in the fields of cell tissue

culture, biochemical/molecular genetics and cytogenetics.

The BRU will concentrate on methodology and technique development. Once a given technique has shown its practical value, its routine application will become the responsibility of the respective commodity program. This decentralization strategy will allow the BRU to concentrate resources on other priority areas.

3. **Training**. In cooperation with the commodity programs, special programs will be conducted for personnel from developing countries, the objective being to expand the network. Training will also provide the BRU with the opportunity for fulfilling its bridding role between advanced research institutions and the NARS of developing countries.

Specific Activities

Biotechnology research at CIAT includes: (a) the utilization and development of selected techniques at CIAT headquarters and (b) collaborative research projects at advanced research institutions. Table 22 summarizes the current activities in cassava, common beans, rice and tropical pastures. Most efforts have been concentrated in the application of cell and tissue culture methods, and recently applications of selected biochemical techniques have been developed through special collaborative projects. More advanced techniques are being developed by means of research projects in other institutions.

Work at the BRU has been addressed to facilitate germplasm management processes in cassava, common beans and tropical pastures (i.e., in vitro germplasm conservation and exchange, electrophoretic genotype characterization, and germplasm dispersal and evolution studies), and to accelerate certain breeding strategies in rice (i.e., achieving rapid homozygocity using anther culture) (Table 22). Routine activities in the areas of in vitro conservation of cassava germplasm and production of doubled haploid lines of rice are being passed to the Genetic Resources Unit and the Rice Program, respectively. Genotyping of cassava germplasm is being utilized jointly by the Cassava Program and the BRU. Similar techniques for common beans will be carried out on a routine basis by the Genetic Resources Unit using methodologies developed in the BRU.

As techniques develop and move out from the BRU, efforts are addressed to new priority areas in CIAT commodities. Thus monitoring techniques for in vitro germplasm management and long-term conservation through cryogenic techniques in cassava are two current developing activities at the BRU (Table 22). Expression of recessive traits such as acyonogenesis is not possible by traditional methodologies. An approach to this constraint in cassava is being developed through haploid/dihaploid induction. Selection at the gametophytic level will accelerate the transfer of important traits such as heat tolerance in common beans. Tissue culture techniques are being used to assess the utility of somaclonal variation for selecting *Stylosanthes* lines with tolerance to anthracnose.

Selected research projects are being carried out in collaboration with other research institutions, with the BRU playing a catalytic role. Currently the

BRU is collaborating with eight institutions on projects addressing future needs for advancing biotechnological applications to CIAT commodities (Table 22). These projects, as well as those being carried out at CIAT, will become natural parts of the larger network once this has been established for cassava and common beans.

CIAT is currently planning a collaborative effort involving advanced research institutes in developed and developing countries. This network approach will facilitate the setting of priorities, the exchange of information and materials, and the generation of financial resources, preferably from outside the CG System, for both short- and long-term projects.

The areas of research pursued are those where traditional approaches have shown limited promise, where cellular and molecular biology research and tools are expected to aid in solving the problem, and where the results will probably be widely used.

Initial plans for advanced research and biotechnology applications in cassava have been made, and they are to be peer reviewed in the fall of 1988. A similar strategy will be followed for common beans in 1989.

In cassava, constraints that may be dealt with by biotechnology are cyanide toxicity, postharvest physiological root deterioration, viral diseases, photosynthetic capacity under stress, nutritional quality (protein, vitamin A, tannin content), propagation-related problems, the cassava hornworm pest, and starch quality under stress.

In common beans, the constraints are still being evaluated so that priorities can be set. One problem that lends itself to biotechnological approaches is the difficulty encountered in moving traits between the two major gene pools of *P. vulgaris*; for example, it has not been possible to transfer the high yield potential of small-seeded germplasm (Central America) to large-seeded cultivars (southern Andes). Other potential focuses in common beans are screening methods for disease resistance (e.g., common bacterial blight) and sensitivity to high temperatures in most *P. vulgaris* germplasm.

For each constraint, one or more projects are envisaged at CIAT and collaborating institutions. Cyanide (HCN) toxicity is an example. The principal research objective is to eliminate or greatly reduce the level of HCN in the cassava roots. Projects to address this constraint include development of screening techniques (in vitro and at the field level) for cyanogenic content, development of microspore/anther culture techniques for expression of acyanogenesis, mutagenesis of haploid/somatic all populations, and in vitro gene manipulation for removal or control of biosynthesis of cyanogenic glucoside.

Screening *Phaseolus* beans for disease resistance would be simplified if molecular genetic markers (isoenzymes and DNA-RFLPs) were developed for bean varieties having multiple resistances. Then it would be possible to link inheritance of markers with the presence of resistance.

Resource Requirements

Currently, there is only one senior position—the plant physiologist/tissue culture specialist—approved for the BRU (Table 23). This scientist has

Table 22

PLANT BIOTECHNOLOGY ACTIVITIES AT CIAT (July, 1988)

	AT CIAT HEADQUARTERS		Research Projects at collaborating Inst.*
	Technique utilization	Technique development	
CASSAVA	1. Cloning disease-free stocks	1. Pilot gene bank**	1. Nonsexual gene transfer techniques
	2. Germplasm conservation and international exchange	2. Cryopreservation of germplasm**	
	3. Electrophoretic genotyping	3. Haploid induction	
		4. Cell culture plant regeneration	
COMMON BEANS	1. Recovery of wild germplasm	1. Cell culture plant regeneration	1. Gene tagging by molecular markers
	2. Assessing germplasm dispersal/evolution by protein electrophoresis	2. Selection at gametophytic level	2. Cell culture plant regeneration
			3. Nonsexual gene transfer techniques
RICE	1. Anther culture breeding	1. Anther/microspore culture	1. Rice Biotechnology network
		2. Intravarietal variation	
TROPICAL PASTURES	1. International exchange <u>Brachiaria</u> germplasm	1. <u>Stylosanthes</u> intravarietal variation	----------
		2. <u>Brachiaria</u> electrophoretic genotyping	

* USA: Univ. of Florida, Louisiana State Univ., Univ. of California, Colorado State Univ., Canada: Univ. of Manitoba; Germany: Univ. of Bonn; Italy: Inst. Bio. Agr., Viterbo, Inst. Ortic., Montanaso.

** In collaboration with IBPGR and the Plant Biotech. Institute, Saskatchewan, Canada.

Table 23

BIOTECHNOLOGY RESEARCH UNIT
Resource utilization by activities for the years
1988, 1989 and 1993

	1988	1989	1993
RESEARCH	%	%	%
Genetic Resources	20.0	20.0	15.0
Crop Improvement	10.0	10.0	15.0
Crop Protection	5.0	5.0	5.0
Exploratory & Methodology Development	25.0	30.0	45.0
TOTAL RESEARCH	60.0	65.0	80.0
INSTITUTION BUILDING & NETWORKING			
Training	10.0	8.0	5.0
Conferences and Seminars	10.0	5.0	3.0
Documentation & Information	5.0	5.0	2.0
Counseling/Advising NARS	10.0	7.0	0.0
Network Coordination	5.0	10.0	10.0
TOTAL INST. BUILD.& NETWORKING	40.0	35.0	20.0
T O T A L S	100.0	100.0	100.0

overall responsibility for all the research areas in addition to duties as Head of the Unit. Some additional staff are proposed over the next 5, years (Table 23). To free up time for the senior scientist, a research assoaciate would be hired to support the expanding research activities in tissue culture. This would allow the Head of the Unit to coordinate collaborative projects and to ensure that research is focused on relevant problems and that promising results are channeled to CIAT for further development and utilization.

A second senior position is proposed for 1989 to oversee research on biochemical and molecular genetic techniques that are critical to the development and application of advanced biotechnological tools. A biochemical/molecular geneticist is envisaged and will be expected, among other duties, to adapt techniques for the development of genetic maps based on molecular markers. Identification nd mapping of traits of economic importance are relevant to both traditional and new (i.e., genetic engineering) breeding approaches. In particular, this scientist will work with other CIAT staff in defining priority research to be conducted in the network.

A third senior position is considered essential in 1991 to take on the responsibility of developing a cytogenetic understanding of CIAT crops, especially *Phaseolus* and *Manihot*. Cytogenetic studies, which have been neglected for these two crops, are fundamental for applications of traditional and new breeding approaches. The cytogeneticist is expected, among his/her main duties, to develop techniques for facilitating the introgression of traits from the primary and secondary gene pools of these crops. Cytogenetic research on tropical pasture species will also be carried out as problems arise. A key role of this scientist will be to act as a catlyst in developing collaborative research proposals with other institutions.

The allocation of resources (Table 23) reflects the decline expected in training as other CIAT staff assume these responsibilities. It also shows increased efforts in coordinating the network once the cooperative research projects have been launched. The development of methods will demand a progressively larger proportion of effort over the next five years.

Virology Research

In 1988, CIAT formally created the Virology Research Unit to provide centralized service to the commodity programs and to the Seed Health Laboratory. The goal of the unit is to isolate and characterize viruses constraining production of the commodities researched by CIAT and to develop and adapt procedures to eradicate or control viruses. The applied research differs from that on most other pathogens and pests, which can be cultured or reared artificially for observation and characterization. Viruses are infectious nucleoproteins, which require specialized human and material resources for their isolation and characterization.

As several viruses can be transmitted in reproductive plant material, research in virology at CIAT promises to make a major contribution to safe and effective transfer of germplasm internationally.

The unit's two virologists specialize by research activity rather than by species. During the next 5 years, no increase in the numbers of senior staff is proposed (Tables 4 and 5). To provide continuous support to the commodity programs, the current staff have divided the work into:

- Virus characterization;
- Epiphytology;
- Input for breeders, particularly in techniques of screening for resistance; and
- Surveillance, especially to prevent the inadvertent spread of exotic viruses in improved germplasm produced for international distribution.

The unit provides training for national scientists and for research personnel from the four CIAT commodity programs involved in routine virological evaluations. In addition, the senior virologist regularly consults with the leaders, pathologists and breeders about the status of research in the unit.

One constant activity is development of methods and serological materials for detection of viruses in germplasm maintained by the Genetic Resources Unit at CIAT. For the commodities in which viruses are seed-transmitted—cassava, beans and forage legumes—the unit supplies antisera and methods for enzyme-linked immunoassays performed by the Seed Health Testing Laboratory.

For the Bean Program, all improved germplasm must show resistance to BCMV. Breeding lines evaluated as susceptible to the virus are generally discarded without evaluation for other desirable agronomic characters. The screening for this virus alone requires inoculation and evaluation of up to 1500 individual bean plants every day, and the unit must use different screening for improved materials bound for East Africa, where local strains of BCMV challenge the resistance gene incorporated in Latin American cultivars.

Also for the Bean Program, the unit is searching for sources of resistance to geminiviruses transmitted by the whitefly *Bemisia tabaci*, in particular bean golden mosaic virus and bean dwarf mosaic virus. These two geminiviruses are directly responsible for the abandonment of more than a million hectares of traditional bean-producing areas in Latin America. Other viral pathogens of beans are kept under surveillance, and the unit maintains a complete collection of antisera against all the plant viruses known to attack beans in Latin America.

For the Rice Program, the unit's efforts at present are mainly to supply serological materials for screening against rice hoja blanca virus, which causes one of the most devastating diseases of rice in Latin America. Continuous, cyclical epiphytotics of this virus have occurred since 1935, causing the collapse of several commercial cultivars over the years. Fortunately, the causal virus was finally isolated and characterized at CIAT in 1985, making possible the implementation of reliable screening. The method is based upon detection of the virus in the insect vector, using a sensitive immunoenzymatic serological test.

The focus of work for the Cassava and Tropical Pastures programs is characterization because most of the viruses affecting these crops in Latin America have not been properly characterized and often occur in mixed infections.

For cassava, this research is complicated by the nature of the crop and the limited range of hosts that the viruses infect under experimental conditions. Besides the known viral diseases of cassava, such as cassava common mosaic, several others are evident in Latin America but occur in latent form in commercial cultivars. To minimize losses induced by these viruses and to ensure against their presence in propagative materials for international exchange, the unit, with members of the Cassava Program, is seeking practical measures of control and reliable techniques for diagnosis and virus detection.

The major change over the next 5 years is expected to be in the effort related to crop improvement; at present the work in characterizing major viruses and devising methods for screening accounts for more than 50% of the resources of the unit (Table 24). Once screening for the existing viruses becomes routine, the unit will increase markedly the resources it devotes to institution building and networking.

Table 24

VIROLOGY RESEARCH UNIT
Resource utilization by activities for the years 1988, 1989 and 1993

	1988	1989	1993
RESEARCH	%	%	%
Crop Improvement	40.0	39.0	12.0
Crop Protection	10.0	10.0	10.0
Exploratory & Methodology Development	16.0	16.0	26.0
TOTAL RESEARCH	66.0	65.0	48.0
INSTITUTION BUILDING & NETWORKING			
Training	5.0	6.0	10.0
Conferences and Seminars	5.0	5.0	8.0
Documentation & Information	5.0	5.0	6.0
Counseling/Advising NARS	10.0	10.0	15.0
Technical Assistance	5.0	5.0	9.0
Network Coordination	4.0	4.0	4.0
TOTAL INST. BUILD.& NETWORKING	34.0	35.0	52.0
TOTALS	100.0	100.0	100.0

Genetic Resources

The germplasm collections at the CGIAR centers increase in value with time in two ways: as a source for genes in landraces progressively eroded in the countryside and as a source of information obtained during screening to identify useful properties. In its work, CIAT's unit, under the direction of a botanist, is able to take advantage of economies in scale in many activities, as the center houses the largest collections in the world for beans, cassava and tropical pastures grasses/legumes.

The collections are the foundation upon which all crop development is built and from which links with national programs evolve. Germplasm is invariably collected with close cooperation from national scientists, and duplicate collections are deposited in national storage. The rich diversity of stored germplasm will increasingly be needed to sustain production in the face of future threats from pests and diseases.

The CIAT collection includes species of *Phaseolus* with great differences in environmental tolerance marginal peoples; and a great range of forage species including trees and bushes that may enable not only increased production in tropical pastures but the rehabilitation of degraded lands.

As the collections have become increasingly comprehensive, the expectation is that activities in collecting will decline; as storage systems improve in efficiency, maintenance costs will also decline (particularly the cost of routine field rejuvenation, which is necessary mainly as a result of poor storage conditions; and as basic evaluation proceeds, the effort in breeding can focus on the promising samples.

CIAT is now reaching a phase of consolidation in some of its collections. Collecting is becoming carefully targeted; the documentation system will become increasingly useful; and, particularly, the improved storage facilities, at present under construction, will reduce future germplasm maintenance costs.

For the three commodities, activities are similar, including:

- Assembly of germplasm through collecting missions or through incorporation of samples from national collections.
- Documentation on origin and characterization of samples.
- Conservation (samples to be stored as seed are multiplied, dried, packed and stored at low temperatures).
- Appropriate duplication of samples and storage for security at other institutions.
- Distribution free of charge to other countries after inspection by the Seed Health Laboratory.
- Training national scientists on the job and, occasionally, through special courses for particular groups.

The unit has collaborated with IBPGR in projects to collect cassava, beans and tropical pastures species in various parts of the world. In addition, collection missions organized by IBPGR have contributed to the range of variability at CIAT. Collection work has been complemented by collaborative research on in vitro storage of cassava, for example, to develop a model system for vegetatively reproduced crops.

Resource Requirements

The presente staff of the unit (1988) includes one senior staff position and four scientific and supervisory positions (three in germplasm management and one in the Seed Health Laboratory). The plan for the next 5 years envisages an increase in the resources being allocated to the unit but no increase in senior staff positions (Tables 4 and 5).

To handle the increased activities in *Manihot*, the unit will be joined by another research associate and will require a supervisor of activities at the associate level to assist the head of the unit.

In 1990, the Seed Health Laboratory is expected to be transferred to a new location within the Seed Unit, where it will continue to serve the needs of international exchange of germplasm. Reductions of scientific and supervisory staff will thus occur in the Genetic Resources Unit. As the techniques for elimination of bacterial and fungal diseases will be routinely applied by the staff in the Seed Health Laboratory, the staff in the Genetic Resources Unit will turn its attention to eradication of virus and nematode problems in germplasm.

The budget includes provisions for a temporarily greater investment of resources to prepare and transfer collections to the new storage facilities. Samples will be multiplied and rejuvenated by a field grow-out to provide sufficient seed for the working collection (i.e., for distribution to users), for a reserve or base collection, and for at least two duplicate collections to be stored at other institutions. The new facilities will allow attention to be given to testing of the viability and germination of stored samples.

During the next 5 years, the allocation of resources (Table 25) will change only slightly as a reflection of the unit's increase in efforts devoted to conserving the *Manihot* collections, when parameters for in vitro maintenance emerge from the collaborative research project with IBPGR. Activities in quarantine clearance, field multiplication, and testing of viability of some collections, particularly *P. vulgaris*, will increase as materials are rejuvenated for the new storage facilities.

The unit will attempt to forge and strengthen research links with other institutions in areas such as seed physiology and pathology, gene pool identification, wild species and interspecific hybridization, and in other areas to be identified. There are opportunities for further collaborative projects such as one under way with the University of Gembloux (beans).

Table 25

GENETIC RESOURCES UNIT
Resource utilization by activities for the years 1988, 1989 and 1993

	1988	1989	1993
RESEARCH	%	%	%
Genetic Resources	68.5	67.5	65.5
Crop Improvement	8.8	9.8	11.8
Crop Production	3.3	3.3	3.3
Crop Protection	5.0	5.0	5.0
TOTAL RESEARCH	85.6	85.6	85.6
INSTITUTION BUILDING & NETWORKING			
Training	5.8	5.8	5.8
Documentation & Information	4.6	4.6	4.6
Counseling/Advising NARS	2.0	2.0	2.0
Technical Assistance	2.0	2.0	2.0
TOTAL INST. BUILD.& NETWORKING	14.4	14.4	14.4
T O T A L S	100.0	100.0	100.0

Seed Unit

Since its creation in 1979, the Seed Unit at CIAT has contributed to the public and private seed sectors of Latin America and the Caribbean by offering training and technical consultations. At the same time, it has participated in technology transfer through the production and multiplication of basic seed of improved germplasm.

After 9 years, during which 1425 people received training in seed-related issues, CIAT arranged an external review of the unit's work. The results of that review are contained in the panel's Seed Unit Study Report (February 1987). The response to the panel's recommendations (The CIAT Seed Unit: CIAT Management Recommendations on the Nature and Future of the Seed Unit, 1987) was adopted by the Board of Trustees in May 1987 as the blueprint for the unit during the next decade.

The unit is directly assisting in the increased use of good seed of improved cultivars of CIAT-mandated commodities and those of other IARCs in the region (primarily CIMMYT). The unit's two senior staff (Table 4) collaborate closely with appropriate groups in the public or private sector throughout Latin America and the Caribbean; for example, to develop nonconventional seed production activities, specially in areas where the existing seed sector shows little interest in CIAT or CIMMYT commodities. In addition to serving as a vehicle to transfer improved genotypes from the reseach institutions to the farmer's fields, good-quality seed minimizes the dissemination of weeds and seed borne diseases, thereby decreasing the dependence on chemicals and increasing the potential for sustainable agricultural systems.

The unit assists national programs in:

- Diagnosing constraints to dissemination of improved varieties.
- Developing plans and policies to overcome seed-related constraints.
- Designing and adapting technologies and strategies to support seed production, including those appropriate for small farm groups.
- Upgrading human resources.
- Establishing and supporting seed research and technical networks to foster integration of efforts.

Its activities are grouped into five ares: human resource development, seed-related research, seed production, seed testing and documentation.

Human Resource Development

CIAT-based advanced courses and in-service training concentrate on seed production, quality control, seed conditioning (drying, processing and storage), and nonconventional systems, with emphasis on CIAT commodities. Training for trainers will be an essential component to promote in-country courses oriented toward solving specific constraints. Thesis research opportunities will be expanded to promote work on seed technology research and organization of seed systems for small-farm groups.

Workshops and seminars will be carried out at CIAT with leaders, researchers, policymakers, donors and others from both the public and private sector to assist in the formulation of adequate strategies and plans to strengthen national seed programs.

Seed Research

Research on seed technology will work on field production for CIAT commodities as well as drying, conditioning and storage. Applied research to support commodity programs will focus on screening technologies for seed quality characteristics, drill box surveys, field deterioration, dormancy, quality-testing methods, and appropriate technologies for small-scale seed production.

Research on organizational aspects of seed production will emphasize the development of methods to diagnose institutional constraints for the development of small-scale systems, designing alternative models according to commodities and socioeconomic circumstances.

Other Activities

The unit will, when necessary, produce breeder and basic seed to accelerate initial multiplication phases in national programs. Also, it will concentrate on the identification of scientific and technical information considered valuable to support the seed network in the region. Activities include the collection, production and dissemination of proceedings, newsletters, case studies of interest to the whole seed network; scientific and technical publications of interest to seed workers; and training mateials including audiotutorials, videos, handouts and reference books.

Resource Requirements

Starting in 1989, the unit will require additional resources to provide quality control services to the CIAT programs (physiological, genetic and sanitary aspects) for seed distributed to national programs. This represents a transfer of resources from the GRU.

The two current senior staff are essential to continue activities through 1993 (Tables 4 and 5), and they will draw on support from visiting scientists, short-term consultants, postdoctoral fellows and national scientists.

Emphasis within the unit will gradually change, as will the allocation of resources by activity. Increases are expected for human resource development at the country level, research on the development of small-scale systems, diagnosis and planning, and seed-quality testing services for CIAT commodity programs, whereas the proportion devoted to conferences and short courses at CIAT headquarters will decline (Table 26).

Table 26

SEED UNIT
Resource utilization by activities for the years 1988, 1989 and 1993

	1988	1989	1993
RESEARCH	%	%	%
Crop Production	11.0	11.0	13.0
Analysis	8.5	9.0	11.5
Exploratory & Methodology Development	5.0	5.0	6.0
TOTAL RESEARCH	24.5	25.0	30.5
INSTITUTION BUILDING & NETWORKING			
Training	30.5	30.5	32.5
Conferences and Seminars	18.0	18.0	15.0
Documentation & Information	10.0	10.0	8.0
Counseling/Advising NARS	6.0	6.0	6.0
Technical Assistance	8.0	8.0	6.0
Network Coordination	3.0	2.5	2.0
TOTAL INST. BUILD.& NETWORKING	75.5	75.0	69.5
T O T A L S	100.0	100.0	100.0