

GATIE

RESEARCH AND EDUCATION FOR
SUSTAINABLE AGRICULTURAL DEVELOPMENT



1989 • HIGHLIGHTS • 1990

Introduction

CATIE stands before the important challenge of focusing its research and education activities so that they will make a significant and rapid impact on sustainable agriculture in a region where the quality of the natural resources has deteriorated and where rural poverty has accentuated during the past decade.

The Institution has developed a Strategic Ten-Year Plan, which has been implemented since the beginning of 1988. This Plan intends to meet the challenge by means of an interdisciplinary program that integrates the elements of production with those of management and conservation of natural resources. Such an integration must necessarily consider the ecological hierarchies with which CATIE works.

These hierarchies extend from a commodity, to an agroecological zone. All of these, in turn, should function in an integrated manner within the framework of a development and management of regional resources perspective.

For CATIE, integrated action within such a framework, presumes not only the integration of the different disciplines and programs falling within this framework, but also the harmonized and concerted effort with which to complement national institutions and programs for research and education, as well as the interaction with development programs which operate beyond the generation and transfer of technology.

Furthermore, within this framework of cooperation, CATIE aims to encourage mechanisms for the concertation of efforts in priority development areas, so that its research and teaching will show an obvious multiplying effect and will produce the impact required to generate a sustainable agricultural development in the region.

A recent external evaluation of CATIE reaffirms this strategy and mandate and emphasizes that: "It is clear for the External Review Team that the greatest potential for positive impact of CATIE's research output in Central America and the Caribbean lies in an integrated and concentrated program thrust in those areas where CATIE has a clear comparative advantage"

CATIE is moving in that direction in order to become a center of excellence in research and education for sustainable agricultural development in Central America.

But, in order to achieve this, CATIE must struggle to change the present structure of special short-term projects -which currently comprise 80 percent of its total annual budget- into an integrated program structure with long-term financing. This view was expressed by the Board of Directors, CATIE's Management and the External Review Team.

In addition to this, CATIE has been taking positive steps in this direction, since the initial implementation of its Strategic Plan in 1988, and has obtained significant results in those priority areas where it holds comparative advantage: Tropical Crops Improvement, Forestry and Agroforestry Production, Tropical Livestock, Integrated Pest Management, and Integrated Management of Natural Resources.

This document presents the principal achievements during 1989-90, in those areas of undoubted strength which, over the years, have established CATIE as the nucleus of a regional system of research and education for sustainable agricultural development.

We present these achievements, not only with the intention to point out the efforts contributed to the Central American Region, but also with the hope that this contribution will promote the exchange of experiences and the coordination of actions with other regions of the world which confront similar problems, granted that the challenge arises not only from the needs of a few but from the whole of mankind.



Dr. Rodrigo Tarté
General Director

MANAGEMENT OF NATURAL RESOURCES: THE BASIS FOR SUSTAINABLE DEVELOPMENT

Because CATIE's research and development efforts integrate both production and conservation aspects, a fundamental pre-requisite to any agricultural research activity in the tropics is the management of natural resources. Their appropriate use constitutes the basis for sustainable development.

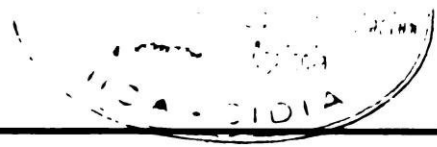


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- 1 *Obvious problems of deforestation and erosion of a watershed in Central America.*
- 2 *Improved management systems in a watershed*



This is implemented through a cooperative mechanism among several institutions in Central America. As part of the Regional Watershed Management Project, CATIE has promoted the establishment of national watershed management commissions, with the participation of a total of 37 agriculture, education, energy, planning, transportation, and water supply institutions (NGOs as well) in five Central American countries.

Demonstration pilot watersheds have been identified, in cooperation with these committees, for which economically feasible and bankable watershed management plans have been jointly developed.

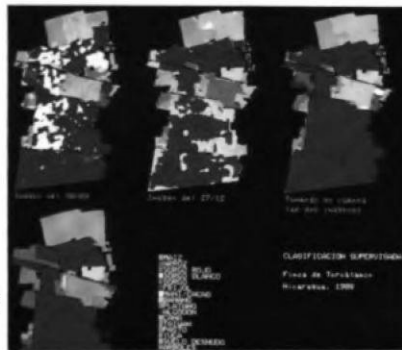
In Honduras and Guatemala, these plans are now being negotiated for funding with international financial organizations.

Related to this activity, CATIE has continued to expand its remote sensing and satellite image-processing laboratory which is being used by various national institutions and CATIE programs. This system is an important aid for appropriate land use planning and resource management. Soil and water conservation are also given a great deal of attention, particularly in relation to the management of watersheds and water conservation in irrigated areas.

CATIE, in cooperation with the World Meteorological Organization, installed the CLICOM system, a climatological data base, in the various countries of the region, and provided training to the national institutions in its operation and data collection.



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- 3. *Appropriate land-use planning and resource management has been expanded by acquiring additional hardware and software for our satellite imagery processing system, an important aid that will improve the services to CATIE's member countries and to the institution's research, training and development programs*
- 4. *CATIE has developed a method for crop prediction based on remote sensing, combined with agrometeorological models, and the establishment of a standard format for a climate data base in the region*
- 5 - 6. *CATIE has taken a leadership role in promoting watershed management methodology in the region*

Of equal importance in this conservation for development approach is the conservation of protected areas. Sustainable economic development in tropical forest areas is a global concern. Most efforts, however, have confirmed one objective reality: if use exceeds what the natural resource base can sustain, degradation will occur and eventually may affect essential ecological processes and diminish genetic diversity.

In Central America, as in any other part of the world, sustainable development is closely related to conservation. CATIE has played an important role in the establishment, planning, and management of a regional system of protected wildlands in Central America, constituted by more than 300 individual areas that cover more than 40,000 km².

At present, one of the main activities concerning conservation for development is the establishment of demonstration areas at the field level. Secondary products of the forest, such as medicinal plants, ornamentals and insecticides are major components of demonstration areas.

Ecologically sustainable and economically attractive, multiple use of natural vegetation is carried out in two life zones of Costa Rica -very wet tropical forest and wet montane forest. Data bases on ecological information are being generated.



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7. *Attention is concentrated on the controlled exploitation of the forest, the study of growth and yields; the development of silvicultural techniques, and the financial and economic analysis of the operations.*
8. *Ryania spaciola, a natural insecticide, grows in the humid tropics in Costa Rica and Panama*

CATIE, in a joint effort with IUCN and WWF, has just released a publication for the planning of an integrated system of protected areas in Central America.

CATIE considers it necessary to analyze objectively the role of natural forests in integrated systems of rational land use.



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9 *Reinhartia gracilis*, an ornamental palm.

10. Proper management of mangrove ecosystems involves the communities that depend on these resources for their livelihood. CATIE has established demonstration areas of conservation for sustainable development of threatened natural ecosystems, which aim to study and demonstrate the possibilities for economic production with conservation of natural resources.

GENETIC RESOURCES AT CATIE: CONSERVATION, CHARACTERIZATION AND UTILIZATION

Another important activity at CATIE, related to its role in conservation and management for development of natural resources, is the conservation and utilization of tropical America's genetic resources.

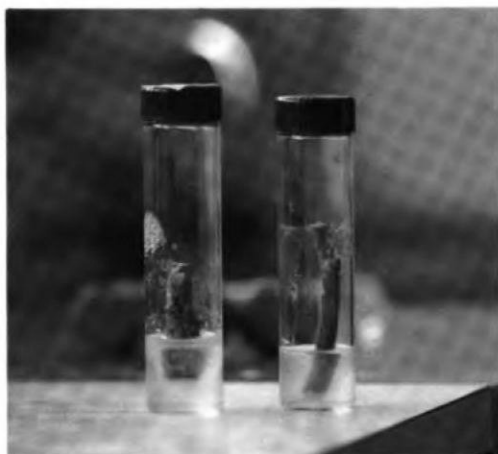
This activity is carried out by the Tropical Crops Improvement Program, whose strategy is based on the conservation and the appropriate use of genetic resources, on the basis of the following principles: to promote the unrestricted use of germplasm as a legacy for mankind; to increase the collections; to select superior genotypes in support of national plant genetic improvement programs; and to improve characterization and conservation methods for germplasm held at CATIE.

CATIE's collection of plant genetic resources, particularly from Tropical America, has increased considerably, including forest species, medicinal plants, fruit trees, roots, tubers, spices, etc. These collections will secure the necessary germplasm to improve yields and quality of the most important crops in the region.

In 1989, CATIE initiated the characterization and identification of promising genotypes of cocoa, through the use of the Restriction Fragment Length Polymorphism (RFLP) technique, in collaboration with Pennsylvania State University. The Biotechnology Unit has recently established a molecular biology laboratory where germplasm characterization is carried out using genetic markers such as isoenzymes, RFLP, and fingerprinting.



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Number of accessions maintained before and after the establishment of the Tropical Crops Improvement Program.

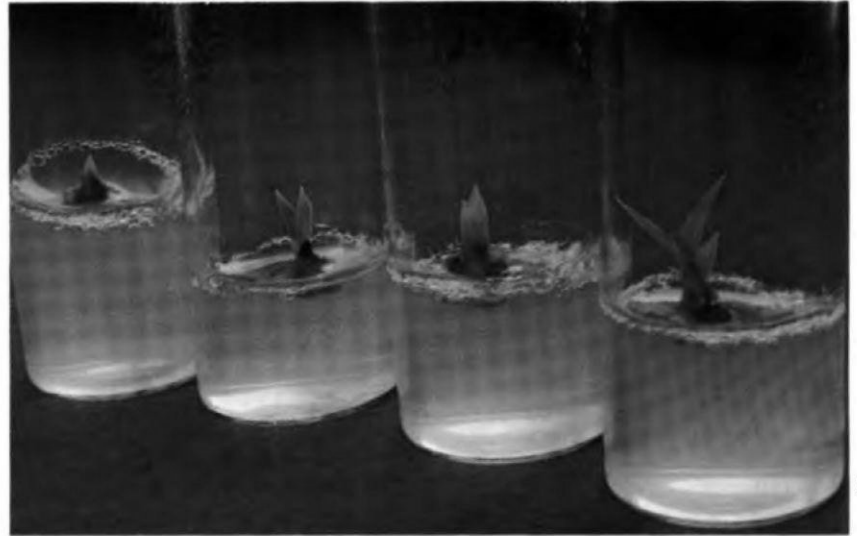
Conservation Unit	Period		Total
	1976 - 86	1986 - 90	
Cold chambers	5634	34148 [*]	39782
Live collections	4556	944	5500
<i>In vitro</i> cultivation	243	94	337
TOTAL	10433	34366	45619

^{*} Increase in accessions mainly due to maintenance of *Phaseolus* replicate in accordance with CIAT convention established in 1987

11. *In vitro* conservation is currently applied in CATIE's Biotechnology Unit.

Regarding the management and distribution of germplasm, CATIE has been designated by the IBPGR for the establishment, of a Seed Handling Unit (SHU) to serve the Latin American countries. With this, CATIE becomes the headquarters to one of the three worldwide seed handling units.

Since 1989, CATIE has continued the development of a cryoconservation unit with the support of the IPBGR.



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12 CATIE has developed a methodology for plant regeneration of coffee through somatic embryogenesis and shoot tips

13 Promising genotypes of coffee, tiquisque, taro and yam has been distributed to countries in Latin America and Africa



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14. Cocoa germplasm collection at CATIE is one of the most extensive in the world, comprising 619 clones, mostly consisting of elite selections from the main cocoa research stations of Latin America and representing the main cultivated varieties of the Tropical America. Local selections made at Turrialba are also included. In addition, there are 8 species of the genus *Theobroma* and 6 species of the genus *Herrania*.
15. CATIE is making a contribution to the international cocoa mapping program and is beginning molecular genetic analysis of the cocoa fungal pathogens of the genus *Phytophthora*. The germplasm collection, will be characterized systematically to obtain data for future breeding research.
16. From our cocoa collection, CATIE personnel has produced planting material (clones an hybrids) with high yields, good size of beans and fruits, and resistance to *Phytophthora palmivora* (black pod disease), *Moniliophthora roreri* and *Ceratocystis fimbriata* (Ceratocystis wilt).

One of the central aspects of work in plantain is the search for resistance to Black Sigatoka disease (*Mycosphaerella fijiensis*) for which a clonal multiplication methodology has been established. At the same time, methods for inducing variants and mutants have been developed.

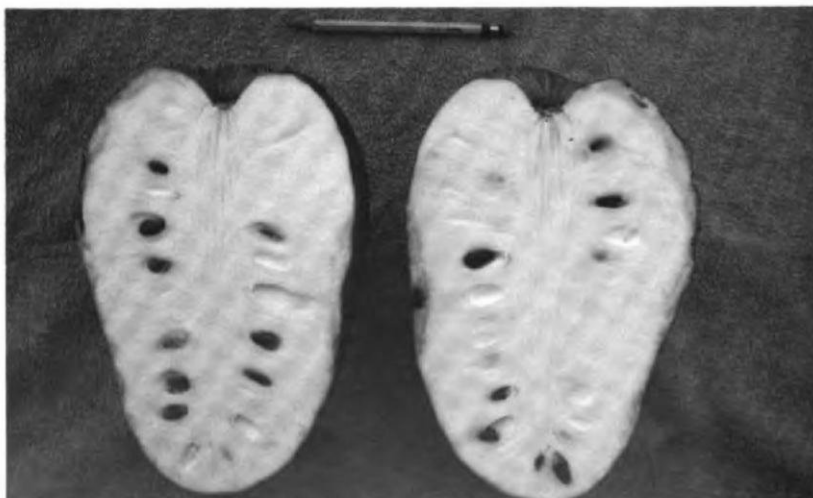
CATIE's collections include potentially valuable species for export or local consumption, of which clonal gardens of selected genotypes have been established. Nine species have been selected as promising crops: achiote (*Bixa orellana*), peppers (*Capsicum* spp.), pejobaye or peach palm (*Bactrix gasipaes*), guanabana or soursop (*Annona muricata*), zapote (*Pouteria sapota*), black pepper (*Piper nigrum*), vanilla (*Vanilla planifolia*), macadamia nut (*Macadamia integrifolia*) and tiquisque (*Xanthosoma* spp.). Genotypes, which are outstanding under Turrialba conditions, have been propagated in order to establish clonal nurseries at the La Lola experimental station and to supply demands for plants or propagules of these species. The main objective of this work is to supply alternative crops with export potential, to small and medium scale farmers in the region. After a selection process of several cycles, individuals with outstanding agronomic characteristics have been identified and these are now the superior genotypes of the collections. In this respect, *Capsicum* exemplifies this process; the collection was evaluated and characterized in Turrialba and the University of Costa Rica with financial assistance from IBPGR. More than 700 accessions were evaluated, of which some stood out due to their properties demanded by the export market. The best genotypes were donated to a Costa Rican firm and it was possible to obtain peppers suitable for the industry. These have been extensively cultivated and the firm now exports packaged products to different countries. In the case of "achiote", CATIE has provided seed for the establishment of over 500 ha., in Costa Rica alone.



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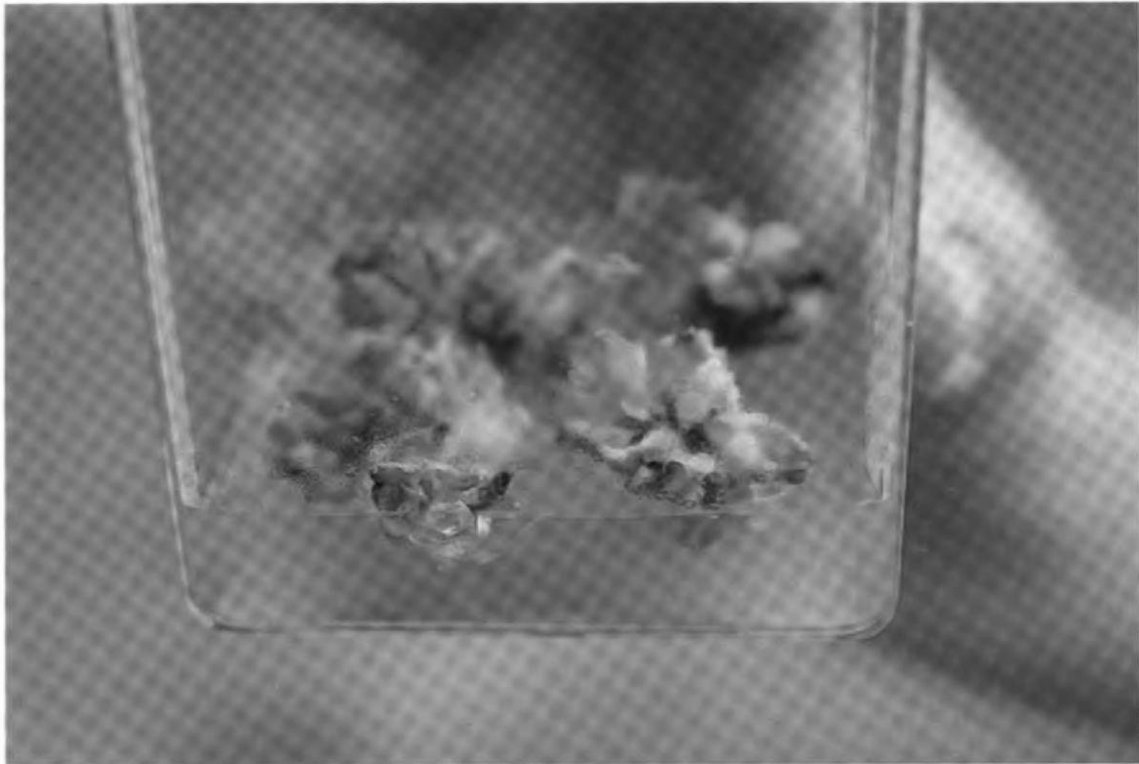


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17. Achiote (*Bixa orellana*), a food coloring and dye.

18. Peach palm (*Bactrix gasipaes*), a starchy and nutritious fruit.

19. Soursop (*Annona muricata*), a promising fruit species.



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20. With the support of INIBAP whose regional headquarters is located at CATIE, our institution has started introducing germplasm under in vitro conditions.
21. A cryoconservation technique is being developed for plantain using two types of explants: apical meristems and embryogenic structures.

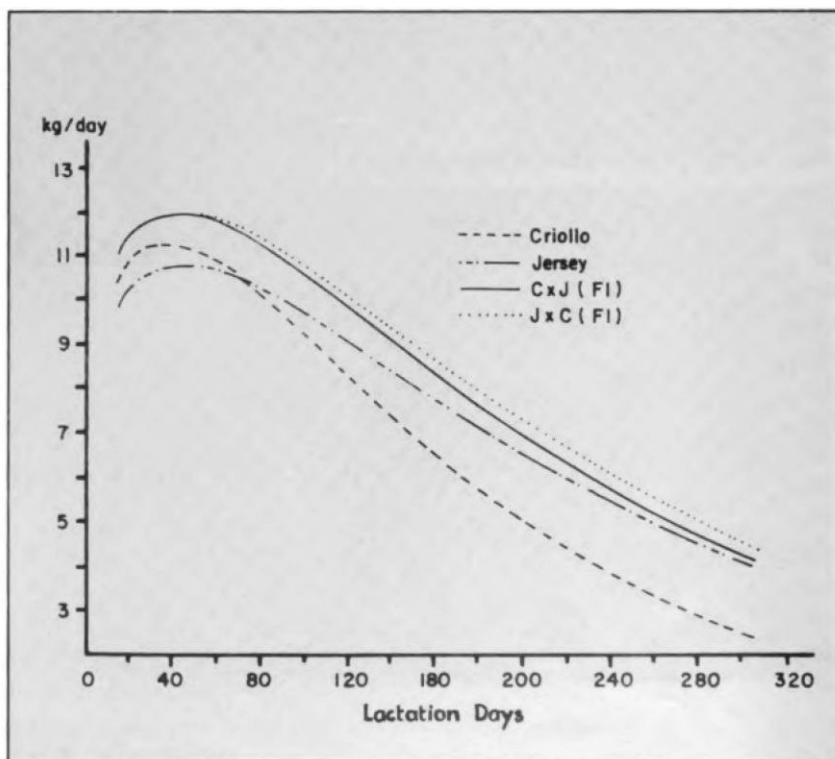
CATIE also maintains and utilizes animal genetic resources, specifically Romosinuano, a Colombian Criollo beef breed, and Reyna, a dairy Criollo from Nicaragua. These Criollo genotypes represent valuable adapted sources of tropical livestock germplasm that can be used in bioeconomically efficient crossbreeding programs to improve the efficiency of dairy and beef production systems. The criollo cattle show a significant tolerance to gastrointestinal parasites under the humid tropical and management conditions existing in Central America. In CATIE's experimental farm, the average number of eggs per gram of faeces (h.p.g.), was 750, in calves less than 6 months of age; 230, in calves above 6 months of age; and 50, in their dams. Blood parameters analyzed were normal in all experimental groups. These criollo genotypes, conserved and utilized at CATIE for the last 35 years, under tropical conditions, are the largest herds in a foot-and-mouth disease-free country. Determination of productive, reproductive capacity and tolerance to endoparasites traits of the bovine criollo breeds and their potential within crossbreeding programs for milk and meat production in the tropics, have led to the establishment of data bases as well as semen and embryo banks which are available for distribution to farmers in the region, including: Costa Rica, Nicaragua, Panama, El Salvador and Dominican Republic.



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FIGURE 2

Lactation curb adjusted for milk production in different races of the CATIE milk herd



22. Romosinuano, a Colombian Criollo breed with great potential for Central America

RESEARCH IN CRITICAL AREAS

It is worth mentioning that all of CATIE's research activities in critical or priority areas are planned and conducted by considering the basic guiding elements to obtain technological innovations needed for accelerated and sustainable agricultural production and development. This is specified in CATIE's ten-year strategic plan.

CATIE has gained a reputation over the years for its outstanding research in cocoa and coffee, two major export crops of the region. Plantain (cooking banana), an important food staple in Central America, has been added recently to the priority list. At present, no other institution in the region plays such an important role in research and improvement of this species. Research conducted in cocoa resulted in the *in-vitro* regeneration of plants, through micrografted somatic embryo. Individuals obtained by this method have already been transferred to soil conditions thus demonstrating that this technology could become an ideal mechanism for the transformation of cocoa to obtain disease-resistant genotypes.

This is the most outstanding achievement in the search for reliable systems to obtain complete plants using somatic embryo micrografts.



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In the tropical livestock area, many years of research with native breeds of cattle have provided valuable information.

Efforts to increase livestock productivity must take into account the unfavorable environmental conditions and poor management that have contributed to make this ecosystem fragile and subject to degradation if not properly managed. Hence, CATIE's research efforts in tropical livestock, besides its activities in germplasm dissemination of Criollo breeds previously described, are oriented towards developing and introducing effective technologies for increasing and sustaining productivity while preserving a stable ecosystem.

Also, where environmental conditions are difficult for cattle production, adequately managed goat production systems are a viable option for providing milk and meat to a small farmer, and are therefore being studied.

Development of efficient systems for feeding ruminants (cattle and goats), where emphasis has been placed on the use of agricultural and industrial products, will contribute to diminish dependence on imported foodstuffs for human consumption.



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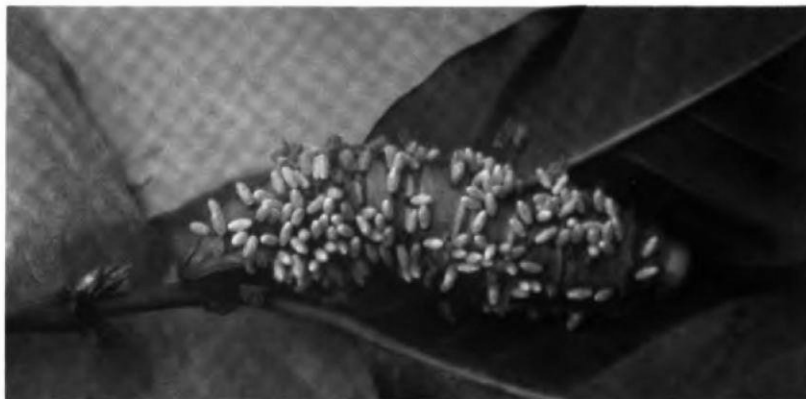
24 - 25. Identification and characterization of the dynamics through which bovine and caprine systems function in the region, have allowed the development of research, validation and transfer of technology programs aimed at the improvement of these animal production systems. Through these actions, national programs have consolidated their research and promotional programs using a production systems approach.

26. Degraded African star grass pasture rehabilitated by oversowing a tropical legume (Kudzu).

CATIE has taken a pioneer role in developing integrated pest management (IPM) strategies in Central America during the last four years. The pesticide abuse in horticultural crops in Central America as well as the need to find more economical methods of controlling pests and diseases have made CATIE build a strong team of plant protection specialists.

These researchers have developed or adapted several improved methodologies in plant protection to Central American conditions, and have made them available to national institutions. Examples of these are: a system for the evaluation of resistance to plant parasitic nematodes in crops such as coffee; the development of techniques for the evaluation of resistance of tomato and pepper cultivars to *Phytophthora* spp., *Pseudomonas solanacearum*, *Alternaria solani* and a viral complex; the evaluation of plantain cultivars for resistance to Black Sigatoka; the evaluation of coffee varieties for their resistance to rust; and the evaluation of cocoa cultivars for their resistance to *Monilia*.

IPM programs developed rational pesticide usage through the implementation of action thresholds, switching pesticides to more specific, target-oriented (narrow spectrum), safer chemicals and the use of biological pesticides, such as *Bacillus thuringiensis* and, insect diseases.



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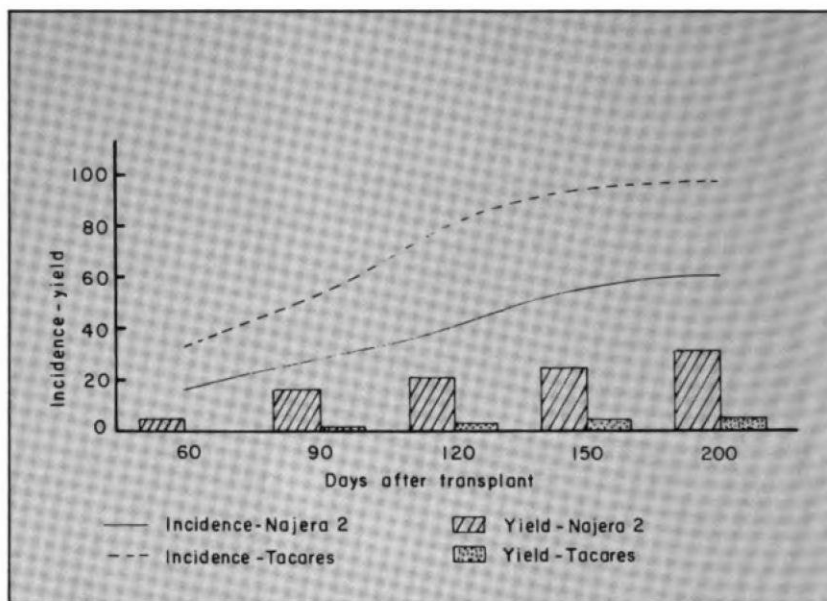
27. A parasite, *Apanteles* attacking defoliator *Rothschildia* of Coffee.
 28. Evaluation of coffee varieties for resistance to rust.
 29. Basic epidemiological studies in plant diseases have led the way to major accomplishments in plant disease management. These include a system to manage cocoa plantations based on sanitary pruning, to reduce the incidence of *monilia* and black pod rot, and the validation of a "biological forecasting system" based on the development of *Sigatoka* symptoms and plantain phenology

IPM guidelines have been produced, covering all aspects of plant protection, for tomato, pepper, cabbage and maize. These guidelines are being distributed to researchers and extension workers in Central America promoting IPM approaches to pest management. The impact of these programs on the economy and environment of the countries of the region is far-reaching. A model IPM approach developed by CATIE for tomatoes, reduces the number of applications of insecticides for the control of *Heliothis* between 25 and 35% and the cost of control by 15%, compared with the present system used by the farmers. If this IPM program were to be adopted by all tomato growers in Guatemala, the country could save up to US\$1.0 million in pesticide imports. Environmental and human health benefits, although difficult to measure, need to be added to the financial benefits of this IPM program.

CATIE is presently distributing three quarterly publications in IPM, with more than 800 copies of each, reaching more than 300 national institutions in the region. Three data bases are fully operative, providing information on "Pests", "IPM Regional Institutions and Specialists", and "IPM Bibliographic References".

Technical cooperation between CATIE and national institutions in member countries has covered many diverse areas. Worth mentioning is the consolidation of a Regional Pest Diagnosis Network organized at CATIE's initiative to promote the exchange of information on proper diagnosis techniques among more than 80 national laboratories located in six Central American countries. The Network is operational on a regional basis with Sub-Networks in each country.

FIGURE 3
Incidence of disease and yield of two pepper varieties.



Forestry and Agroforestry constitute areas of excellence at CATIE. Its leadership in these areas comes from many years of experience and experimentation. Efforts in this critical area are integrated in the activities of multipurpose trees, N-fixing trees forestry species, alley cropping, sylvopastoral systems.

A network of more than 250 silviculture trials and 500 permanent demonstration plots of high priority multiple-use tree species continue to provide information used to produce regional silviculture manuals for species such as: Eucalyptus camaldulensis, Leucaena leucocephala, Bombacopsis quinatum, Guazuma ulmifolia, Gmelina arborea, Tectona grandis and Pinus caribaea var. hondurensis.

A strategy for genetic improvement of 14 different multiple use tree species has been developed, in which more than 60 seed source plantings have been selected and managed so that countries in the region will have their own sources of seed of improved genetic quality. At the same time, more than 30 provenance trials of multiple-use species have been established to select the best germplasm sources.

National Extension Programs are making use of the information which CATIE's research has provided, both for the establishment of pure stands and for various types of on-farm tree plantings. The multiplying effect of the demonstration units, together with the work of extensionists, has resulted in the involvement of thousands of small farmers in producing multiple purpose trees.



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In order to strengthen the growing interest in tree cultivation, a strategy of forestry extension in which 18 national institutions, and a similar number of non-governmental organizations, are involved. The strategy will be strengthened by the production of specialized materials and training courses.

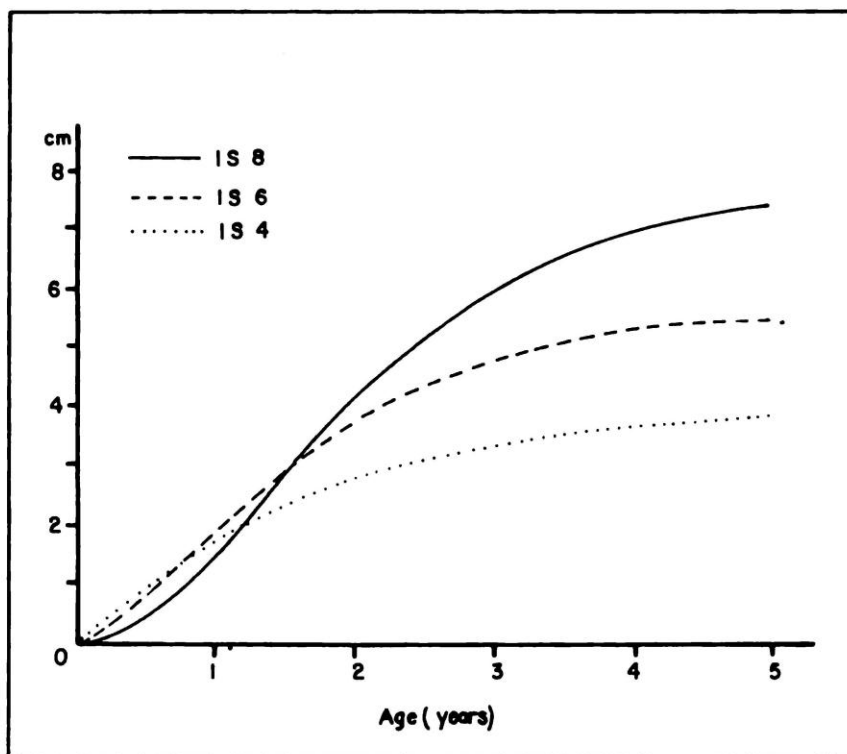
This activity is reinforced through marketing studies for forest products, as well as analyses of production costs in order to continue promoting the establishment of economic incentives for reforestation.

The first set of training manuals has been published covering such subjects as training in forestry measurements, silviculture of plantations of multiple-use tree species, agroforestry systems with multiple-use trees for extension workers, and various technical manuals for the management of computerized information, a manual for research with multiple-use trees, and guidelines for the establishment and management of seed banks.

Microcomputer equipment was installed in each participating country and the training of national personnel, responsible for analyzing experimental data, was initiated. Also, preliminary steps were taken to feed information directly into CATIE's central data base, through the equipment installed in each participating country. The information generated has permitted the development of mathematical models which permit the prediction of growth and yield under different site conditions for species such as *E. camaldulensis*, *L. leucocephala*, *Gliricidia sepium*, *Guazuma ulmifolia*, *Acacia mangium*, *Caesalpinea velatina* and *Cupressus lusitanica*.



FIGURE 4
Models for diameter increase of *Guazuma ulmifolia* in different site conditions



31 - 32 Farmer pruning multiple purpose trees. Wood is used as fuel by 70% of rural families in Central America, and by more than 80% of the small industries.

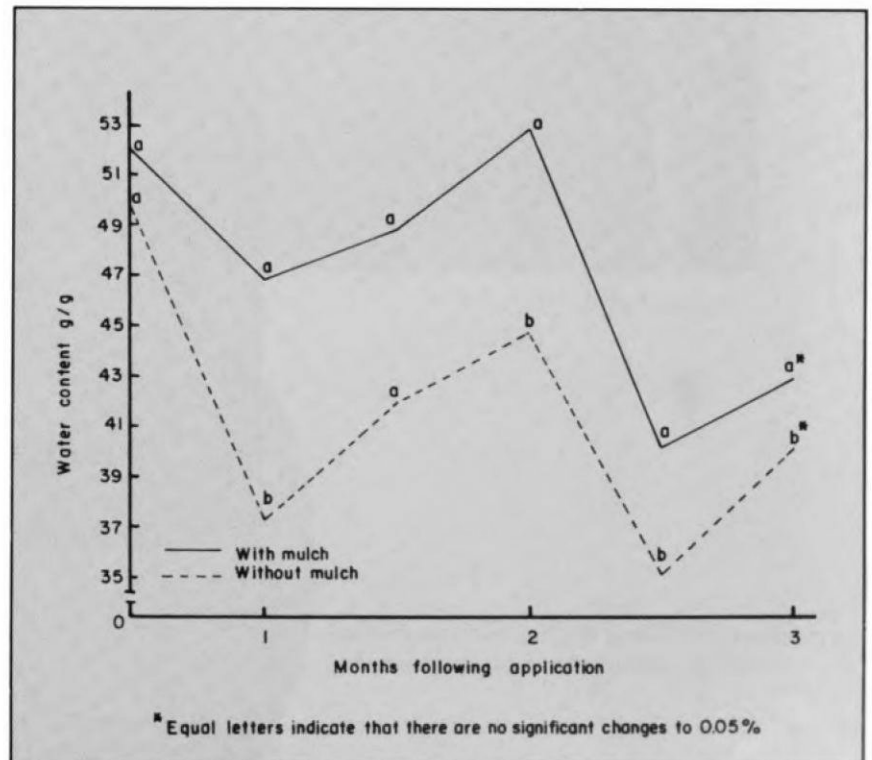
CATIE has become the pioneer institution in the selection of N-fixing trees for use in agroforestry systems. This, and other types of studies, are particularly stressed in three of the most common legume-tree genera in Central America: Erythrina, Gliricidia and Inga. The use of superior material has improved the biomass production of G. sepium by 210% and by more than threefold in Erythrina berteriana. This year, CATIE made available Erythrina spp. for experimental activity and for the transfer of a base-collection to national institutions of Panama, Costa Rica and Nicaragua. The first superior genotypes of Erythrina spp. are now available.

In the propagation of N-fixing species, the major breakthrough has been the field vegetative propagation of the genus Inga, by cuttings.



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FIGURE 5
Effect of Inga mulch on soil moisture.



CATIE possesses one of the most complete collections in the world, of Erythrina spp. and of G. sepium in the Latin American arboretum of Nitrogen Fixing Trees:

1. Erythrina: 23 different species and 65 superior clones of E. poeppigiana, E. berterroana and E. fusca.
2. Gliricidia sepium: 3300 introductions of provenances from Mexico, Central America and Panama. 88 superior clones.
3. Inga: Collection of 17 species of Inga: The first 36 clones of I. densiflora, I. edulis and I. patenna are in process of evaluation.



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- 34 The establishment of nitrogen-fixing trees, as protein banks, has resulted in the production of 6 tons of crude protein per hectare, which out-yields by almost twice, the protein yield obtained from herbaceous legumes
- 35 The cropping system of beans grown between rows of Erythrina poeppigiana are ready for validation in pilot areas and demonstration farms

In 1989, explorations and collections were carried out of more than 500 superior trees from eight important hardwood species in danger of genetic erosion in the region. Realizing the urgent need for gene conservation in the region, other activities include explorations of isolated areas of Mexico, Central America and Colombia, with support from the Central American and Mexican Resource Cooperative (CAMCORE), to select and collect seeds from superior individuals of endangered species.

Selected material is distributed to the countries where it is collected with the aim of preserving endangered genotypes, evaluating a larger range of populations and widening the genetic base. Superior individuals from the provenance trials are selected for advanced genetic improvement work. Outstanding provenances of Acacia mangium, Eucalyptus grandis, E. saligna, E. urophylla, Gmelina arborea, Pinus caribaea, P. oocarpa and P. tecunumanii were identified through an intensive evaluation of 47 experiments with species and provenances. Yield increases of up to 400% have been obtained with the best provenances. The information gathered from the provenance trials is immediately transferred to seed banks and forestry commissions of the region, as a guide to better match the right seed source to the environment of the planting area.



36 Vochysia hondurensis



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Research has given emphasis to simple low-technology plant propagating techniques of forest species.

Research has concentrated on the development of simple, low-technology propagators, and on techniques appropriate for reforestation programs. Outstanding rooting percentages have been obtained with early stem cuttings of *A. quachepele* (95%), *A. acuminata* (40%), *C. alliodora* (90%), *E. grandis* (57%), *E. deglupta* (90%), *G. arborea* (95%) and *V. hondurensis* (85%), some of which were formerly considered as "difficult-to-root" species.

In order to strengthen national programs, 20 foresters are trained per year through a short course on tree improvement. As a mechanism for the exchange of information on genetic improvement activities in the C.A. region, CATIE edits and produces a biannual newsletter which presently reaches more than 500 users in 25 countries.

Alley cropping has become an option for small holder agriculture due to the fact that they can obtain sustainable maize and common bean yields higher than the Central American average.

CATIE has demonstrated the viability of alley cropping as a productive and sustainable agroforestry system, and has maintained leadership in this field.

Results from seven years of experimentation of alley cropping with *Erythrina poeppigiana* (EAC), with and without nitrogen fertilizer are shown in figures 6 and 7. Furthermore, data have been obtained which show the effects of alley cropping on mineralization indices, microbial biomass, native rhizobia, and ureid content in beans. This information throws new light on the interactions occurring in this agroforestry system.



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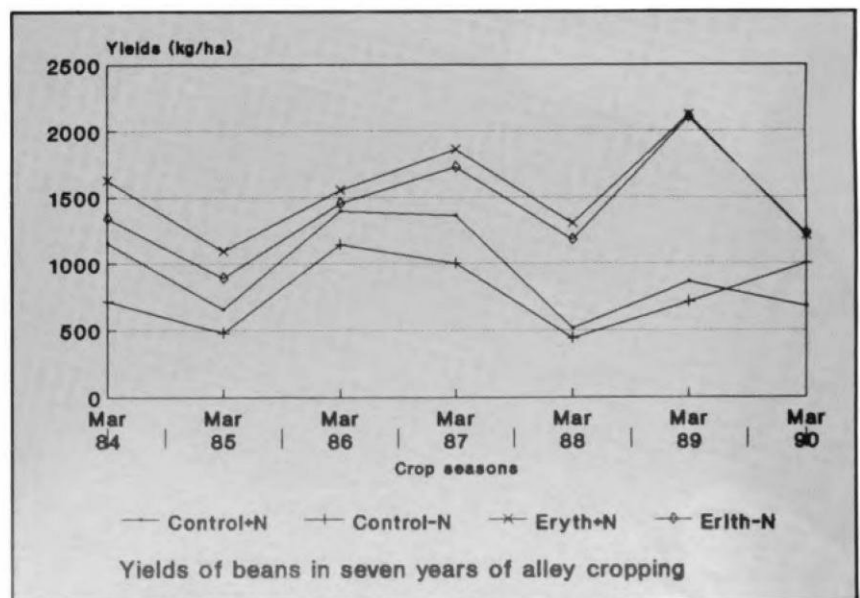
FIGURE 6

Net profitability, need for capital and return per unit capital of maize and beans produced with mineral fertilizer or mulch of *Erythrina* (\$/ha/6 years).

	Net return	Cash requirement	Return per unit capital
Mineral fertilizer	3737	2820	3.02
<i>Erythrina</i> mulch	4061	1272	7.70

FIGURE 7

Yields of in seven years of Alley Cropping.



On-farm agroforestry experiments were established in more than 50 small and medium-sized farms in Costa Rica (lower Talamanca) and Panama (Bocas del Toro) in the last two years. The project has three dominant features: 1) there is a strong link between research topics and reality; 2) farmer's collaboration is sought at all stages of the research (e.g. planning, execution, monitoring); and 3) biological data are coupled with both socioeconomic and extension data. Research issues were identified at the onset of the project through intensive interviews and discussion with local farmers. Possible research issues addressing major problems were discussed and nine topics were selected for research, such as: the selection of several forms of timber species; selection of living support trees for black pepper vines; forestry plantations using taungya; multipurpose management of small patches of natural forest in private farms; shade management in cocoa plantations using either leguminous or timber tree species; conversion of unmanaged shade to managed shade canopies in established cocoa plantations, and more complex systems including cocoa, plantain, and timber species.

The economic characteristics of technologies under evaluation have been documented. Cost-benefit analyses, and some marketing studies of these crops, which have not been documented, are being carried out. Besides these activities, at the "agroecosystem level", technologies are to be evaluated in terms of their future adoptability.



39. Agriculture, with respect to productivity and sustainability, must be considered on a regional basis integrating resource planning and management with the development of improved production systems, if lasting results are to be attained

40. Pepper farmer in Talamanca, Costa Rica.

In the latter context, care is devoted to understanding the way farms are “designed” in the study area, and how this influences the adoption of technologies. Great effort was devoted to the selection of both farmers and farm sites that would be most effective in demonstrating the performance of the new or adapted technologies. Community-level studies concerning the structure of local organizations, communication media, etc. are also made. This information is aimed at providing a basis for future direct extension work by local and national organizations. These studies are complemented with training activities at various levels. Research efforts under way draw heavily on basic research conducted at CATIE headquarters. Some important ecological processes, such as nutrient cycling, biological competition, etc. can more easily be researched in existing plots in Turrialba. Current, on-farm experiments include improved germplasm of cocoa, and both leguminous and timber trees. These materials were selected by other programs and projects at CATIE. Furthermore, experimental results fill knowledge gaps (e.g. plot sizes, sample sizes, repetitions, experimental designs, etc.) identified in previous research.

Research on grazing, under forestry plantations, provided biological data and a bioeconomic model to explore the economics of plantation forestry with cattle raising. The Tropical Livestock Area, in collaboration with the Agroforestry Area, has conducted research on the use of non-traditional resources for animal feeding. More than 50 shrubs and trees with potential as fodder sources, due to their crude protein content and digestibility, have been identified (Acacia, Mimosa, Guazuma, Gliricidia and Erythrina). Several alternatives to intensify production of high quality edible biomass from these resources have been studied by CATIE.

The intercropping of legume trees and cutting forages did not affect grass yield, but increased total edible biomass production by 50%, and the yield of crude protein, per hectare, by 300%.



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41. The utilization of Erythrina poeppigiana, as protein supplement for grazing milking cows, has led to a 10% increase in daily milk production as well as to a 10% reduction in production costs in Jersey-Criollo cows. Also, when E. coccleata was supplemented to young bulls, under grazing conditions, a significant increase of 42% in the daily beef production has been obtained.

PRODUCTION SYSTEMS WITHIN A REGIONAL PERSPECTIVE: THE INTEGRATED APPROACH

Most of the previously described highlights are meaningless and useless by themselves, unless they are related to each other, and incorporated into technological packages that would constitute improved, economical, sustainable, and, above all, adoptable production systems. For a production system to meet these requirements, the biological components of the production and productivity aspects need to be linked to the socio-economic aspects of agricultural production and to the management of natural resources. Moreover, the integrated technological packages must go beyond the technology transfer phase to ensure their adoption by farmers; otherwise, they will never produce the needed impact on agricultural development.

The development of production systems requires the investigation and integration of critical components to improve trees as well as pastures and animals (i.e., genetic improvement of trees, animal breeding, pastures agronomy, development of data bases, embryo transfers, etc.). Research on each of these components cannot be planned or conducted in isolation. They need to be related from the very early stages of the research process. Moreover, the sustainability of such a system can only be achieved by working simultaneously on the land use and natural resource components (in addition to the socio-economic and institutional aspects as well) of the particular area or region involved. An improved production system developed with this integrated approach is not necessarily an agroforestry, silvopastoral or mixed system. The integrated approach can and must be applied to any conceivable production system, even to a one-major-crop system (not to speak of a monoculture). Ideally, research and development activities should be oriented with a perspective of integrated regional development that considers spatial interactions among the different activities.

A new integrated approach to promote interdisciplinary work, stressing sustainable agricultural production and development, has been introduced by CATIE in the region. This approach considers the establishment of pilot areas

for integrating resources management, research, education and development activities. Following the concepts described above, besides the specific farm activities, the actions carried out in such areas take into consideration the spatial interaction of farms and the resources within watersheds or agricultural regions. During 1989, activities towards the establishment of four pilot areas have started in the Dominican Republic, Costa Rica, Honduras and Panama.

Multidisciplinary research conducted in pilot areas will provide the basis for developing sustainable production systems and for designing improved methods for agrotechnology transfer.



42. The World Bank estimates that over 70% of the rural families in Central America and Dominican Republic could be classified as poor. These people derive most of their income from agriculture. Population expansion in the region (2.8% annually) has put a tremendous strain on the natural resource base.

EDUCATIONAL PROGRAMS

Let's now turn our attention to the other column of CATIE's activities: the educational programs. A most significant achievement is the consolidation of REDCA (The Regional Cooperative Network for Education and Research in Agriculture and Renewable Natural Resources) (see list). Started in 1985 with 14 institutions from CATIE's member countries, it now covers more than 70 institutions, including public and private universities, agricultural research institutions, ministries of agriculture, natural resources institutions, etc. REDCA is the major networking mechanism by which CATIE focusses its educational activities (and hopefully, in the near future, its research activities) within the context of a research-education-development system involving its seven member nations (Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador and Dominican Republic). Through the operation of this network, CATIE seeks to strengthen the national research and educational institutions, and contribute to the strategically vital formation of human resources needed in accelerating and sustaining development in the region. While promoting exchange and cooperation among all of the member institutions of REDCA, this network enables CATIE to integrate diverse scientific, academic, and development projects, both at the national and regional levels. REDCA operates in each country through the organization of national committees formed by the country's member institutions. CATIE's representatives in each country act as secretaries of the national committees.

The pilot area approach is now the main subject of discussion in each of the national committees. The academic strengthening of CATIE has been significant in terms of infrastructure. The strengthening of CATIE's academic programs is shown also in the significant increase in the number of graduate students since 1985. From a total of 29 students admitted in 1982, the number has increased to 57 in 1989. By the time the present expansion program is completed, CATIE will be able to accept 75 students per year with a total student population of 150. CATIE's Graduate Program in

Agricultural Sciences and Renewable Resources provides qualified training at the Master's degree in the areas of:

1. PRODUCTION SYSTEMS, with emphasis on:
 - TROPICAL LIVESTOCK
 - SILVICULTURE AND AGROFORESTRY
 - TROPICAL CROPS
 - (A) CROP IMPROVEMENT
 - (B) CROP PROTECTION
2. MANAGEMENT OF NATURAL RESOURCES, with emphasis on:
 - WATERSHED MANAGEMENT
 - PROTECTED AREAS MANAGEMENT

FIGURE 8

Distribution of graduate students in each program.

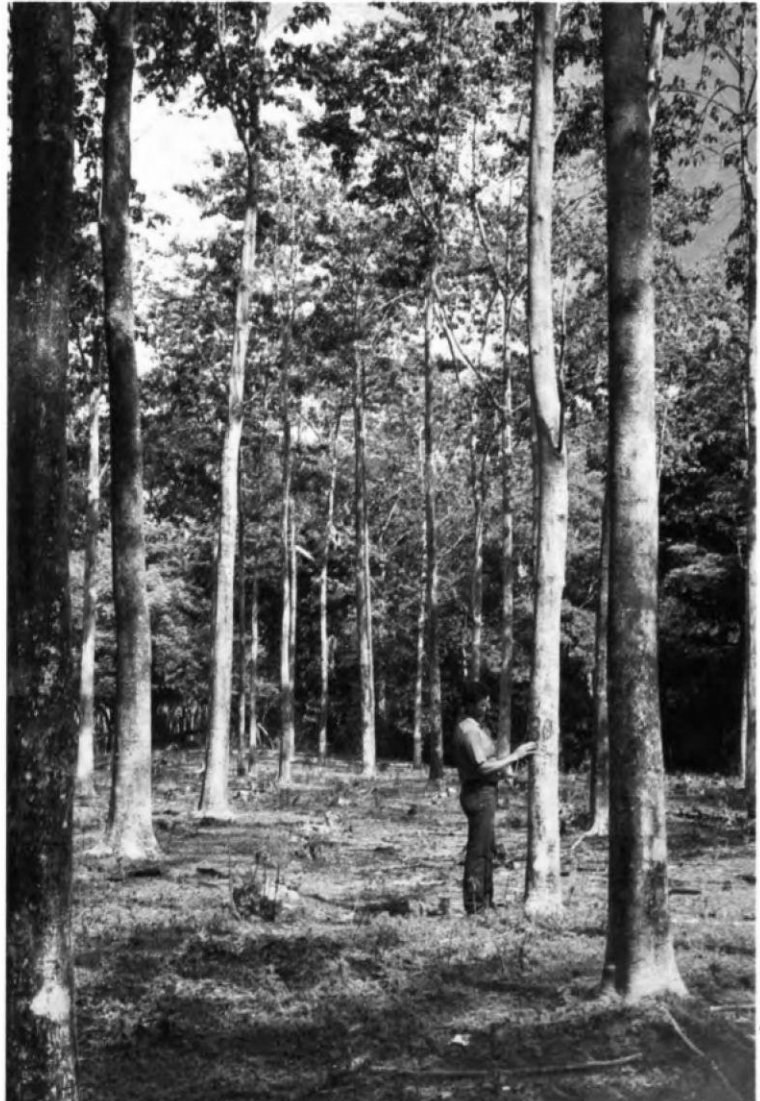
YEAR	PROGRAM			TOTAL
	I	II	III	
86-88	5	27	12	44
87-89	2	33	22	57
88-90	9	39	9	57
89-91	13	21	14	48
TOTAL	29	120	57	206

CATIE's Continuing Education Program (Courses, In-Service Training and Technical Meetings) is guided by specific norms and, in the case of the courses, they are divided into Courses, Workshops or Seminars. This activity is in permanent expansion as is shown by the constant increase of participants: 774 in 1987, 1036 in 1988 and 1101 in 1989; for 1990 it is expected to be 1206. The main areas for which these events are offered, are: Genetic Engineering, Tissue Culture, Promising Crops, Plant Pathology, Plant Protection, Forest Management, Project Formulation, Project Management and Evaluation, Agroforestry Systems, Watershed Management, Agrometeorology, Protected Areas Management, Communication and Extension, Animal and Plant Genetics, Health, Nutrition and Animal Production, Training of Instructors, Administration of Training Activities, Microteaching, Curricular Development and Strategic Planning of Human Resources Management.

FIGURE 9

Some of the facilities available for the implementation of the educational program are the following:

- **An Academic Staff of more than 100 researchers-professors (M.S. and Ph.D.).**
- **The Library has some 80,000 books and pamphlets and 11,000 periodicals.**
- **The Computer Center has an IBM 9370 and there are 120 personal computers on campus. It also has a Biometrics and Statistical Analysis Unit.**
- **Experimental Farms and Specialized Labs give support to research and education programs.**
- **CATIE provides an Instructional Video production service.**



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REDCA INSTITUTIONS 1985-1989

Costa Rica

Ministry of Science and Technology (MICYT)
National Council for Scientific and Technological Research (CONICIT)
National University of Costa Rica (UNA)
State Open University (UNED)
Technological Institute of Costa Rica (ITCR)
Ministry of Agriculture (MAG)
Ministry of Natural Resources, Energy and Mines (MIRENEM)
National Production Council (CNP)
School of Agriculture of the Humid Tropical Region (EARTH)
Central American Livestock Raising School (ECAG)
Costa Rican Association of IICA-CATIE Graduates

El Salvador

Ministry of Agriculture (MAG)
University of El Salvador (UES)
Jose Simeón Carías Central American University (UCA)
Agricultural Training Center (CENCAP) Politechnic University of El Salvador (UPES)
Agricultural Technology Center (CENTA) National School of Agriculture (ENA)

Guatemala

San Carlos of Guatemala University (USAC) Rafael Landívar University (URL)
Del Valle University (U. del V.)
Institute of Agricultural Science and Technology (ICTA)
Ministerial Agency for Agriculture, Cattle Raising and Nutrition (MAGA)
National Central School of Agriculture (ENCA)

Honduras

Regional University Center of the Atlantic Coast (CURLA)
National School of Agriculture (ENA) National School of Forestry (ESNACIFOR)
Ministry of Natural Resources (SERENA)
Pan American Agricultural School (EAP)
Jose Cecilio del Valle Private University (UPJCV)
San Pedro Sula Private University (UPSPS)
Technical Education Directorate (DET)
National Autonomous University of Honduras (UNAH)

Nicaragua

National Directorate of Agricultural Technology (DGTA)
National Directorate of Rural Development and Agrarian Reform (DGFCRA)
National Directorate of Natural Resources and the Environment (DIRENA)
National Autonomous University of Nicaragua at León (UNAM-León)
National Autonomous University of Nicaragua at Managua (UNAM-Managua)
People's Higher Education Center of Matagalpa (CPES-Matagalpa)

Higher Institute of Agricultural Sciences (ISCA)
Central American University (UCA)
National Engineering University (UNI)
International Agriculture and Livestock Raising School of Rivas (EIAG-Rivas)
Francisco Luis Espinoza Agriculture and Livestock Raising School - Esteli Politechnic University (UPOLI)

Panama

Agricultural Research Institute of Panama (IDEAP)
University of Panama (UP)
Ministry of Agricultural Development (MIDA)
National Renewable Natural Resources Institute (INRENARE)
Technological University of Panama (UTP)
Santa Maria La Antigua University (USMA)
Institute for the Training and Exploitation of Human Resources (IFARHU)
Hydrological Resources and Electricity Institute (IRHE)
Ministry of Education (MINEDUC)

Dominican Republic

Ministry of Agriculture (SEA)
National Higher Education Council (CONES)
Dominican Association of University Presidents (ADRU)
Pedro Henríquez Ure a National University (UNPHU)
Autonomous University of Santo Domingo (UASD)
Madre y Maestra Pontifical Catholic University (PUCMM)
Northeastern University (UNNE)
Central Eastern University (UCE)
Acción Pro Educación y Cultura University (UNAPEC)
Cibao Technological University (UTECI)
Eastern Cibao Technological Institute (ITECO)
Higher Agricultural Institute (ISA)
Santo Domingo Technological Institute (INTEC)
Loyola Politechnic Institute (ITL)
Salesian Agronomical Institute (IAS)
CDEP University (CDEP)
National Evangelical University (UNEV)
St. Ignatius Loyola Institute (INSIL)
Executive Office, National Technical Forestry Commission (CONATEF)

United States

(A network in support of REDCA)

University of Wisconsin
Cornell University
Iowa State University
University of Florida
Colorado State University
University of Missouri
University of Maryland



CATIE is a civil, non profit, autonomous association, scientific and educational in nature. It carries out, promotes and stimulates research, training and technical cooperation in agriculture and natural renewable resources in benefit of the American Tropics, particularly the countries of the Central American Isthmus and the Antilles. The Center was created by Costa Rica and IICA. Accompanying Costa Rica as a founding member, Panama joined in 1975, Nicaragua in 1978, Honduras and Guatemala in 1979, Dominican Republic in 1983 and El Salvador in 1987.

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