~~A~~ SPECIAL REPORT
ON THE STATUS OF CIAT TECHNOLOGY DEVELOPMENT AND TECHNOLOGY TRANSFER ACTIVITIES IN LATIN AMERICA

May 11, 1979

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Centro Internacional de Agricultura Tropical

CONTENTS

INTRODUCTION

The Centro Internacional de Agricultura Tropical (CIAT) has been established to provide an international research development input in the generation of improved food technologies, with particular emphasis on benefitting the lowland tropics of Latin America. Within the mandate of the Center are the following five commodities: the *common field bean*, *cassava*, *tropical forages* (beef), *swine*, and *rice* (the latter in cooperation with the International Rice Research Institute IRRI).

CIAT invests its resources in the development of selected technology components which are then made available to collaborating national research and development institutions for incorporation into agricultural production systems tailored to specific agro-climatic and socio-economic conditions. Thus, in its role as a generator of technology components, CIAT clearly exercises a service function to the national agricultural research agencies.

CIAT serves national institutions mainly in Latin America in three interrelated capacities. First, it provides *germplasm*, i.e., selections from existing collections or improved materials from the Center's breeding programs. Secondly, it *trains* national research and development workers in research methodology and/or in the validation/adaptation of new technology. And, third, the Center provides *technical assistance* and information channels (conferences, workshops, etc.) for the efficient interchange of technical information.

On the following pages, an attempt is made to identify the Center's activities in these three areas. In this account, the reader must take into consideration that CIAT is a relatively young institution. The physical infrastructure to support its research programs was inaugurated only in 1973. In the intervening six years, CIAT has made significant strides in clearly focusing on the commodity structure described above.

In its three major programs (beans, cassava and tropical pastures) fundamental efforts are focused on plant improvement endeavors. Obviously, for this focus there is a considerable delay between the time that materials are collected or hybrids made and enough evaluations have been done for the improved technology to be ready for testing by national programs. Breeding programs worldwide normally require from 5 to 10 years of research, depending on the rate of generation turnover, to produce new genotypes. This time lag has been considerably reduced at CIAT due to the obvious advantages provided by the various CIAT research locations.

New bean genotypes are on farms for validation in 1979 in a number of countries. These lines originated from crosses made mainly in 1975 and 1976, a time lag of only three to four years. The cassava crop requires one year per growing cycle and the breeding process is somewhat more delayed. Nevertheless, new materials are experiencing only a six-year delay to reach farm level trials. At this stage, the validation work is of the pre-release type for cassava and beans to allow us to adjust the breeding program objectives after on-farm validation experiences.

While some germplasm materials and complementary technology have already entered the validation stage, considerably more materials are at lesser stages of development and can be expected to move forward rapidly as the respective programs mature. The preliminary technology validation data presented in this report constitutes important feedback information that is crucial for design modifications of new technology; nevertheless, it would be inappropriate to use it as a basis for determining real or potential impact of the three major commodity programs. Such determination must await the more complete evaluation of the bulk of new technology currently under development and which will become available over the next two to five years.

With respect to CIAT's associated commodity efforts -- rice and swine -- the data presented are more clear-cut. In the case of rice, CIAT could draw immediately on the advanced stage of rice research in the United States and Asia; its basic task has been to adapt the new high-yielding varieties to Latin American conditions.

The Rice Program has a very vigorous program of international testing and new materials have a delay time of some three or four years from the first cross. The ready acceptance of CIAT/IRRI materials by national programs and growers in Latin America is exceptional and has contributed to production increases in many areas.

In the case of swine, a considerable amount of basic technology is available and CIAT's efforts have mostly been directed toward technical assistance and training. As will be reported, this dissemination strategy appears to have worked as a number of Latin American swine programs have become viable entities as a direct result of CIAT collaborative efforts.

I. BEANS

1.1 For the period 1973-1975 annual production of dry beans (Phaseolus vulgaris L.) in Latin America averaged 4.7 million tons, an increase of almost 1.8 percent per annum over figures from the previous decade, but clearly inferior to the 2.8 percent annual population growth rate for the region. As a consequence the per capita consumption of beans has declined alarmingly in most Latin countries while accompanied by a massive price increase. Worse, production increases have not been obtained through yield increases, but mostly through increase in the area sown. Thus, although there is increasing political interest in, and support for the crop, yield averages for Latin America in recent years have been, in general, less than those achieved on the continent during the 1950's and 60's.

1.2 Against this background the CIAT Bean Program has a single goal : to develop the technology which will permit major yield increases in beans in South America. As with many similarly oriented international programs, it must move to this goal in a series of overlapping steps. Principal phases in this development are :

(A) Identification of factors limiting bean production in Latin America. These limiting factors must be evaluated for their relative importance, and the ease or difficulty and cost of overcoming them.

(B) Collection and evaluation of available germplasm.

(C) Improvement of wild or land race cultivars by plant breeding to produce lines with improved yield and resistance to the principal diseases and pests of the region.

(D) Development of cultural practices which will be complementary to the improved cultivars.

(E) Transfer to national programs of the improved cultivars with their complementary technology to be evaluated under a range of climatic conditions.

(F) Testing and fine tuning of the proposed innovations under farm level conditions.

A. FACTORS LIMITING BEAN PRODUCTION

1.3 Since the Bean Program attained a multi-disciplinary research capability in 1974, its scientists have basically completed phases (A) and (B). Evaluation of the limiting factors to bean production was achieved by extensive consultation with national program scientists, by evaluation of published literature in English, Spanish and Portuguese, and by farm surveys undertaken in three regions of Colombia, in Honduras and in Brazil. Results of the studies undertaken in phase (A), together with recommendations and priorities for research developments are summarized in three publications :

(i) de Londoño, N.R. et al. (1978) Factores que limitan la productividad del fríjol en Colombia. CIAT Series 06SB-2, 44 pp.

(ii) Graham, P.H. (1978) Some problems and potentials of field beans (Phaseolus vulgaris L.) in Latin America. Field Crops Res. 1, 295-317.

(iii) Schwartz, H.F. and Sanders, J.H. (1978) Plant diseases of dry beans (Phaseolus vulgaris L.) in Latin America, and strategies for their control. Paper presented to the International Symposium on Diseases of Tropical Food Crops, Belgium 1978.

B. GERMPLASM COLLECTION AND EVALUATION

1.4 Considerable progress has been made in Phaseolus germplasm collection and evaluation. CIAT now has the world's largest collection of P. vulgaris with recent collections in Spain, Portugal, Peru and Mexico increasing the number of accessions held to more than 20,000 (Table I-1). Approximately

Table I-1 Phaseolus samples acquired, seed increased and evaluated in CIAT (as of November, 1978).

Species	No. of accessions	Accessions for which seed has been increased	Number evaluated
P. vulgaris	19,910	12,600	9,500
P. lunatus	1,010	310	-
P. coccineus	430	150	-
P. acutifolius	70	60	60
Other Phaseolus 1/	100	50	-
Total	21,520	13,170	9,560

1/ Includes samples from eight wild species.

10,000 of these have been evaluated for disease and insect resistance, yield and maturity characteristics, tolerance to soil acidity and low phosphorus supply, etc. Not only have known sources of resistance to the races of bean pathogens found in Latin America been identified, but also alternate resistance sources of differing seed coat colors have been found. National preferences for seeds of differing coat colors make this an essential step for the rapid development of varieties satisfying specific tastes. Much germplasm work is still underway in the program but this is mainly to identify additional sources of pathogen and insect resistance, and to study certain characters of secondary priority.

C. CULTIVAR IMPROVEMENT

1.5 The program is currently concentrated in phase (C), the development of improved cultivars by plant breeding. Given the many pathogens and pests attacking this species, and that the species has physiological defects, the goal of high-yielding pest resistant cultivars is a difficult one to achieve. The need to simultaneously satisfy national seed shape and color preferences, and to limit needed inputs to these readily available to small farmers make the task even more difficult. It has been necessary to develop novel and imaginative approaches to this task.

1.6 The series of events by which large numbers of hybrid materials are screened and made available to national programs is detailed in Figure I-1.

1.7 Though only initiated in 1975 rapid gains have been made in the breeding program. This is evident in results obtained from the 1978 Uniform Screening Nursery (VEF) where 937 CIAT breeding lines and 577 other accessions were evaluated. In this trial 83.2 percent of the lines tested showed resistance to BCMV; 24.3 percent resistance or immunity to local rust races; 17.2 percent resistance to anthracnose; 12.3 percent tolerance to the leafhopper (Empoasca); and 2.8 percent tolerance to bacterial blight. As is evident in Table I-2, numerous multiple disease resistant lines were obtained, some possessing resistance or tolerance to as many as five of the major pests and pathogens. Of the best materials, 185 moved into preliminary trials in 1979, and are now available to national programs. All of these have resistance to BCMV, while 73.5, 38.9, and 17.8 percent are resistant to rust, anthracnose and Empoasca, respectively.

1.8 Table I-3 shows results for approximately 500 germplasm and 278 breeding lines evaluated in the 1978 Preliminary Trial. Again the results show significant gains as a result of the breeding program. Thus :

- Virtually all hybrid lines included in this trial were resistant to BCMV.

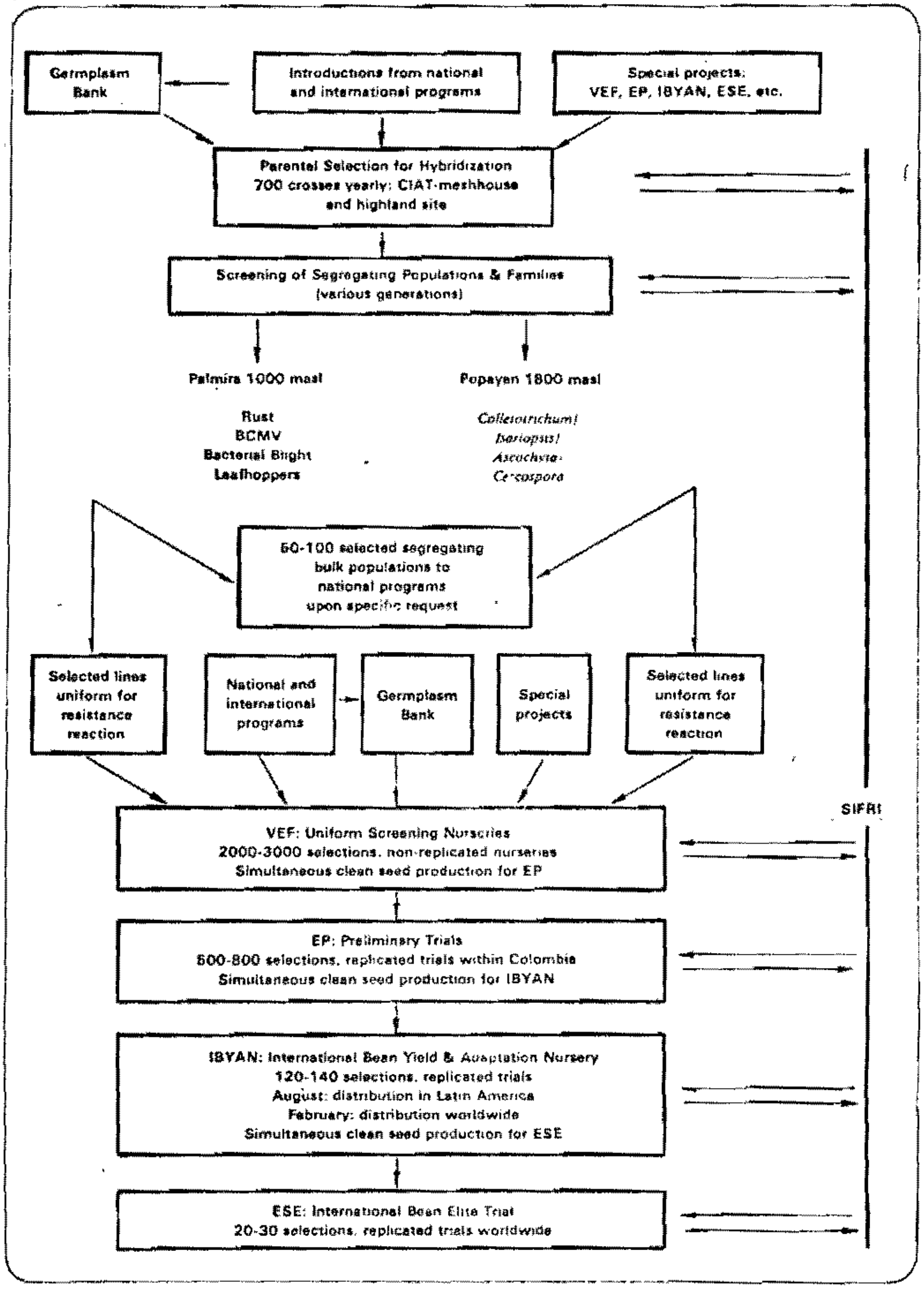

Figure I-1 Program for simultaneous and sequential development and evaluation of bean germplasm proposed by the CIAT Bean Program, 1977.

Table I-2 Characteristics of the best entries for major grain types, obtained from the 1978 VEF trial.

	1978 VEF Number					
Characters	1681	1064	1740	2068	1787	1176
Origin	Hybrid	Hybrid	Hybrid	Germ. Bank	Hybrid	Hybrid
Seed color	Red	White	Cream	Pink Mottled	Brown	Black
Seed size	Small	Small	Small	Medium	Small	Small
Days to flower	38	41	39	35	38	42
Growth habit	3	3	2	2	3	2
BCMV	R	R	R	R	R	R
Bacterial blight 1/	4	3	2	4	2	3
Rust	R	R	R	Ip3/	S	Ip
Empoasca 1/	2.3	2.7	3.7	3.7	3.2	3.5
Adaptation 2/						
CIAT	4	3	4	3	3	3
Popayan	3	3	3	4	4	3
Anthracnose	R	S	R	R	R	R
Angular leaf spot 1/	3	3	1	-	-	-

1/ Scored from 1-5, 1 being resistant and 5 fully susceptible.

2/ Scored from 1-5, 1 being highly adapted, 5 poorly adapted.

3/ Intermediate with small pustules.

Table I-3 Percentage frequency of selected traits in germplasm and hybrid selections evaluated by Bean Program disciplines in the 1978 Preliminary Trial (EP).

	Selected germplasm				Hybrid selections			
	Seed color			No. of entries	Seed color			No. of entries
	Black	Red	Other		Black	Red	Other	
1. Yield > 200 g/m^2 1/	37.0	7.0	7.2	455	61.5	46.4	48.5	277
2. Adaptation > 2.5 2/	44.4	2.2	10.5	498	29.1	7.1	13.9	277
3. Bacterial blight < 3.5 3/	11.5	49.4	31.3	472	44.3	71.4	47.5	278
4. Intermed. or Resist., Rust	6.4	28.4	14.1	401	57.1	35.7	34.7	278
5. Resist. or Segreg. Resist., BCMV	72.6	5.6	40.3	208	99.3	88.9	96.0	274
6. Angular leaf spot ≤ 3.0 3/	67.8	28.2	41.5	461	29.3	68.4	48.5	267
7. Leafhopper ≤ 3.0 3/	64.1	14.3	21.1	493	65.8	32.1	29.7	278
8. Photoperiod insensitive or slightly sensitive	95.8	54.6	86.8	150	81.8	56.3	62.3	206
9. 1 + 2 + 3 + 5 + 7	0	0	0	500	19.5	10.7	5.9	278
10. 1 + 2 + 5 + 6	0	0	0	500	4.0	1.0	3.5	278

1/ Combined average of replicated trials in two locations.

2/ Rating scale: 5 = excellent; 1 = poor.

3/ Rating scale: 5 = highly susceptible; 4 = susceptible; 3 = resistant; 2 = highly resistant; 1 = immune.

- Breeding lines were consistently less susceptible to local rust races than the germplasm lines tested.
- There was a major shift in the proportion of red and non-black cultivars giving yields in excess of two tons/ha. While approximately 7 percent of the germplasm accessions yielded over 2 tons/ha, 46-48 percent of the breeding selections attained this yield. Further, and for each seed coat color, the best lines from the breeding program outyielded the best germplasm lines by as much as 500 kg/ha.

1.9 Given the difficulties mentioned earlier, results up to now are very satisfying. Since some problems - for example the improvement of yield potential in non-black cultivars, or the pyramiding of resistance genes against bean golden mosaic virus (BGMV) - have proved (to the moment) less difficult than was anticipated, the program is ahead of the breeding timetable it set itself in 1974-1975.

D. DEVELOPMENT OF IMPROVED CULTURAL PRACTICES

1.10 Yield advances in a crop come not only from new varieties, but also from agronomic practices permitting full expression of yield potential. In beans, where the principal producer is likely to be the small farmer, such agronomic practices must be very different from the fertilizer intensive and irrigation dependent package developed for wheat and rice. Thus, in phase (D), CIAT scientists are investigating factors affecting the compatibility of maize and beans, whether nitrogen fixation by Rhizobium can replace nitrogen fertilization, and how to improve the efficiency of usage of phosphorus fertilizers. More traditional components of "technological packages" such as seed quality and planting density have already been moved into on-farm testing, and will be discussed under heading (F).

E. TRANSFER OF MATERIALS TO NATIONAL PROGRAMS

1.11 This phase has been consistently emphasized within the Bean Program Initially this could only be achieved by shipping germplasm bank materials with some promising features. To date more than 14,000 lines have been included in germplasm shipments, figures for 1978 being detailed in Table I-4. Many selected materials have performed well in national program testing. Accession G3807 is in the final stage of recommendation and release in Ecuador, where it will be available for commercial cultivation under the name INIAP-Bayeto. Similarly G4525 (ICA Pijao) is undergoing extensive testing for possible release in Cuba. Other cultivars have proved useful as sources of resistance to BGMV in Brazil and Guatemala, and to the bean fly in Asia.

Table I-4 Distribution of *Phaseolus* materials (mostly *Phaseolus vulgaris*) by countries, in 1978.

Region	Country	No. of samples
Africa	Kenya	102
	Malawi	754
Asia, Middle East, Far East, Oceania	China	191
	India	2
	New Zealand	46
	Thailand	6
Europe	Belgium	128
	East Germany	10
	France	78
	Italy	25
	Poland	3
	The Netherlands	60
	United Kingdom	69
	Yugoslavia	3
Mexico and Central America	Costa Rica	1374
	Cuba	302
	Dominican Republic	641
	El Salvador	2750
	Guatemala	1187
	Honduras	90
	Mexico	5
North America	United States	185
South America	Brazil	42
	Chile	50
	Ecuador	13
	Guyana	14
	Peru	162
	Venezuela	20
Total 28 countries		8312

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	Poland	3
	The Netherlands	60
	United Kingdom	69
	Yugoslavia	3
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	Chile	50
	Ecuador	13
	Guyana	14
	Peru	162
	Venezuela	20
Total 28 countries		8312

1.12 Increasingly, however, the emphasis is toward the use of CIAT-developed hybrid materials. This is most evident from a consideration of developments in the International Bean Yield and Adaptation Nursery (IBYAN). When this nursery was initiated in 1975-1976 only 20 varieties were included and all were from the CIAT germplasm facility. This notwithstanding, the trial was grown in 54 locations throughout the world, with 41 trial sites in Latin America alone (Table I-5). For the 1977 trial, 39 new materials were evaluated, of which two were hybrid selections from CIAT. The number of hybrid materials rose to 30 in 1978, and in 1979 it is anticipated that virtually all materials will be hybrid lines from the breeding program at CIAT. Finally in 1978 three new trials each using climbing bean cultivars have been introduced. Currently therefore, participating programs can select from five trials encompassing approximately 88 new materials each year.

1.13 In the 1976 and 1977 trial series CIAT germplasm selections consistently outyielded local cultivars in both temperate and tropical locations (Table I-6). Results received to date from the 1978 IBYAN suggest that the improved hybrid materials are also performing extremely well.

1.14 CIAT bean scientists also distribute and coordinate a number of nurseries to evaluate race development of pathogens causing rust, anthracnose and BGMV. As well as contributing to the distribution of promising materials, these trials have established a methodology being widely used by national programs in the region.

F. TESTING AT THE FARM LEVEL

1.15 On-farm testing of improved cultivars and associated technologies is necessary at both the international and national program levels. For the CIAT Bean Program on-farm testing provides an early insight into how new varieties and methodologies will function under farmers' conditions. It not only confirms profitable, viable new technologies, but specifies to the research team what additional problems must be solved before such technologies can be suggested confidently to national program scientists. Furthermore, it establishes a methodology by which national programs can study the modification of suggested technical changes under their production conditions.

1.16 On-farm trials undertaken by the CIAT Bean Program in 1978 are summarized in Table I-7. Simple agronomic changes increased estimated income for small farmers at each testing location. Yield increases of from 34-92 percent were obtained without higher fertilizer use or new varieties. Income gains were also substantial — from 33-129 percent. Costs were increased with the simple changes in agronomy, but cost increases were generally moderate and with limited risk. In Antioquia, use of the fungicide Benlate to control anthracnose and increased planting density were the missing pieces in the puzzle needed to double farm yields (Figure I-2). By contrast,

Table I-5 Number of trials of the International Bean Yield and Adaptation Nursery (IBYAN) dispatched during 1976-1978.

			Trials dispatched			
	1976 IBYAN		1977 IBYAN		1978 IBYAN[1]	
Region and country	Trials dispatched	Data received	Colored seed	Black seed	Colored seed	Black seed
South America						
Argentina	-	-	-	1	2	2
Bolivia	3	-	-	-	1	1
Brazil	15	9	3	11	16	16
Chile	4	3	2	3	3	2
Colombia	7	6	8	4	4	4
Ecuador	5	2	1	2	1	-
Guyana	-	-	-	1	1	-
Peru	6	5	1	2	5	3
Uruguay	-	-	-	1	-	1
Venezuela	4	1	-	3	-	3
Total	44	26	15	28	33	32
Central America and Mexico						
Belize	1	-	1	1	3	1
Costa Rica	1	-	2	4	4	5
El Salvador	5	5	-	4	5	4
Guatemala	2	-	-	5	-	5
Honduras	4	3	5	2	11	3
Mexico	3	3	1	1	3	5
Nicaragua	3	2	1	-	2	-
Panama	1	-	-	-	2	-
Total	20	13	10	17	30	23
Caribbean						
Cuba	-	-	-	1	3	3
Dom. Republic	3	2	3	-	3	-
Haiti	1	-	1	-	2	-
Jamaica	-	-	2	-	2	-
Puerto Rico	-	-	-	1	1	1
Trinidad & Tobago	1	-	2	-	1	-
Total	5	2	8	2	12	4

[1] Through Nov. 30, 1978.

continued

Table I-5 (continued)

	Trials dispatched					
	1976 IBYAN		1977 IBYAN		1978 IBYAN[1]	
Region and country	Trials dispatched	Data received	Colored seed	Black seed	Colored seed	Black seed
North America, Europe and Oceania						
Australia	1	1	-	-	-	-
Bulgaria	-	-	1	-	-	-
Canada	1	1	1	-	2	1
Great Britain	2	2	-	1	-	-
Portugal	-	-	1	1	-	-
Russia	1	-	-	-	-	-
Spain	-	-	1	-	-	-
United States	2	2	2	1	1	1
Yugoslavia	1	-	-	-	-	-
Total	8	6	6	3	3	2
Asia						
India	-	-	-	1	-	-
Iran	1	1	-	-	1	-
Israel	1	1	1	-	-	-
Japan	2	1	-	-	-	-
The Philippines	1	1	6	6	-	-
Syria	-	-	-	-	1	-
Thailand	4	1	-	-	-	-
Total	9	5	7	7	2	-
Africa						
Cameroons	-	-	-	-	1	-
Egypt	-	-	1	-	1	-
Gabon	-	-	-	-	3	-
Lesotho	-	-	-	-	1	1
Malawi	1	1	1	-	-	-
South Africa	-	-	1	1	1	-
Swaziland	-	-	1	-	1	-
Tanzania	3	1	-	-	-	-
Total	4	2	4	1	8	1
Grand Total	90	54	50	58	88	62

[1] Through Nov. 30, 1978.

Table I-6 Mean yield of 20 common and 5 local entries in the 1976 IBYAN at 31 tropical and 10 temperate locations.

Group	Zone	Yield in kg/ha Group mean	Mean of 5 1/	Mean of highest yielders 2/
IBYAN entries	Tropical	1392	1758(135)	1959(118)
	Temperate	2078	2601(135)	2768(116)
Local entries	Tropical	----	1303	1660(100)
	Temperate	----	1925	2391(100)

1/ Mean of the five highest yielders at each location among IBYAN entries and mean of five local entries at each location.

2/ Mean of highest yielding variety at each location within each zone.

Table I-7 CIAT Bean production technology tested at the farm level in Colombia during 1978.

Region/ season	Bean type	Technologies tested	Results and comments
Huila (1978A)	Bush	1-H Improved agronomy Curative spraying against *Empoasca* and anthracnose Timely weeding	50% yield increase on most farms. Highly profitable, low risk.
		2-H Improved seed : Certified and "Cleaner" (disease-free or nearly so)	Negligible yield effect. Farmers' seed was better than indicated by earlier results. Improved seed may be an overrated practice without resistances in a new variety.
		3-H Fertilizer	Most farms did not show a return due to high initial fertility on previous crop history. Those farms below the critical nutrient levels showed a physical and economic response but higher fertilizer levels demand substantially increased costs and are risky.
Antioquia (1978B)	Climbing	1-A Substitution of Benlate for Manzate for control of anthracnose	50% yield increase. Efficient anthracnose control is highly profitable in spite of high cost of the appropriate chemical.
		2-A Increased density combined with stakes for between maize reinforcement	Another 37% yield increase. Needs to be combined with 1-A because higher density leads to significantly higher disease incidence. Reinforcing supports are expensive but not a high-risk technology.
		3-A *Rhizobium* inoculation	Technical problems being resolved by Soil Microbiology for 1979B.
		4-A Less aggressive and earlier varieties	Ineffective. Will be some time before one can improve upon variety Cargamanto. Cargamanto has excellent yields, high value seed type, good density response, and tolerance to a range of insects including storage insects. Backcrossing in climbing bean breeding presently for disease resistances.
Restrepo (1978B)	Bush	1-R Improved agronomy a) Higher density b) More appropriate chemical for anthracnose c) Micronutrients d) Timely weeding	34% increase in yields. Profitable and expensive. Absolute yields low (1.3 tons/ha) as fertility constraining. Initial phosphorus levels of 2 to 3 ppm on farms in trials.
		2-R "Clean" (disease-free) seed	Highly infected by bean common mosaic virus (BCMV) in spite of roguing. Were unable to produce seed free of BCMV where high aphid populations exist (Chile). Indicates importance of basic resistance to BCMV in all new materials.
		3-R Herbicide	Technical problems. Yield reduction. Still too complicated for farmers.
		4-R Fertilizer	Physical and economic response to increased phosphorus up to 150 kg P_2O_5. Risky.

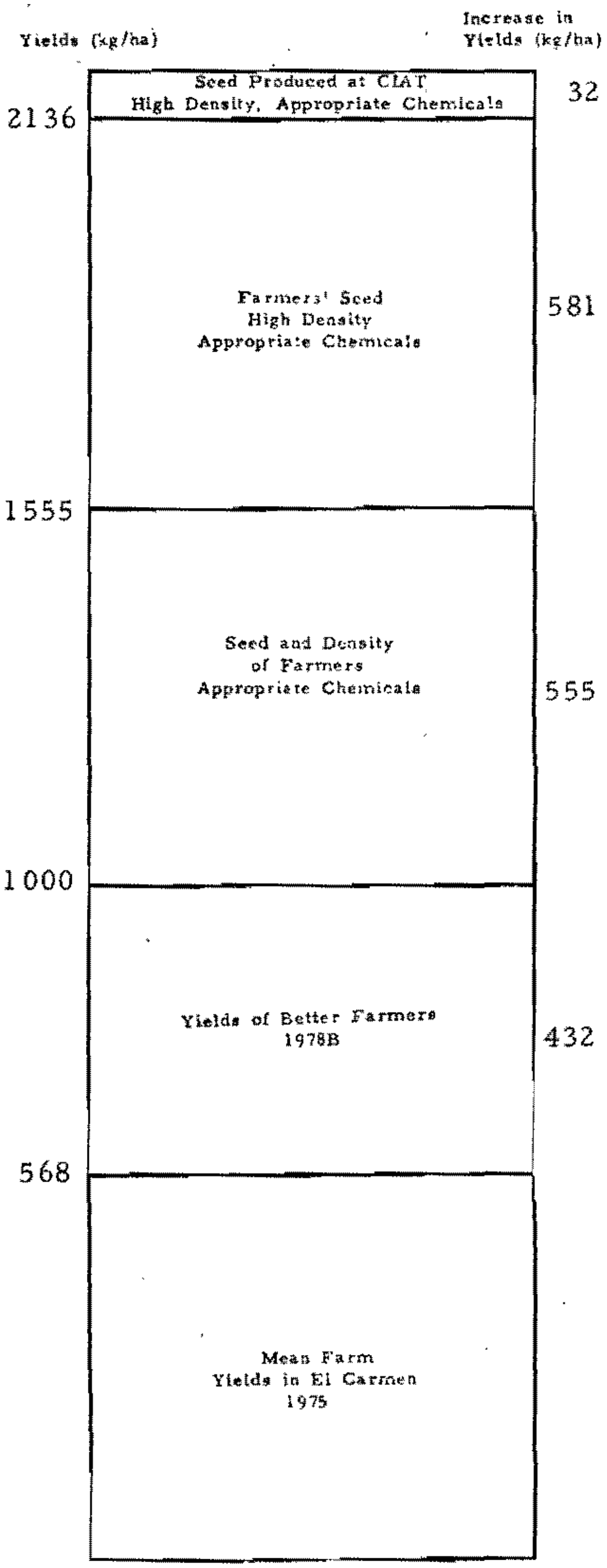


Figure I-2 Effects of the new technology in the on-farm trials on bean yields, El Carmen, Antioquia, Colombia, 1978B.

increased fertilizer application has been of limited value in on-farm trials, especially since its use often exposes the farmer to much higher levels of risk.

G. SUMMARY

1.17 In synthesis, while yield gains are unlikely to be as spectacular as those obtained with rice and wheat, there is now reason for guarded optimism at the progress achieved to date for dry beans. For the first time germplasm is moving freely in Latin America. No insuperable disease problems have been identified, and many resistance breeding problems seem less difficult than first anticipated. It is also worthwhile to mention that Program strategies and goals have needed little modification with time, assuring steady progress. High yields, initially available in black cultivars, are now attained with other seed coat colors, and a wide range of materials are reaching national programs throughout Latin America. As stated previously, this is earlier than was anticipated in program planning, and comparable to rates of achievement in other international crop commodities. The degree to which these initial changes will enhance bean production in Latin America should be evident in the near future.

H. SPECIFIC COLLABORATIVE PROJECTS IN LATIN AMERICA

1.18 The Bean Program has formed an intensive network of international collaboration of bean research and technology transfer. An active program of exchange of germplasm, training and mutual visits has been established. The presence of a Central American Regional Coordinator stationed in Costa Rica has greatly enhanced the collaborative efforts. Following are brief statements of collaboration in each country.

Central America

1.19 The regional coordinator is involved in all activities with CIAT, as well as the between-country transfer of technology. His area of operation includes Mexico as well as the principal bean-producing countries in the Caribbean.

Mexico

1.20 This country has advanced bean programs and collaboration mostly exists as exchange of parental material and improvement of several of their commercial varieties via a backcrossing program. About two visits per year are made, and the Mexico bean program coordinator usually visits CIAT annually.
Institute : Instituto Nacional de Investigaciones Agrícolas (INIA)

Guatemala

1.21 Due to the stationing of two CIAT outreach scientists in beans, intensive collaboration exists. Important bean pests, like bean golden mosaic virus (BGMV) and bean pod weevil, do not occur in CIAT and via this program an active international resistance breeding effort has resulted in regional testing of black-seeded lines resistant to bean golden mosaic virus. The Colombian variety ICA-Pijao has been released as Suchitan. This country is visited about 4 times a year, among other reasons in order to check disease nurseries.
Institute : Instituto de Ciencia y Tecnología Agrícolas (ICTA)

Honduras

1.22 Special collaboration exists with Honduras through the IDB-financed PROMYF activities. As a result of training they have selected two lines (Acasia lines) after regional testing for release and naming. These are progenies of CIAT crosses, taken to Honduras as early generation materials. Honduras participates in bean golden mosaic and bean pod weevil nurseries. About 2 visits per year are made.
Institute : Ministerio de Agricultura y Ganadería / Proyecto Piloto de Maíz y Fríjol (MAG-PROMYF)

El Salvador

1.23 Due to the lack of a breeder on their bean program, advance is less than desired. They actively participate in bean golden mosaic and bean pod weevil nurseries. About 2 visits yearly are made.
Institute : Centro Nacional de Tecnología Agropecuaria (CENTA)

Nicaragua

1.24 Collaboration is being directed towards advanced degree training to prepare staff once the political situation stabilizes.
Institute : Instituto Nacional de Tecnología Agropecuaria (INTA)

Panama

1.25 Most legume production in Panama is cowpeas. Elite germplasm is planted at the experiment station level.
Institute : Ministerio de Desarrollo Agropecuario (MIDA)

Dominican Republic

1.26 An active collaborative program exists among others on the BGMV

nurseries. Germplasm exchange and training are strongly involved, however materials with their seed coat color preferences are still lacking. About three visits per year are made.
Institute : Centro Nacional de Investigación, Extensión y Capacitación Agropecuaria (CNIECA)
Centro de Desarrollo Agropecuario (CENDA)

Cuba

1.27 A very active collaborative project is underway to make Cuba self-supporting in bean production within two years. (Current imports are 90,000 tons yearly). Seed multiplication was started on 150 ha with ICA Pijao, a variety resistant to rust, golden mosaic and bean common mosaic virus. Expected yields are between 2.2-2.4 tons/ha. This seed will be used for further increase, followed by commercial large scale plantings. About two visits are made per year.
Institute : Ministerio de Agricultura

Haiti

1.28 Germplasm is exchanged, however due to the many institutes involved in bean research, progress is slow. One visit per year.

South America

Ecuador

1.29 After an intensive training program the national program is going to release germplasm selections as new varieties (e.g. G3807 as INIAP Bayeto). Heavy involvement and promise in climbing beans. Three to four visits are made annually.
Insititute : Instituto Nacional de Investigaciones Agropecuarias (INIAP)

Peru

1.30 Due to economic restraints, progress is slower than can be expected after strong training involvement. Progress is made especially in the northern and central highlands, the latter with new early climbing selections of our germplasm bank and breeding program. Soon a bilateral project supported by the Government of Switzerland will start operating on bean research. This will form a collaborative link between the newly formed national bean program and CIAT. Four visits a year are made.
Institute : Ministerio de Agricultura.

Chile

1.31 A strong, self-supporting program, strongly backed up by CIAT training exists here. Collaboration is mostly on bean common mosaic resistance breeding. Part of the CIAT disease-free seed production occurs in Chile.
Institute : Instituto de Investigaciones Agropecuarias (INIA)

Brazil

1.32 Brazil has strong collaborative research networks, especially with the national center and IAPAR. Training forms a strong component, as does research methodology and exchange of germplasm, often for parental use. Some lines are being further tested for release like Diacol Calima. Strong collaboration in golden mosaic resistance breeding. Three to four visits are made a year.
Institutes : Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA)
Centro Nacional de Pesquisa em Arroz e Feijao (CNPAF)
Fundacao Instituto Agropecuario de Paraná (IAPAR)
and other state institutes.

Venezuela

1.33 There has been little meaningful collaboration despite the excellent germplasm available to meet their requirements. One to two visits are made a year.

Institute : Fondo Nacional de Investigaciones Agropecuarias (FONAIAP)

Colombia

1.34 Collaboration is intensive, in visits to each others nurseries, joint nurseries, or nurseries in which we provide disease resistant ratings in their lines. They are to release six new varieties from their crossing and selection programs in which we participated. Visits are numerous.
Institute : Instituto Colombiano Agropecuario(ICA)

II. CASSAVA

A. INTRODUCTION

2.1 In this section an attempt is made to accurately state the present stage of development of the new cassava technology. It should be noted that much of the technology now being developed is based on new clones or varieties. There is approximately a six-year delay between making a cross and having the resulting progeny ready for testing by national agencies. As a result, there is presently a great deal of promising material from crosses made from 1974 onwards under various stages of evaluation. While the preliminary technology validation trial showed little advantage to using the CIAT selections, it should be expected that hybrids from crosses will show marked superiority and that these coupled with the agronomic practices already developed should be capable of greatly increasing productivity.

2.2 The impact of CIAT's efforts on increasing production are very difficult to assess in a crop with a major part of total production on small farms. In addition, at present production gains to be made are from improved agronomic practices that are not so easy to quantify as gains from, for example, a new variety. However, conversations with the Programa de Desarrollo Integrado and the Federación Nacional de Cafeteros suggest that in certain areas of Colombia the improved practices are being used by farmers and are having a positive impact on production. Similarly, in Cuba, the improved practices are being used on a large scale and with this year's harvest, the impact will be measurable.

B. RESEARCH STRATEGY AND PROGRAM STRUCTURE

2.3 Technology development within the Cassava Program has two major components: research on farm production technology components and research on post-harvest technology. The two branches of the research program are complementary components of a strategy designed to expand production and utilization of cassava in Latin America, i.e., to develop technology that will make cassava a major cash crop in Latin America.

2.4 The development of cassava production technology focuses on two major target zones, each of which requires slightly different strategies. The primary target zone is the current production areas of cassava. The limited data that exist suggest that these areas are characterized by rather unfavorable agro-climatic conditions and production systems are predominately small-scale. Given these two conditions, the research strategy has been to produce technology components that raise yields with a minimal increase in purchased inputs. Following this strategy the technology is designed to be widely adapted, low-risk and easily adopted and therefore new varieties are the central component. The design focuses on minimizing constraints to adoption and therefore is directed at developing varieties that yield well without large capital outlays for inputs.

2.5 The second target area is the under-utilized frontier lands of the Amazon Basin. Cassava is already a principal crop in the jungle areas of Ecuador, Peru, and Bolivia, serving as a major subsistence crop. Brazil is considering its savanna areas as the principal zone for expanding cassava for use as an alcohol source. Because of the very low pH and low fertility status of these soils, some soil amendments are considered necessary. Cassava technology for these zones is, therefore, designed around a medium amount of fertilizer and lime, although purchased inputs to control pathogens, and other high stress factors such as long dry seasons are avoided through the development of resistant varieties. In both target zones new varieties are the major technological component.

2.6 Post-harvest technology development was devised to insure that the benefits of new cassava production would not be constrained by limited demand. The research focuses on three principal aspects: 1) reducing post-harvest perishability through low-cost storage methods; 2) development of efficient on-farm chipping and drying technologies (necessary for entry of cassava into the animal-feed component market); and, 3) on-farm utilization of cassava, including the leaves, as an animal feed. Because of the much lower prices required before cassava can enter these alternative markets, high yielding production technology (and therefore cost-reducing technology) must complement the post-harvest technology.

2.7 A third component of the cassava program is its technology transfer activities. These focus on strengthening cassava research in national institutions through training, information flows and liaison activities of CIAT scientists; transferring germplasm for evaluation; and aiding national research programs in problem identification and research strategy development. Technology transfer is necessarily channelled through national programs. A strong cassava research network throughout Latin America is thus critical to the successful adoption of the technology, both in terms of extending the technology to farmers and in terms of testing and evaluating the technological components, particularly the varieties.

C. CURRENT STAGE OF TECHNOLOGY DEVELOPMENT

2.8 The CIAT cassava program was initiated in 1971 and became fully operational in 1973. The principal concentration of the program during its first five years was on production technology. This was divided naturally between research on cultural practices and breeding for new varieties. The program had little previous research to draw upon. The research on cultural practices proceeded most rapidly. By the end of the first five-year period a set of low-cost cultural practices had been developed which gave significant yield increases with either local or selected varieties under experimental conditions and in trials on farmers' fields in a research site on the Colombian Atlantic Coast.

2.9 The breeding program has taken a longer time to produce results that would have an impact on farmers' fields. The germplasm bank had to be evaluated for potential parents, selection characteristics had to be experimentally determined, breeding methodology defined, and crosses, selection, and yield evaluations made. By 1978 five or six high-yielding widely adapted varieties from the germplasm bank had been identified and the first promising hybrid lines had entered the regional trial network for multi-environment testing. By 1979 the first hybrids were going into international trials. It is important to note that these hybrids are from crosses made in 1973. Thus, the Cassava Program has only just reached the stage of being able to release hybrid lines to national institutions for testing and evaluation. The release of hybrid lines to farmers is still in the future.

2.10 With the research on the production technology reaching the initial release stage, organization of the other two branches of the Program were begun. This was a logical progression as post-harvest technology development and technology transfer depended on a well-functioning production research program. Thus, post-harvest technology research was consolidated in one unit and will begin full operation in 1980. Technology transfer activities were also consolidated in one section and with the potential addition of several out-posted staff will as well begin expanded activities in 1980.

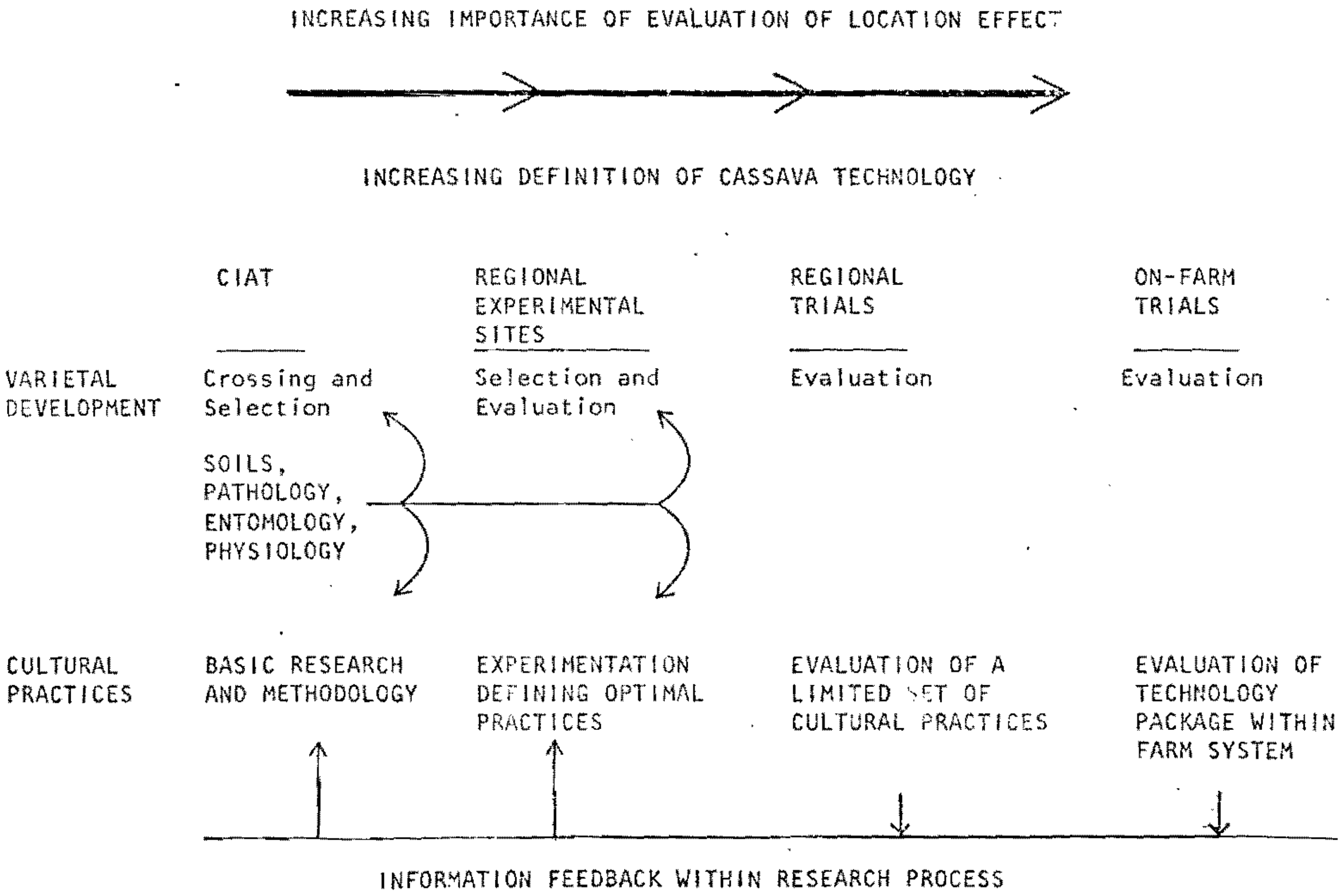
2.11 In summary, the Cassava Program in its five years of operation is just to the stage of releasing technology components to national institutions. Cultural practices are the most well defined; a limited number of widely adapted high-yielding varieties have been identified, but only the first set of hybrids are available. The Program is thus entering a critical stage of pre-release testing, before the technology goes out to extension agencies and thus to farmers. This testing process by necessity requires the input of national cassava research programs.

D. TECHNOLOGY EVALUATION

2.12 The structure of cassava technology evaluation is shown in Figure II-1. The more complicated process is the testing and evaluation of improved varieties. After initial selections, promising materials go into replicated yield trials in three diverse sites. From these, promising hybrids then move into the Colombian regional trials network and international trials. Varieties that emerge from these trials advance into on-farm trials where they are combined with cultural practices developed at the CIAT station. The

Figure II-1

CASSAVA TECHNOLOGY DEVELOPMENT PROCESS



on-farm trials evaluate the profitability, riskiness, and potential acceptance of various technical packages that combine different combinations of farmer practices and CIAT technical components.

Replicated Yield Trials

2.13 The hybrid yield trials are the last selection procedure within the breeding section. From as many as 45,000 crosses, eight to ten advanced lines emerged from these trials for entry into the Colombian regional trial network. These replicated yield trials take place in three sites: the optimal production conditions at CIAT-Palmira, a high-temperature coastal zone with a long dry season (Caribia), and the infertile soil, high-disease pressure conditions of the Colombian Eastern Plains (the savanna zone of the Amazon Basin). The yield results from the first two years of evaluations produced hybrids that yield 50 tons per hectare in CIAT, 40 tons in Caribia, and 25 tons in the Eastern Plains (see Tables II-1 to II-4). Hybrids were produced that could meet these objectives across all three sites, possibly indicating wide adaptability. These high-yielding selections then move into multi-environment regional trials.

Regional Trial Evaluation

2.14 The Cassava Program early in its development established a network of varietal evaluation sites, broadly representative of the wide diversity of agro-climatic conditions existing in Colombia. In the first stages selections from the germplasm bank were evaluated to identify widely adapted varieties that would serve as parents in the breeding program and as initial releases to national institutions. The varieties were evaluated for yield using low-cost cultural practices that included only planting stake selection, stake treatment, a fixed plant population, and timely weeding. High yielding lines were required to go through a three-year evaluation period to test for yield stability.

2.15 From the regional trials five varieties have been selected from the germplasm collection that give significantly higher yields than the local varieties across a broad spectrum of agro-climatic conditions. Analysis of the yields of these varieties (see Table II-5) suggest two conclusions: 1) special varietal adaptation is required to yield well at above 1500 meters (and probably where either night or seasonal temperatures are low); and, 2) yields vary widely depending on soil and climatic conditions. These two conclusions suggest that the expected yields of cassava in Latin America from widely-adapted new varieties will depend principally on the agro-climatic conditions in the primary production zones.

2.16 The first year for evaluating hybrids in the regional trials was 1978. The yield results are presented in Table II-5. The results suggest that in this initial series of trials these first hybrids yielded nearly as well as

Table II-1 Results of replicated yield trials of cassava at CIAT-Palmira

Trial	I[1]		II[1]		III[1]	
	Fresh root yield (ton/ha)	Root dry matter content	Fresh root yield (ton/ha)	Root dry matter content	Fresh root yield (ton/ha)	Root dry matter content
Average of all genotypes	28.5	.340	40.3	.362	34.1	.359
Local cultivar	22.8	.286	23.3	.305	18.9	.341
Average of control cultivars[2]	18.9	.326	27.8	.338	27.6	.354
Average of top ten CIAT line yielders	51.3	.343	58.4	.362	53.0	.370
Maximum yielder	54.2	.350	79.2	.354	67.2	.375
	(CM 440-5)		(CM 489-1)		(CM 321-188)	

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[1] I - 223 genotypes; planted 3 May 1977; harvested 22 May 1978
II - 121 genotypes; planted 24 Sept. 1977; harvested 24 Sept. 1978
III - 90 genotypes; planted 15 Nov. 1977; harvested 13 Nov. 1978

[2] Llanera, M Col 22.

Table II-2 Results of replicated yield trials of cassava at Caribia, Colombia

Trial	I 1/		II 1/		III 1/	
	Fresh root yield (ton/ha)	Root dry matter content	Fresh root yield (ton/ha)	Root dry matter content	Fresh root yield (ton/ha)	Root dry matter content
Average of all genotypes	26.7	.285	30.4	.309	29.7	.286
Local cultivars	16.9	.324	26.7	.366		
Average of control cultivars 2/	23.2	.261	20.6	.306	17.3	.291
Average of top ten CIAT line yielders	39.7	.296	41.7	.311	37.9	.284
Maximum yielder	49.4	.299	51.9	.284	54.6	.302
	(CM 309-277A)		(CM 323-403)		(CM 305-38)	

1/ I - at Caribia; 64 genotypes; planted 17 May 1977; harvested 19 April 1978, locally prepared planting stakes were used.
II - at Caribia; 30 genotypes; planted 11 Oct. 1977; harvested 5 Sept. 1978, locally prepared planting stakes were use
III - at a farmer's field near Cienaga; 23 genotypes, planted 23 Nov. and 7 Dec. 1977; harvested 23 Oct. 1978.

2/ Llanera, M Col 22.

Table II-3 Results of replicated yield trials of cassava at Carimagua, Colombia

	I[1]	II[1]	
Trial	Fresh root yield (ton/ha)	Fresh root yield (ton/ha)	Root dry matter content
Average of all genotypes	5.3	15.4	.276
Local cultivar	2.5	9.8	.263
Average of control cultivars[2]	2.2	12.3	.270
Average of top ten CIAT line yielders	6.5	21.2	.283
Maximum yielder	12.0 (M Col 638)	24.6 (M Col 1684)	.271

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[1] I - 26 genotypes; planted 9 Jun. 1977; harvested 18 May 1978
II - 43 genotypes; planted 20 Sept. and 28 Nov. 1977; harvested 2 Oct. 1978.

[2] Llanera, M Col 22

Table II-4 Characteristics of selected promising cassava lines from CIAT

			Root fresh yield (ton/ha/yr)							Reaction to:[1]	
	Cross parents	Year of hybridization	CIAT	North Coast	Carimagua	Root dry matter content	Eating quality	Ease of harvest	Root skin color	Cassava bacterial blight	Super-elongation
Promising lines											
CM 305-38	M Col 113 x M Col 22	1973	34-51	55	20	medium	good	easy	brown	S	S
CM 305-120	"	1973	39-51	39	21	low	acceptable	average	brown	S	S
CM 305-125	"	1973	37-48	42	16	medium	good	average	brown	S	S
CM 321-188	M Col 22 x M Ven 270	1973	61-67	42	14	medium	acceptable	easy	white	S	S
CM 323-375	M Col 22 x M Mex 59	1973	36-63	41	7	medium	good	easy	brown	S	S
CM 326-407	M Col 22 x M Ven 307	1973	27-57	33	8	high	good	average	white	S	S
CM 430-37	Llanera x M Col 647	1974	64	-	-	medium	good	average	brown	R	MR
CM 459-5	Llanera x M Mex 23	1975	40	-	-	high	good	difficult	brown	R	MR
Control											
CM 308-197	M Col 22 x M Col 361	1973	44-50	33-39	3-21	low	poor	difficult	white	S	S
M Col 1684			25-51	23-44	10-25	low	unacceptable	difficult	white	MR	MR
M Col 638			17-31	21-31	12-22	low	unacceptable	average	yellow	R	MR
M Ven 218			27-60	21-37	3-13	medium	good	difficult	brown	S	MR
Llanera			20-29	9-19	2-15	low	acceptable	difficult	brown	S	S
M Col 22			13-31	21-35	2-19	high	good	easy	white	S	S

[1] S = susceptible; MR = moderately resistant; R = resistant.

Table II-5 Yield comparison of selected varieties, regional varieties, and hybrids in CIAT regional trials

Regional trial sites	1975-78 Four-year average				Selected variety average	Regional variety average	Hybrid[1] average
	CMC 40	Mex 59	CMC 84	M Col 22			
	Tons/ha						
Zone 1							
Popayan[2]	3.8	0.9	1.0	0.3	1.5	22.9	-
Tambo	22.2	18.7	25.2	11.1	19.3	24.3	-
Quilichao	22.8	27.5	22.9	-	24.4	27.7	20.6
Zone 2							
Pereira	36.6	17.9	18.1	8.8	20.4	35.7	-
Caicedonia	27.8	33.6	26.5	25.2	28.3	25.4	36.9
CIAT	38.4	24.8	35.0	27.9	31.5	23.9	30.3
Zone 3							
Rio Negro	24.7	34.4	30.4	19.8	27.3	13.9	18.4
Nataima	34.1	31.0	24.0	26.0	26.3	17.2	28.9
Zone 4							
Florencia	20.6	21.2	12.2	8.8	15.7	18.5	-
Carimagua	23.9	22.6	24.1	15.5	21.5	13.5	27.5
Zone 5							
Media Luna	21.9	21.9	13.5	14.5	18.0	8.3	12.5
Colombian average[3]	26.1	26.6	21.3	17.8	23.0	14.6	21.1

[1] Represents only one year of testing. Yields are average of the five highest yielding, most widely adapted varieties.

[2] Location above 1500 meters in altitude.

[3] Average for Colombia weighted by total cassava production in individual zones.

the best selections and considerably better than the regional varieties. The selected lines, hybrids and local varieties yielded 23, 21 and 15 tons/ha, respectively, when the data were calculated and weighted for the importance of cassava in each region of Colombia (Table II-5).

International Yield Trials

2.17 Yield trials have now been established in six Latin American countries, including Colombia. The international cooperation section is moving to establish an international network of variety yield trials. The organization of the network has been slow for a number of reasons, the primary ones being: 1) the lack of cassava research programs in most Latin American countries to oversee the trials; 2) the bulkiness and expense of sending planting stakes; and, 3) the disease transmission risk of sending vegetative material. Stiff quarantine measures have been the primary constraint. This is being overcome by the development of clone propagation through meristem culture.

2.18 The yield results are summarized in Table II-6. (For a detailed presentation of data on all varieties tested see Appendix II-A.) The five widely-adapted varietal selections in most cases yielded well above the regional variety, although yield variance across sites was again large. The few trials with hybrids gave similar results to the Colombian trials: 1) yield variation between sites was similar to the selections; 2) the best hybrid yields were never as high as the best selection but the average of the three best hybrids usually was higher than the average of the five widely adapted selections; and, 3) yields of the best hybrids at a given site tended to group closely together. In all trials there was a significant yield increase over the regional variety. The best CIAT line or selection in each site yielded an average of 29 tons/ha while the local lines yielded 17 tons/ha in the seven trials in which comparisons were made (Table II-6).

On-farm Trials

2.19 The final stage of cassava technology evaluation is on trials on farmers' fields. These trials evaluate the best varieties from the regional trials jointly with different combinations of farmer and CIAT-recommended cultural practices. These trials have a dual purpose: to identify technical components that are accepted by the farmer and that therefore can go directly to national institutions for diffusion to farmers; and to define characteristics of the technology or technical components that are not profitable or too risky or not compatible with the farmers' resource constraints and which therefore require further research. These trials also provide the data on which ex-ante economic evaluations of the new technology are made.

2.20 The farm trials were initiated in 1978. One site was initially chosen to develop and test methodology. This has been completed and currently these farm trials are being expanded to four additional sites within Colombia in collaboration with Colombian research agencies. With the development of national cassava programs in Latin American countries and stronger links between CIAT and these programs this type of trials will hopefully be under-

Table II-6 Summary of International Yield Trials of Cassava

Materials	Location and planting cycle								
	Ecuador			Mexico		Dominican Republic	Costa Rica	Guyana	
	1	2	3	1	2	1	1	1	2
Widely adapted selections									
CMC 40	24.5	26.4	36.6	7.2	14.9	47.0	22.0	17.9	18.1
Mex 59	28.3	12.5	31.7	13.0	5.0	21.5	27.9	17.3	16.1
CMC 84	25.6	20.6	29.5	9.3	6.4	31.3	26.2	-	-
M Col 1684	-	23.6	42.4	-	15.4	36.1	30.3	-	-
M Col 22	18.8	-	26.2	14.0	9.5	23.5	19.7	6.3	9.9
High-yielding hybrids									
CM 305-41	-	-	34.3	-	-	37.5	-	-	-
CM 323-375	-	-	33.1	-	-	40.0	-	-	-
CM 308-197	-	-	31.2	-	13.9	36.9	-	-	-
CM 323-87	-	-	-	-	12.9	-	-	-	-
Regional variety	21.6	18.6	18.0	-	-	24.6	14.8	11.6	10.0

taken by national research institutes in conjunction with their own regional yield trials. However, information flows between CIAT and national programs are necessary to link CIAT research to technology evaluation throughout the cassava production zones of Latin America.

2.21 The farm trials for cassava were initiated among a sample of small farmers in a lowland coastal zone, characterized by very poor soil and a long dry season. Under adverse soil and climatic conditions cassava can still yield well relative to other crops. Indeed, it was the principal cash crop in the zone. Cassava has a comparative advantage in unfavorable agricultural zones and the majority of marketed cassava comes from such zones.

2.22 The technology tested consisted of three major components:

- Low-cost agronomic practices designed principally to improve plant population especially by increasing low germination rates;
- Fertilizer, as the soils appeared to have nutrient deficiencies; and,
- CIAT selections of high-yielding, widely-adapted varieties.

2.23 With simple agronomic practices net income from cassava was increased 65 percent per hectare (Table II-7). In these adverse conditions farmers were not able to overcome low germination rates with replanting. However, simple agronomic practices of stake selection and treatment did increase germination, thereby enabling higher plant populations to be achieved at low cost. Two other technological components of the farm trials increased yields but were not profitable. These are discussed below.

2.24 FERTILIZER. Even though the soils were below the defined critical levels of both phosphorus and potassium, there was little physical response to fertilizer at moderate to high applications by either the local variety or the improved selections; response was so small that fertilizer use was not profitable. Cassava appears to be very efficient in its absorption and use of limited soil nutrients. Moreover, fertilizer apparently contributes to excess leaf formation rather than to root enlargement. Since significant increases in yields are possible without high levels of purchased inputs, even in adverse climatic and soil conditions, cassava is an excellent crop for small farmers.

2.25 CIAT SELECTED VARIETIES. These selections gave only a marginal yield increase over the local variety. Their yields were approximately one-half the 30 to 40 tons per hectare yields obtained in the good soils and excellent management at CIAT-Palmira. Under adverse soil, climate and pest conditions, yields fell to the level of the local variety. Moreover, these selections had quality problems with starch content well below the local variety. This results in a large price discount on local markets and makes

Table II-7 Profitability of the cassava technology tested on the North Coast of Colombia in farm trials, 1977-78

Location	Technological practice	Income Pesos	Increase %	Increased costs of Inputs	Comments
Media Luna, Atlantic Coast	Agronomic practices: Stake selection Stake treatment Plant population Timely weeding	11,750	65	155[1]	This practice is dependent upon an intensive extension input to substitute management for high input use.

All New Technologies Tested in Media Luna

Technology	Yield (t/ha)	Profitable	Comments
Traditional technology	7.4	Yes	Low plant population due to intercropping with maize; germination problem due to inadequate stake storage.
Agronomy practices: Seed selection Seed treatment Plant population Timely weeding	12.1	Yes	Higher plant populations and greatly improved initial germination raise yields. Discarding maize may introduce cash flow problems.
Improved varieties	14.6	No	Though giving a slight yield advantage, starch content was lower resulting in a price differential, which the yield advantage does not overcome.
Fertilizer			
Local variety	13.0	No	Not profitable and starch content was reduced by fertilization.
Improved varieties	16.6	No	Not profitable due to sharp price discoun

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[1] Few or no cash inputs are utilized by these small farmers.

these varieties unprofitable. Starch content is heavily influenced by environmental factors and the local variety has been selected for its ability to maintain high starch levels under adverse conditions. Moreover, fertilizer use further lowered the starch content.

2.26 These results are based on only one site, making any broad conclusions about the yield gap between the experimental station and farmers' fields impossible. The varieties tested were only the widely-adapted selections and therefore do not give an accurate idea of potential farm level yields with future hybrids. Nevertheless, these initial results show the value of these trials in the testing and evaluation process to insure a dynamic flow of information between the farm and the research station.

2.27 More sites are thus necessary before any broad conclusions can be reached about the farm level effect of new cassava technology. The regional and on-farm trial results have shown that the increase in expected productivity (at least for the varieties) is highly dependent on the agro-climatic conditions. This result points to the need for the location of international yield trials and on-farm trials to be linked to identification of major cassava production zones and the characteristics of these zones. This identification of production zones for cassava in Latin America and a definition of their agro-climatic characteristics and predominant farming systems will soon be undertaken with the Economics Section of the Cassava Program. With this data base yield results from strategically located regional trials, and farm level monitoring of productivity increases and adoption information will then be available to make a reasonable assessment of the potential yield impact of new cassava technology in Latin America.

E. GERMPLASM DISTRIBUTION

2.28 The cassava program has followed a policy of sending planting material from its germplasm collection and sexual seed from the Breeding Section to national research institutions for their own independent testing and evaluation and as parental material for their own breeding programs. A detailed listing of countries receiving the vegetative stake material and the sexual seed are given in Table II-8 and Appendix II-B. This process has been partially hampered by the disease transmission problem and quarantine restrictions. With the development of the meristem culture techniques, this constraint will be overcome and the germplasm distribution expanded.

F. RESEARCH METHODOLOGIES

2.29 A primary output from CIAT cassava research is not only new technology for use by the farmer but also research methodologies that enable scientists in national institutions to develop and strengthen their own cassava research programs. This methodology and information flow is important in the development of on-going cassava research programs in target countries.

Table II-8 CIAT distribution of cassava sexual seed, 1973-78

Country	Hybrid seed by controlled pollination			Open pollinated seeds		
	1973-76	1977	1978	1973-76	1977	1978
Brazil	4400	900	1300	2000		4200
Colombia						1050
Mexico	200		350			550
Cuba			400			350
Venezuela						650
Bolivia			50			350
Ecuador						
Peru			50			300
Nicaragua						300
Dominican Rep.						300
Trinidad	600	500				
Jamaica						
Bahamas						
Guyana		500				
India	1300	850				
Thailand	3900	6169	2256	4500	21	5463
Malaysia	900	1500				
Philippines	1450	950				
Indonesia	900	700				
Taiwan	1200					
Japan	2000					
Australia	900					
New Zealand	300					
IITA (Nigeria)	1550			41,500		
Kenya	400					
Tanzania	1000					
South Africa		650				
Tonga	350					
Samoa	350					
Seychelles	250	650				
Hawaii						
United States				1000		
Canada				100		
United Kingdom				1000		
Total	21,750	13,369	4406	50,100	21	13,513

Over the past years CIAT has developed several different research methodologies. Below are presented only those that are relevant to national research programs.

Rapid Propagation

2.30 A simple rapid propagation system has been developed that requires no specialized equipment and can be managed by technicians. The system is presently being used in Colombia, Brazil, Mexico and Cuba to produce large quantities of bacterial-free planting material of promising varieties.

Tissue Culture

2.31 Conventional means of germplasm exchange always involve the risk of introducing new diseases and pests. By tissue culture techniques the risks can be minimized, and probably eliminated. The first exchange of material using tissue culture plantlets in test tubes has been made from Colombia to Brazil. Training of technicians from other countries is now in progress.

Regional Trials

2.32 At a meeting in 1975 the norms for "exchange and testing of germplasm" were determined. The methodology has since been further developed and is now used in more than ten countries in Latin America in the International Regional Trials Network.

Breeding Techniques and Selection Methods

2.33 Methods of crossing have been determined, screening techniques developed and the use of harvest index as an indicator of yield at the early selection stages proven. These techniques are being used in Brazil, Mexico, and Cuba in their improvement programs.

Systematic Designs

2.34 In cassava fertilizer and plant population trials using standard techniques are extremely large and complicated. Simple systematic designs have been developed at CIAT to determine optimum plant population and fertilizer levels in different areas. These have been used in Brazil.

General Practices

2.35 Several publications have been produced which describe various research technologies and many of these are being used in different national programs.

Technology Validation

2.36 Methodologies have been developed to validate improved technology at the farm level and these have now been tested in one site in Colombia and plans have been made to use this methodology to validate technology in other countries.

G. ADOPTION MONITORING

2.37 The current stage in the development of cassava technology, where at least some technological components are ready to be extended to farmers, raises the need for some system of monitoring the adoption and diffusion of varieties and cultural practices. The objectives of diffusion monitoring are many. It is a means for CIAT to assess the economic returns from research investment in cassava. Secondly, it is a means for the CIAT Cassava Program to evaluate the design of its technology in relation to constraints on adoption or biological constraints on productivity gains. It also provides a means for national agencies to plan marketing and processing investments for cassava, and, finally, it is a means of assessing the socio-economic impact of new cassava technology.

2.38 The monitoring requires first of all an accurate base line survey. This process will be tied into the Program's identification and characterization of production zones. The other data needed are an accurate assessment of traditional farmer technology, yields, costs of production and prices. Current yield levels are especially critical and aggregate secondary data sources for yields for a subsistence crop such as cassava have too high an error component to accurately evaluate the yield impact of new technology. Thus, if data on yields and traditional technology are not produced by a systematic on-farm trial system, this data must come from a survey of the major target areas. Data on adoption and the increase in productivity would then come from either national extension agencies or follow-up surveys. The structure of adoption monitoring system is under consideration.

H. SUMMARY

2.39 Technology development within the CIAT Cassava Program is currently at the critical testing and evaluation stage before release of the first technology packages to national extension agencies. The overall structure for this evaluation process has been largely defined and is now in the process of implementation, with principal focus being put on expanding this system into all major cassava producing countries in Latin America. The International Regional Yield Trials have shown that germplasm selections and first hybrids can yield well, but that yield is highly dependent on agro-climatic conditions. The selected line M Col 1684 has shown very broad adaptability giving consistently high yields in Colombia and, in four international trials, it gave an average yield of 33 tons/ha while the regional varieties in the same trials yielded only 19 tons/ha. Results from farm level trials are limited and more extensive testing is only getting underway. Initial results show that the yields of local varieties can be markedly increased by use of CIAT improved cultural practices. The yields of the selected varieties have highlighted the important interaction between yield and agro-climatic conditions and have defined other varietal characteristics as being important to farmers. These results emphasize the importance of these trials in the evaluation and testing procedure.

2.40 The evaluation of new cassava technology is in the ex-ante stage. Definition and characterization of the major production zones is critical to an evaluation of the impact of new cassava technology, as this will define which of the results from the regional and on-farm trials are most representative and will as well define sites where such trials ought to be located. This process is under way but at this time much of the data points only to possibilities. Methodologies and data gathering services are now in place to move to a more thorough analysis of the ex-ante impact of new cassava technology.

I. SPECIFIC COLLABORATIVE PROJECTS IN LATIN AMERICA

Brazil

2.41 The Brazilian national cassava program was placed on a firm basis in 1974. Three CIAT staff members participated in the planning phase of this program. Since then, there has been continuous contact and consultation, and during 1978 and 1979, a CIAT staff member was stationed with the Brazilian program. In addition, the regional trial network in Brazil was planned with help from CIAT personnel. A total of 54 Brazilians have received training in cassava research and production.

Mexico

2.42 The Mexican national program is now operational according to the structure made with the participation of a CIAT staff member during the planning process. Ten members of a multi-disciplinary team to work in cassava research have been trained at CIAT.

Cuba

2.43 After a visit by the CIAT Cassava Program coordinator the Cuban program is now recommending the improved agronomic practices for use at the farm level. In addition, a CIAT-selected line (originally bred in Brazil) is now being multiplied for release to farmers. Two professionals have received training at CIAT.

Other Countries

2.44 CIAT is continually supporting national programs by visits and training. Consultation has been given to national programs in Costa Rica, Honduras, Belize, Haiti, the Dominican Republic, Guyana and Ecuador.

APPENDIX II-A

Results of International Regional Trials in cassava in Latin America

Pichilingue (Ecuador)

Cycle I (1976-1977)

Days to harvest: 314 Precipitation mm/cycle: 1483

Variety	Fresh root yield (ton/ha)
M Mex 59	28.3
CMC 84	25.6
CMC 40	24.6
Yema de Huevo (R)	21.6
Negrita (R)	21.1
Quintal (R)	19.5
CMC 76	19.4
M Col 22	18.8
CMC 9	17.3
Mecu 159	17.2
M Mex 52	15.7
M Col 113	15.6
M Ven 156	11.1
M Ven 119	10.8
M Col 673	7.3

Note: (R) Regional Variety

Pichilingue (Ecuador)

Cycle II (1977-1978)

Days to harvest: 265 Precipitation mm/cycle: 995

Variety	Fresh root yield (ton/ha)
MPTR-26	26.7
CMC 40	26.4
M Mex 17	25.0
M Ven 218	24.3
M Col 1684	23.6
M Ven 168	23.4
M Col 561	21.4
M Pan 70	21.0
CMC 84	20.6
Yema de Huevo (R)	18.6
Quintal (R)	15.0
M Col 1686	13.8
M Col 677	13.0
M Mex 59	12.5
M Col 655 $\underline{A}$	11.8

Note (R) Regional Variety

Pichilingue (Ecuador)

Cycle III (1978)

Days to harvest: 334

Precipitation mm/cycle: 1399

Variety	Fresh root yield (ton/ha)
M Col 1684	42.4
ICA - HMC - 7	41.8
CMC 40	36.6
CM 305-41	34.3
MPTR 26	33.3
CM 323-375	33.1
ICA-HMF-1	31.9
M Mex 59	31.7
CM 305-145[A]	31.4
CM 308-197	31.2
CM 305-38	29.6
CMC 84	29.5
CM 309-211	27.9
ICA - HMC - 4	27.5
M Col 22	26.2
M Mex 17	25.2
Yema de Huevo (R)	18.0

Note: (R) Regional Variety

Xulha (Mexico)

Cycle I (1976-1977)

Days to harvest: 397 Precipitation mm/cycle: 1608

Variety	Fresh root yield (ton/ha)
M Col 22	14.0
M Mex 59	13.0
CMC 84	9.3
M Ven 156	9.0
SM 1-150	8.6
M Ven 218	7.2
CMC 40	7.2
CMC 76	6.7
CMC 59	5.7
M Col 677	4.1
M Ecu 159	1.7
M Col 113	1.6
M Ven 119	0.1
CMC 9	0.0
CMC 57	0.0

Note: (R) Regional Variety

Xulha (Mexico)

Cycle II (1977-1978)

Days to harvest: 365 Precipitation mm/cycle:

Variety	Fresh root yield (ton/ha)
ICA- HMC 2	17.3
M Col 1684	15.4
CMC 40	14.9
CM 308-197	13.9
CM 323-87	12.9
ICA- HMC 1	11.7
M Ven 218	11.6
SM 1-150	10.2
CM 337-7	10.0
M Col 22	9.5
ICA- HMC 7	9.1
CM 309-41	9.0
CM 192-1	8.5
ICA- HMC 4	7.5
CM 333-19	7.1
CMC 84	6.4
M Mex 59	5.0
CM 314-58	3.6
M Mex 17	3.0

Note: (R) Regional Variety

Dominican Republic

1978-1979

Days to harvest: 363 Precipitation: 1532 mm

Variety	Fresh root yield (ton/ha)
CMC 40	47.0
ICA- HMC 2	42.4
CM 323-375	40.0
CM 305-41	37.5
CM 308-197	36.9
M Col 1684	36.1
ICA- HMC 1	32.6
CM 305-38	31.5
CMC 84	31.3
ICA- HMC 7	30.5
M Ven 218	27.1
CM 309-211	25.3
Zenon (R)	24.6
M Col 22	23.5
ICA- HMC 4	23.2
Cogollo Morado (R)	22.7
M Mex 59	21.5
CM 305-145A	20.9

Note (R) Regional Variety

Argentina

1977-1978

Days to harvest: 276 Precipitation 916 mm/cycle

Variety	Fresh root yield (ton/ha)
ICA- HMC 7	10.7
CMC 40	5.8
M Ven 77	3.6
Cano-R	3.6
M Mex 17	3.2
CMC 76	2.4
M Col 677	1.7
CMC 84	1.7
M Mex 59	1.6
M Ven 218	1.5
Tapo y Moroti-R	1.4
M Ven 168	1.1
M Pan 70	0.6
M Col 946	0.4

Note: (R) Regional Variety

Costa Rica

Cycle I (1977-1978)

Days to harvest: 345 Precipitation mm/cycle : 3779

Variety	Fresh root yield (ton/ha)
M Col 1684	30.3
M Mex 59	27.9
CMC 84	26.2
CMC 40	22.0
CMC 76	21.8
M Ven 168	21.1
M Col 22	19.7
M Mex 17	17.9
M Pan 70	16.2
Valencia (R)	14.8
M Col 677	13.1
M Col 655 A	10.6

Note: (R) Regional Variety

APPENDIX II-B

Table II-B-1 Planting material sent for international trials during 1977

Country	Cultivars
Kuching Sarawak	M Col 22, M Col 1684, CMC 40, M Mex 17, M Mex 59, M Ven 218.
Ecuador	M Col 561, M Col 655A, M Col 677, M Col 1684, M Pan 70, M Mex 17, M Ven 168, M Ven 218, M PTR 26.
Costa Rica	M Col 22, M Col 655A, M Col 677, M Col 1684, M Ven 168, M Pan 70, M Mex 17, M Mex 59, CMC 40, CMC 76, CMC 84.
Indonesia	M Col 22, M Col 1684, M Mex 59, CMC 40, CMC 84.
Venezuela	M Col 22, M Col 1684, M Mex 59, M Ven 218, M Pan 70, CMC 9, CMC 40, CMC 84, CM 314-66, M Col 677, M Mex 59.
United Kingdom	M Col 22, M Col 1684, CMC 9, CMC 40, CMC 76, CMC 84, M Mex 59.
Seycelles	M Col 22, M Col 638, M Mex 17, M Pan 70, CMC 40, CMC 84.
Kenya	CM 309-56, CM 309-196, CM 308-197, CM 314-58, M Col 638, M Col 647, M Col 1684, M Col 12, M Col 677, M Mex 17, M Mex 59, CMC 40.
Venezuela (two locations)	CM 192-1, CM 308-197, CM 314-66, SMI-150, HMC 4, M Col 22, M Col 677, M Col 1684, M Mex 59, CMC 40, CMC 76, CMC 84, M Ven 218.
Canada	M Col 22, M Col 113, CMC 9.
Argentina	M Col 677, M Col 946, CMC 40, CMC 76, CMC 84, M Ven 77, M Ven 168, M Ven 218, M Mex 17, M Mex 59, M Pan 70, HMC 7.
United States	M Col 12, M Col 22, M Col 677, CMC 40, CMC 76, CMC 84, M Mex 17, M Mex 59, M Ven 77, M Ven 218, CM 192-1, HMC 4, M Col 22, CMC 40, M Mex 59, M Ven 218.

Table II-B-1 (cont.)

Country	Cultivars
Mexico	CM 192-1, CM 306-197, CM 309-41, CM 314-58, CM 333-19, CM 323-87, CM 337-7, SMI-150, HMC 1, HMC 2, HMC 4, HMC 7, M Col 1684, CMC 40, CMC 84, M Mex 17, M Mex 59, M Ven 218.
Cuba	CM 305-122, CM 308-197, CM 309-41, CM 323-375, CM 326-407, CM 344-27, HMC 7, M Col 22, M Col 638, M Col 1292, M Col 1684, CMC 40, CMC 76, CMC 84, CMC 99, M Mex 59, M Ven 77, M Ven 218, M Pan 70.
French Polynesia	CM 308-197, M Col 22, CMC 40, M Mex 59, M Ven 156, M Ven 218.
Guatemala	CM 308-197, M Col 22, CMC 40, M Mex 59, M Ven 156, M Ven 218.
South Africa	M Col 22, M Col 638, M Col 647, CMC 40, CMC 76, CMC 84, CMC 99, M Mex 20, M Mex 59, M Ven 77, M Ven 125.

Table II-B-2 Cassava planting material sent during 1978 for international and regional trials and research purposes

Country	Varieties and Hybrids
Ecuador	HMC 1; HMC 2; HMC 4; HMC 7; CMC 40; CMC 84, M Col 22; M Col 1684; M PTR 26; M Mex 17; M Mex 59; CM 308-197; CM 305-38; CM 305-41; CM 305-145^{A}; CM 323-375; CM 309-211.
Dominican Republic	HMC 1; HMC 2; HMC 4; HMC 7; CM 305-38; CM 308-197; CM 309-211; CM 305-41; CM 305-145^{A}; CM 323-375; CMC 40; CMC 84; M Col 22; M Col 1684; M Mex 59; M Ven 218.
Honduras	CMC 40; CMC 84; M Col 22; M Mex 59; M Ven 218; M PTR 26; CM 323-375; CM 309-163.
Costa Rica	CMC 40; CMC 84; M Col 22; M Col 1684; M Mex 59; M Ven 218; M PTR 26; CM 323-375; CM 305-38; CM 309-163.
Bolivia	CMC 40; CMC 84; M Col 22; M Col 1684; M Col 638; M Ven 218; M Ven 156; M Pan 70; M Mex 17; HMC 1; CM 323-375; CM 305-38.
Argentina	CMC 40; M Col 1684; M Mex 59; M Ven 77; CM 308-197; CM 309-163.
Colombia	Ten Regional Trials with 15-20 varieties and hybrids per location
Cuba	M Col 22; M Col-1292; M Col 1684; M Col 638; CMC-76-40-84-99; M Mex 59; M Ven 77; M Ven 218; M Pan 70; CM 323-375; CM 308-197; CM 309-41; HMC 7; CM 305-122; CM 344-27; CM 326-407; CM 996-1377-1423-1123; SM-175-196-216; CM 1277-1422-1425; SM-168-184-204-223.

Continued

Country	Varieties and Hybrids
Colombia	Planting material of few stakes has been sent to 21 localities under special request.
Brazil	CMC 40; M Ven 218; CM 323-375; CM 305-38; M Col 638; M Col 1684; CM 309-41.
Canada	M Ven 218, CMC 9.
United Kingdom	M Col 22; CMC 76; M Col 22.
Philippines	CMC 40; CMC 84; M Col 22; M Col 1684; M PTR 26; M Ven 218; HMC 4; CM 305-38; CM 305-41; CM 323-375; CM 309-41; CM 321-15; CM 308-197; CM 323-52.
United States	M Col 638; CM 309-41; CM 309-196; M Col 22; CMC 40; M Mex 59; M Pan 70.
Haiti	CMC 40; CMC 84; M Pan 70; M Mex 59; CM 323-375; CM 305-41; M Col 22; CM 309-41; M Col 1684; M Ven 218; CM 305-120; CM 309-211; CM 321-188; CM 326-407; CM 340-30; CM 344-27; CM 344-71.
Kenya	CMC 305-41; CM 344-27; CM 309-41; CM 340-30; CM 311-69; CM 321-188; CM 323-375; CM 326-407.
Guyana	M Col 12.

III. TROPICAL PASTURES

A. INTRODUCTION

3.1 The International Food Policy Research Institute has projected the relationship between beef production and consumption in Latin America for the coming decade. The situation looks favorable for the temperate region and for Central America and the Caribbean. On the other hand, the outlook for tropical Latin America is quite discouraging, with net deficits of 680 to 1300 thousand metric tons for 1990. (Table III-1). In spite of the lower per capita beef consumption in tropical Latin America vis a vis the temperate region, beef is a very important source of protein in the diet of consumers from all income levels. During 1970-74, per capita beef consumption in tropical Latin America averaged 13 kg, higher than the observed averages for most Lesser Developed Countries (Tables III-2 and III-3). Also, a study in a series of cities in Latin America, many of which are located in the tropical region, showed that consumers in the lower income strata spend between 6 to 17 percent of their total budget in beef purchases (Table III-4). It is also evident that the poor have a high preference for beef, as reflected by their income elasticities of demand for beef, which range between 0.8 and 1.3 (Table III-5). Thus, beef is a staple food in Latin America, and its demand may be expected to continue to increase significantly over the next years, as a result of economic growth.

3.2 On the other hand, it has been estimated that beef production in tropical South America must increase by 5 percent annually if it is to meet projected demand. Historically, from 1961 to 1976, it increased at an annual rate of approximately 3 percent (Valdes and Nores, 1978). If the gap between the rates of growth of demand and supply persists in the future, prices will be driven up, implying substantial reductions in the consumption levels of the low-income groups.

3.3 On the production side, it may be observed that two-thirds of beef produced in Latin America originates in the tropics, where around 70 percent of the bovine population is located. Yet, annual productivity per head of stock is half the rate observed in the temperate zone (Rivas and Nores, 1978). This is contrasted by the presence of vast areas of savannas and jungles (850 million hectares) which cover half the surface of tropical Latin America and which have a large potential for beef production. According to Valdés and Nores "while it is probably easier to increase beef production in the fertile areas, net gains to society will be higher if it is achieved by using resources of low opportunity cost."

3.4 The main obstacle for a better utilization of these savannas and jungle areas is the low fertility of the soils (Oxisols and Ultisols) and water scarcity during certain months of the year. New technology is needed in

Table III-1 Net deficit or surplus beef production in Latin America, 1973 and 1990[1]

Country group/country	1973	1990 High income growth	 Low income growth	 No income growth
	----	thousand	metric tons	------
Mexico	93	-395	-310	- 83
Central America & Caribbean	83	62	149	297
Costa Rica	19	59	64	77
Cuba	1	- 30	- 2	11
Dominican Republic	8	- 13	- 5	14
El Salvador	3	- 12	- 9	- 1
Guatemala	10	20	32	63
Guyana	0	- 2	- 1	0
Haiti	2	0	5	7
Honduras	20	36	39	45
Jamaica	- 4	- 19	- 16	- 8
Nicaragua	26	42	49	66
Panama	0	- 10	0	27
Trinidad & Tobago	- 2	- 9	- 7	- 4
Tropical South America	220	-1,286	-683	850
Bolivia	14	31	43	75
Brazil	165	-911	-462	661
Colombia	47	-110	- 56	102
Ecuador	0	- 82	- 56	2
Paraguay	9	- 62	- 60	- 52
Peru	- 7	- 83	- 66	- 21
Surinam	0	- 2	- 1	0
Venezuela	- 8	- 67	- 25	83
Temperate South America	304	214	256	371
Argentina	269	108	136	219
Chile	- 53	- 50	- 40	- 10
Uruguay	88	156	160	162
Total Latin America	700	-1,405	-588	1,435

[1] Domestic slaughter and net exports of live animals are covered. Negative numbers indicate deficits

Source: Valdés and Nores, 1978

Table III-2 Per capita beef consumption by region, 1970 and 1975

Region	1970	1975
	------ kg/year	--------
World	10.7	11.2
Developed countries		
North America	52.5	56.1
Western Europe	21.2	23.3
Oceania	62.6	63.9
Others[1]	6.7	7.7
Centrally planned economies	20.3	22.7
USSR	15.6	17.5
Asian centrally planned	2.5	2.8
Developing countries:		
Asia		
South	0.7	0.8
East and Southeast	2.4	2.6
Africa		
Northwest, Central, and West	3.6	3.9
East	9.0	9.6
Latin America	21.2	21.2
Near East		
in Africa	7.2	7.6
in Asia	4.3	4.8

[1] Israel, Japan, and South Africa

Source: Rivas and Nores, 1978; estimated from FAO

Table III-3 Per capita beef consumption in Latin America[1]

Country and region	1960/64	1970/74
	----------kg/year----------	
Tropical Latin America	14	13
Brazil	18	18
Mexico	9	7
Colombia	21	17
Venezuela	17	20
Paraguay	38	21
Peru	8	7
Ecuador	8	9
Bolivia	13	11
Central America	10	8
Nicaragua	16	14
Guatemala	8	7
Costa Rica	17	10
Honduras	7	7
El Salvador	8	5
Caribbean	6	6
Dominican Republic	7	6
Guyana	5	5
Other Caribbean	6	6
Temperate Latin America	60	51
Argentina	79	68
Uruguay	75	61
Chile	19	18
Latin America	21	18

[1] Apparent consumption = Output + (Imports-Exports). Trade includes beef and veal and canned meat in equivalent carcass weight.

Source: Rivas and Nores, 1978.

Table III-4 Percentage of total budget devoted to beef consumption in Latin America

Country	(year)	City	Income strata[1/] I (low)	II	III	IV
			-----------	percentage	---------	
Brazil	(1972)	Sao Paulo	9.0	8.8	6.5	4.[illegible]
Colombia	(1968)	Bogotá	10.0	9.2	7.5	4.0
		Barranquilla	14.8	15.2	11.0	7.[illegible]
		Cali	15.6	13.7	10.5	5.8
		Medellín	13.3	11.7	10.2	4.4
Chile	(1969)	Santiago	6.6	6.1	5.3	4.2
Ecuador	(1968)	Quito	7.3	7.2	6.1	3.7
		Guayaquil	16.6	11.2	9.5	5.1
Paraguay	(1971)	Asunción	11.4	9.3	7.5	4.5
Peru	(1969)	Lima	9.9	7.7	5.9	3.5
Venezuela	(1968)	Caracas	6.2	5.4	4.3	3.0
		Maracaibo	8.2	8.0	8.0	5.6

[1/] Sample quartiles, ordered according to total expenditure per head.

Source: Rubinstein and Nores, 1979.

Table III-5 Latin America: income-elasticities of demand for beef by income strata

		Income strata[1]				
Country	City	I (low)	II	III	IV (high)	Average
Brazil	Sao Paulo	0.86	1.18	0.47	0.43	0.66
Colombia	Bogotá	1.09	0.83	0.52	0.20	0.52
	Barranquilla	1.01	0.62	0.58	0.52	0.62
	Cali	1.28	0.77	0.42	0.41	0.59
	Medellín	0.19	0.88	0.64	0.38	0.60
Chile	Santiago	0.90	1.16	0.55	0.68	0.74
Ecuador	Quito	1.28	0.54[2]	0.68	0.49	0.62
	Guayaquil	1.10	0.68	0.32[3]	0.55	0.56
Paraguay	Asunción	0.80	0.99	0.21[3]	0.11[3]	0.41
Peru	Lima	0.92	0.88	0.79	0.04[3]	0.56
Venezuela	Caracas	0.80	0.54	0.72	0.48	0.59
	Maracaibo	1.20	0.88[2]	0.97	0.47	0.78

1/ Sample quartiles ordered according to total expenditure per head

2/ Not significant at 95% confidence level

3/ Significant only at 95% confidence level

Source: Rubinstein and Nores, 1979

order to use these resources more effectively. CIAT's Tropical Forages Program aims to facilitate the development and utilization of the vast, infertile, acid soil savannas of Latin America, today idle or significantly under-utilized, and hence, with very low opportunity cost. The full incorporation of these areas might well liberate the more fertile areas, now used for grazing, for use in crop production. These infertile soils cannot be used for food production without applying large amounts of lime and fertilizers. As pastures improve the quality of the soils, and simultaneous infrasturcture development takes place, these areas may be expected to eventually become important for crop production as well. In order to make adoption of new technology profitable, the emphasis in research is given to the selection of pasture varieties (particularly legumes) with genetic resistance to diseases and pests, which incorporate tolerance to soil acidity in infertile soils, which have the ability to fix atmospheric nitrogen (thus saving scarce and expensive fossil energy), and with capacity to maintain high nutritive value during the dry season.

B. TARGET AREA

3.5 The target area for the Program consists of the 850 million hectares of acid, infertile soils in tropical Latin America, classified as Oxisols and Ultisols. The area is mainly covered by tropical savannas and the Amazon selvas, with acid soils and low natural fertility. The pH in these soils ranges between 4 and 5, they have low phosphorus content and frequently present toxic levels of aluminum for the plants.

3.6 The less-favored half of the Latin American tropics is constituted by 300 million hectares of savannas, which represent the most immediate livestock potential area currently available for tropical countries. Thus, the Eastern Plains of Colombia and Western Plans of Venezuela, the Cerrado in Brazil and its extension into Paraguay and Bolivia, and the savannas of Rupununi in the Southern Guayana and Northern Brazil are the most extensive ones.

3.7 These savannas are characterized by soils with excellent physical properties and topography which is quite flat and very apt for agricultural mechanization; there is ample availability of solar energy and abundant rainfall during 6 to 9 months of the year. The limiting factor is the high acidity and the low fertility of the soils, and this is why these areas have been called "deserts of fertility." Although these zones constitute a great potential for Latin America, their development is not easy, principally due to economic limitations: high input and transport costs along large distances and inadequate communication routes.

3.8 The Amazon selvas comprise must of the remaining target area. In these, new roads of penetration are being opened as a result of the discovery of mineral resources and petroleum, and as part of colonization policies, in several countries. Farms are being established along these highways and their branches. This migration process from populated areas is a social phenomenon which is impeded by the lack of adequate technology.

3.9 Up to now, almost 5 million hectares in the Amazon have been cleared, most of them sown to pastures, which are in a process of degradation due to the lack of appropriate management. This is why it is necessary to develop a technology that will make it possible to provide good management to these newly established pastures.

C. ORGANIZATION AND STRUCTURE

3.10 CIAT's Tropical Forages Program has had two well-defined stages in its orientation. These are differentiated, not by the objective pursued of providing producers in the acid and infertile soils with technology that will make it possible to increase cattle production, but by the type of technology sought. Between 1969 and 1975, the Program was oriented towards solving problems in the management and health conditions of cattle. During this stage, the obtainment of a group of tropical grasses and forage legumes adapted to the ecological conditions of the target area was only a component of the overall strategy. Nevertheless, it was recognized that the main limiting factor to more efficient production was the lack of forages capable of providing cattle with a satisfactory nutritional level throughout the year, necessary for good production and reproduction.

3.11 The forage component of the Program was, up to 1976, made up of three sections only, which had to carry out the tasks of collection, identification, and selection of new germplasm, mainly legumes; the multiplication of a few seeds from the first steps up to sufficient quantity for several hectares of grazing trials; and conduct of trials under grazing in order to measure their production potential with animals. During this period, 1600 ecotypes were collected, in the Stylosanthes, Centrosema, Desmodium and Macroptilium genera, all of which are well spread in tropical America, and from other genera with less recognized forage value, such as Zornia. In the selection process, it was found out that none of the ecotypes of Stylosanthes guianensis studied, had enough resistance to anthracnose, caused by the Colletotrihum sp. fungus, or to the action of a stem-borer insect. During this stage, four outstanding legumes emerged: Stylosanthes capitata (CIAT introductions 1019 and 1315), Zornia latifolia CIAT 728, and Desmodium ovalifolium CIAT 350. The first three are native in America while Ovalifolium is native to the Far East.

3.12 Simultaneously, studies on soil fertility and determination of fertility levels required for producing the new germplasm in poor soils were initiated, taking into account the application of minimum levels of fertilizers, consequent with the minimum input philosophy of the Program.

3.13 Also during this stage, the capacity for beef production of native savannas and of the main adapted forage grasses was determined, along with information on the productivity of cow-calf herds when grazing native savannas with and without mineral supplementation.

3.14 With the first information on animal productivity in savannas and cultivated pastures in the Colombian Plains, it was possible to establish with the aid of mathematical simulation models, that presently, farms in the area have low return. These returns improve with the use of mineral supplements to the cattle, but returns are very sensitive to farm improvements, including the establishment of cultivated pastures. In this context, it was possible to define the need to establish small areas with improved pastures, to be used intensively and strategically within the overall herd management, and that these legume/grass pastures should [illegible] low inputs and persist for at least six years, so that together with increasing herd productivity, they may provide an attractive economic return to the producer, increasing the farm's profitability. (Nores and Estrada, 1979).

3.15 The second stage in the organization of the Program resulted from recognizing that the basic solution to cattle nutrition was in the supply of legume/grass pastures with the characteristics enumerated above. It was necessary to define a more narrow objective but with deeper, well-defined geographic and ecological scope, such as "to get varieties or types of tropical forage legumes adapted to the Program's target area."

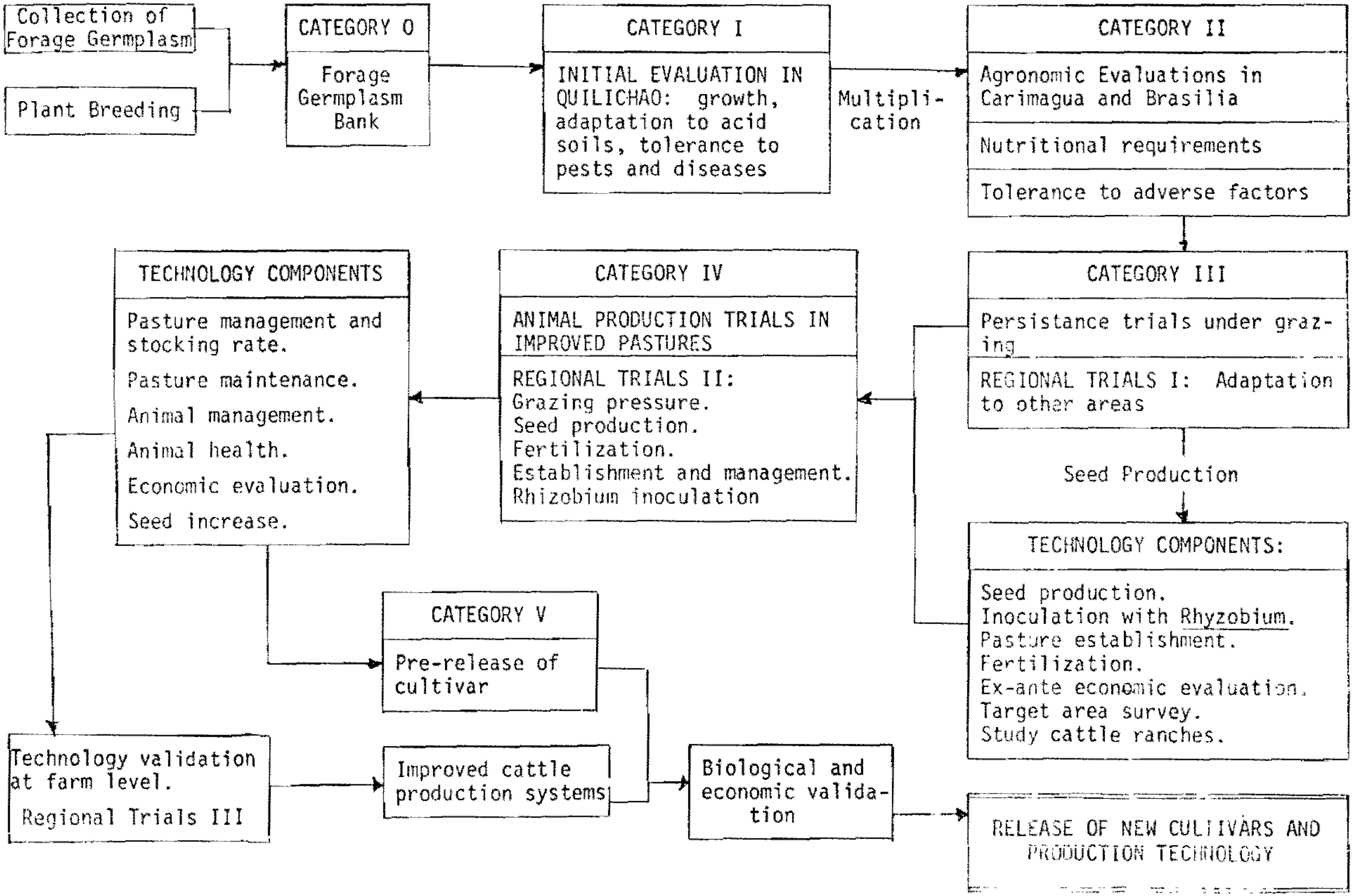
3.16 In the first part of the new stage the research strategy was structured and designed, as presented in the next section. The incorporation of additional sections in the Program which strengthen the areas of germplasm introduction, soils, plant nutrition, agronomy, genetic improvement, regional trials and training, has made it possible to expand and accelerate the Program's activities; the results of this expansion are not yet visible due to the short time span elapsed.

3.17 The selection of the Colombian Plains for the development and validation of the new technology makes it possible to guarantee its application over a wide zone and a large range of ecological conditions. The extremely low conditions of soil fertility and the high loads of diseases and insects prevalent in this area represent an extreme situation of agronomic stress. Also, on-farm validation is done with cow-calf herds, which have a lower rate of capital turnover than fattening operations.

D. RESEARCH STRATEGY

3.18 Figure III-1 is a flow chart of the research strategy comprising the integrated actions of the 23 sections of the Program. The point of departure is the collection of grass and forage legume ecotypes, in acid and infertile soils, in trips organized together with the national institutions.

Figure III-1 Sequence in the research process of CIAT's Beef Production Program



The Plant Breeding Section increases the genetic base with crosses, in order to obtain combinations of characters which are difficult to find in nature. The germplasm arriving at CIAT is incorporated and catalogued in the Germplasm Bank and after going through quarantine procedures, is multiplied in the greenhouses until a sufficient number of seeds is available for planting the first agronomic trials.

3.19 Each ecotype is evaluated by an interdisciplinary team and the Germplams Committee of the Program decides which ecotypes are promoted to the different categories. In Category I the new material is sown in observation plots at CIAT-Quilichao. Those accessions which grow well at pH levels < 4.5, with only 100 kg of P_20_5/ha, that do not present serious problems from insects, diseases and nutritive deficiencies or aluminum and manganese toxicity, and that have good potential for seed production and adequate nutritive value are promoted to Category II. After sufficient seed of material in this category has been produced, larger plots are sown at Carimagua, Quilichao and Brasilia, where legume and grass agronomists, the plant breeder, entomologist, and plant nutritionist make the evaluations on the basis of adaptation to climatic, edaphic and phytosanitary conditions.

3.20 About 20 percent of the material survives this test and is promoted to Category III. After adequate seed production, these materials are sown in Carimagua, Brasilia and Quilichao in grass/legume mixes, and are placed under animal grazing, in order to evaluate resistance to the action of animals. Material in this category is also investigated by other sections, in order to evaluate other technology components such as seed production methods, nutritional requirements for pasture establishment, strain selection and inuculation methods for Rhizobium in the case of legumes, fertilization methods and others. Consequently, studies are conducted on the Target Area, with the purpose of determining under which climatic and edaphic conditions should the genetic material be tested, along with diagnostic studies of cattle ranches. Material chassified as Category III is channelled for evaluation in Regional Trials of Type I, by the collaborating national institutions. Material which does not pass along is moved to a lower category, or if discarded as non-promising, is returned to the Germplasm Bank as Category 0.

3.21 According to the results obtained, the Germplasm Committee promotes a group of accessions to Category IV. In this Category, promising materials are the basis of animal performance in mixtures of grasses and legumes, and more extensive evaluations are performed by almost all other sections of the Program. Later, it is expected that these accessions move to Type II Regional Trials.

3.22 Other technology components are studied in pastures, such as pasture management in relation to stocking rate, fertilization for pasture persistence, systems for strategic use of improved pastures in cow-calf herds, nutrition-animal health interactions and economic evaluations.

3.23 The different components of germplasm and technology are put together to be validated as production systems at the farm level (Regional Trials, Type III).

3.24 Promising germplasm moves on to Category V (Pre-release), requiring large-scale seed production. At the same time, evaluation of the ecotype continues together with national institutions in order to determine its release to farmers for its adoption at commercial scale.

3.25 The complexity of the program and the nature of the impact area, makes it necessary for the development and transfer of technology to be closely integrated. Training of personnel from national institutions is linked to their role as current or potential collaborators in the regional trials and other systems of technology transfer.

3.26 It is necessary for professionals in this area (animal scientists, veterinarians, extensionists, etc.) to have a clear concept of all factors involved in cattle production and their role on Oxisol and Ultisol soils. Theoretical concepts derived in tropical areas with soils of better quality, or in temperate zones, are many times not applicable to the Target Area. The problem is different and therefore the search for solutions is also different.

3.27 For the above reasons, it is necessary to forge a new type of specialist in animal production, who is capable of integrating the soil-plant-animal factors within the context of the less fertile tropical ecosystems. This type of professional will be able to contribute in improving these ecosystems and increase their productivity without damaging the ecology or misusing natural resources which are still present in these zones.

E. CURRENT STAGE OF TECHNOLOGY

Germplasm Bank

3.28 Up to date, 4781 accessions of forage ecotypes have been collected, 94 percent of which are legumes. Collections have been in almost all countries in the Americas, with material also received from several countries outside the continent. All of these ecotypes are kept in the Germplasm Bank, already catalogued and available for utilization whenever is needed, by CIAT or selection programs form the national institutions.

3.29 Contrary to the situation observed for some crops, the enrichment of the Germplasm Bank continues to take place, although less frequently, with collection trips along specific geographic areas where the existence is known of genetic material with characteristics of special interest. This means that for some time to come, the evaluation process will continue of new germplasm and selection of natural ecotypes, from which it is expected to extract new varieties or at least parents with relevant characteristics. Sixty percent of the current germplasm has been already studied.

Germplasm in Categories II, III and IV

3.30 A list of the germplasm currently in Categories II, III and IV is presented in (Table III-6). There are 146 introductions in Category II, which are currently being screened in Quilichao or Carimagua. The most abundant species in this category are S. capitata, Zornia spp. and D. ovalifolium, because they are considered excellent approximations for the Carimagua region. There are 74 grass introductions, mainly of Andropogon gayanus and Panicam maximum, the former due to its excellent adaptation to these soils, and the latter because it performs well in Carimagua with medium fertilization levels, in spite of its preference for more fertile soils.

3.31 There are 24 legumes in Category III, consisting mainly of S. capitata and Zornia spp.

3.32 There are five legumes and three grasses in Category IV, which have reached the level of trials measuring production potential with animals, in Carimagua and Quilichao. Some of these introductions will soon be under grazing in Brazil. All legumes in this category have shown, during the first dry season, the ability to increase liveweight gains of grazing steers by 500 and 700 grams per day per animal, above liveweight losses with the grass alone (-200 g/day/animal). It is worthwhile to point out that animals would lose equal amount of weight when grazing native savanna in the dry season (Tables III-7, -8 and -9).

3.33 Grazing trials must continue for at least one more year, before any of the introductions in Category IV are moved to Category V.

Category V

3.34 All material reaching the "pre-release" stage belong to this category, because it is considered that enough evidence has been collected of their good adaptation and outstanding characteristics over local species.

3.35 In the case of germplasm of forage grasses and legumes for the tropics, one must remember these are natural species or ecotypes rather than varieties, because the whole range of available natural genetic material has not been explored. It is expected that this situation will continue for some years before all the potential has been evaluated.

Table III-6 Promisory germplasm. March 31, 1979

Name	CIAT access number
A. LEGUMES	
Category IV:	
Desmodium ovalifolium	350.
Zornia latifolia	728.
Stylosanthes capitata	1019, 1315.
Pueraria phaseoloides	9900.
Category III:	
Stylosanthes capitata	1318, 1323, 1325, 1342, 1405, 1693, 1728, 1943.
Zornia spp.	9179, 9220, 9245, 9258, 9260, 9270, 9286, 9295, 9648.
Aeschynomene brasiliana	9681, 9684.
Aeschynomene histrix	9666, 9690.
Stylosanthes hamata	147.
Desmodium heterophyllum	349.
D. (-Codarocalyx) gyroides	3001.
Category II:	
Zornia spp.	813, 935, 7041, 7214, 7373, 7376, 7377, 7465, 7475, 9151, 9199, 9215, 9225, 9226, 9265, 9267, 9282, 9284, 9292, 9472, 9473, 9589, 9600, 9616, 9771, 9896.
Stylosanthes capitata (all material from the collection which has not yet been evaluated at Carimagua)	1356, 1357, 1414, 1423, 1440, 1441, 1495, 1497, 1499, 1504, 1516, 1519, 1520, 1535, 1642, 1686, 1691, 1781, 1892, 1899, 1906, 1914, 1924, 1929, 1938, 1986, 1990, 2002, 2008, 2013, 2014, 2016, 2021, 2026, 2035, 2041, 2044, 2049, 2051, 2054, 2055, 2068, 2069, 2081, 2088, 2092, 2104, 2106, 2109, 2112, 2125, 2132, 2138, 2149, 2155, 2159, 2166, 2174, 2194, 2197, 2200, 2201, 1419.
Stylosanthes bracteata (all material from the collection)	1281, 1582, 1643, 1942, 2018, 2025, 2039, 2053, 2056, 2061, 2066, 2067, 2079, 2082, 2087, 2093, 2103, 2113, 2126, 2133.
Desmodium ovalifolium/heterocarpon (all materials from the collection except CIAT 350)	365, 3116, 3442, 3607, 3608, 3652, 3653, 3663, 3666, 3667, 3668, 3669, 3670, 3671, 3672, 3673, 3674, 3675, 3678, 3680, 3687, 3668, 3700.

Table III-6 (continued)

Name	CIAT access number
Centrosema	5063, 5064, 5065, 5066, 5122, 5124, 5126, 5127, 5189.
Stylosanthes humilis	1222, 1303.
Vigna adenantha	4016.
Macroptilium atropurpureum	4085.
Desmodium barbatum	3063.
Category "Regional Trials":	
(All material listed in Categories IV, and III, plus:)	
Stylosanthes guianansis	136, 184.
Stylosanthes capitata	1078, 1097.
Macroptilium sp.	535.
Centrosema: hybrid 17-33	438.
B. GRASSES	
Category V:	
Andropogon gayanus	621.
Category IV:	
Brachiaria decumbens	606.
Brachiaria humidicola	679.
Category III:	

Category II:	
Andropogon gayanus (all material from the collection except CIAT 621)	635, 6053, 6054, 6055, 6159, 6200, 6201, 6202, 6203, 6204, 6205, 6206, 6207, 6208, 6209, 6210, 6211, 6212, 6213, 6214, 6216, 6217, 6218, 6219, 6220, 6221, 6222, 6223, 6224, 6225, 6226, 6227, 6228, 6229, 6230, 6231, 6232, 6233, 6234, 6235, 6236, 6237.
Brachiaria decumbens	664, 6012, 671, 6009, 6130, 6131, 6132.

continued

Table III-6 (continued)

Name	CIAT access number
B. humidicola	6013.
B. brizantha	665, 667, 6021.
B. ruziziensis	654, 656, 660. 6010.
B. dictyneura	6133.
B. eminii	6134.
Brachiaria sp.	6058.
Panicum colaratum	683.
P. maximum	604, 673, 684, 688, 689, 690. 692, 694, 697, 699, 6000, 6001, 6045.
Eriochloa polystachya	6017.
Echinochloa polystachya	6018.
E. pyramidalis	657.
Setaria sphacelata	6043.
S. anceps	6147, 6148.
Category "Regional Trials":	
(All material listed in categories V, IV, and III, plus):	
Brachiaria brizantha	665.
B. ruziziensis	6010.
Paspalum plicatulum	600.
Hyparrhenia rufa	601.

Table III-7 Liveweight gains of steers on Category IV - Legumes mixed with Andropogon gayanus 621 in Carimagua[1/]

Legume of the mixture	Liveweight change (g/day/animal)
Stylosanthes capitata 1019 - 1315	500
Zornia latifolia 728	317
Desmodium ovalifolium 350	-21
Pueraria phaseoloides	371
Andropogon gayanus 621 (alone)	-314

1/ Results correspond to the dry period at December 1978-March 1979

Table III-8 Liveweight changes of steers grazing pure grass pastures in Carimagua [1/]

Species	Liveweight change (g/day/animal)
Brachiaria decumbens	41
Panicum maximum	25
Andropogon gayanus	-314
Brachiaria humidicola	-158

1/ Results correspond to the dry period at December 1978-March 1979.

Table III-9 Liveweight gains of steers grazing the native savanna with free access to 0.2 ha/animal of legume (*Pueraria phaseoloides*) pasture[1]

Stocking rate (ha/animal)	Liveweight change (g/day/animal)
0.25	172
0.50	11

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[1] The corresponding liveweight changes in the pure native savanna are : 0.25 animal/ha - 60 g and 0.5 animal/ha - 210 g

Table III-10 Species and ecotypes of forage legumes and their recommended *Rhizobium* presently included in CIAT's Regional Trials

Species	Ecotype CIAT No.	Rhizobium CIAT No.	Number of Trials
Stylosanthes guianensis	184	71	4
Stylosanthes guianensis	136	71	25
Stylosanthes capitata	1019	71	25
Stylosanthes capitata	1405	71	25
Stylosanthes capitata	1078	71	17
Stylosanthes capitata	1097	71	17
Stylosanthes homata	147	71	25
Desmodium heterophylum	349	80	6
Desmodium ovalifolium	350	46	25
Macroptilium sp.	535	313	25
Centrosema sp.	438	590	25
Zornia latifolia	728	103	15
Pueraria phaseoloides		79	25
Centrosema pubescens		590	7
Macroptilium atropurpureum		79	5
Macroptyloma axilare		79	1
Zornia sp. (native)		103	1
Stylosanthes guianensis cv. Schofield		71	2

3.36 Currently, A. gayanus CIAT 621 is found in Category V, with intense grazing trials in Quilichao, Carimagua, Brasilia and fields located in selected farms in Colombia, in order to determine enough information to see if it can be released in Colombia by the Instituto Colombiano Agropecuario (ICA). This ecotype was introduced by CIAT from northern Nigeria, in 1973.

Genetic Improvement

3.37 In 1977, with the incorporation of a plant breeder into the team, an incipient level of genetic improvement work was begun. The legumes selected for crossing are S. capitata, Leucaena leococephala, Centrosema pubescens, and the grasses P. maximum and A. gayanus, all materials with greater nutritive value in the dry season. It is expected that some of the material resulting from crossing will enter the germplasm flow as Category I in 1979, with trials at Category IV level possibly in 1982-83.

F. GERMPLASM DISTRIBUTION

Regional Trials

3.38 A net of Type I Regional Trials were initiated in a structured and systematic way in 1978; the network presently extends to nine countries within the Target Area. The material included in each regional trial comprises 20 introductions in Category IV. In Tables III-10 and III-11, the selected species for regional trials are presented, and Table III-12 shows the location of the trials by country and regions.

3.39 The first results from the regional trials will be available in 1979, but two years of information are needed at the least.

Seed Production Trials

3.40 Parallel to the development of a network of regional trials of forages, it is necessary to establish regional trials in order to learn about the seed production capacity of the promisory material (Categories III and IV) in different geographic locations. This is necessary both in order to guarantee availability of enough seed for the distribution of germplasm, and due to the strict barriers for the introduction of seeds. Regional trials have been established in the following countries (with the number in parenthesis): Brazil (4), Colombia (5), Ecuador (1) and Peru (1).

G. RESEARCH METHODOLOGIES

3.41 Five developments in methodology are considered of special interest.

Table III-11 Species and ecotypes of grasses presently included in CIAT's Regional Trials

	Ecotype CIAT No.	Number of trials
Andropogon gayanus	621	25
Brachiaria decumbens	606	25
Panicum maximum	604	25
Hyparrhenia rufa		12
Nelinis minutiflora		1
Paspalum plicatulun		1
Digitaria decumbens		1
Digitaria unfolozi		1
Cenchrus ciliaris		1

Table III-12 Distribution of Regional Trials of the Beef Program

Country	Number of trials	Location
Bolivia	2	San Ignacio de Velasco, Cochabamba
Brazil	15	Cerrado and Amazonia
Colombia	7	Cauca, Valle, Antioquia, Meta, Vichada, Caquetá
Cuba	2	La Habana, Matanzas
Ecuador	2	Sto. Domingo Colorados, Oriente
Nicaragua	1	Nueva Guinea
Panama	1	
Peru	4	Yurimaguas, Pucallpa, Tarapoto
Venezuela	6	Zulia, Monagas, Anzoátegui, Delta

3.42 Development and systematization of a scheme for selection of tropical forages in a multi and inter-disciplinary context, that integrates botanical, agronomic, edaphic, genetic, bacteriological, zootechnical, nutritional, animal management and economic aspects. The different disciplines are integrated in the flow of material from its collection in the natural environment up to its adaptation to the livestock production systems.

3.43 Soil microbiologists in the Program developed a laboratory technique which permits the effective selection of Rhizobium strains adapted to acid soils while previous techniques employed a culture media which destroyed the bacteria by action of its own metabolism. This new technique permits selecting Rhizobium strains that will persist indefinitely in the liquid media of acid soils.

3.44 A low-density seeding or planting method for pasture establishment has been developed, which relies on self-propagation for the new pasture to cover the entire area from a small number of original plants. The increased time span required for full pasture establishment is more than compensated by the substantial decrease in costs which results from reduced use of seeds, and labor (CIAT Annual Report, 1977 and 1978).

3.45 An economic analysis was done to evaluate the advantages of the low-density method over conventional methods. It has been shown that the use of a low-density pasture establishment method reduces unit costs, and can partially compensate the economies of scale which characterize all methods of pasture establishment (due to the indivisibility of the machinery used). Thus, it is feasible for smaller farms to plant reduced areas at lower unit costs (CIAT Annual Report, 1978).

3.46 A simulation model (HATSIM) has been developed for the technical and economic analysis of cattle ranches under extensive grazing, and programmed in FORTRAN for its use with computer. Although there are several such models which include herd development and cash flow components, there are several original elements in HATSIM, which make it particularly useful for the economic analysis of the use of improved pastures, and for the study of the impact of credit and price cycles on farm returns.

3.47 Methodology for land resource evaluation was developed, with the purpose of classyfying the Oxisol and Ultisol areas in tropical Latin America in terms of climate, landscape and soil properties.

H. ON-FARM EVALUATIONS

Ex-ante Evaluation of Technology

3.48 Ex-ante economic evaluation of the new technology components at farm level is performed in order to anticipate factors internal and external to the farms which may condition their adoption. In this way, a feedback valuable for the design of the technology is provided to the researchers in the Program.

3.49 A question to be addressed with anticipation is the following: Will the target legume-based pasture be profitable at the farm level? In order to anticipate an answer, a simulation model (HATSIM), which is a computerized activity-budgeting model developed at CIAT, is used. The expected profitability of moving from a "typical native system" to the "target system" is obtained by simulating both systems for a long period of time (22 years). The internal rate of return expected from the movement from one system to the other is estimated for representative farm situations.

3.50 The biological parameters used in these simulations are conservative estimates based on experimental results obtained by the Program. Although they correspond to trials with animals which have been carried out for a limited period of time, they are considered by the team to be feasible as a target at the farm level. Moreover, they are based on experiments carried out at Carimagua, which, as was pointed out earlier, represents the low extreme of soil conditions with a very low-pH and high aluminum saturation. Also, economic evaluation is performed using prices and costs at the farm level, which have been adjusted by transport costs according to distance to markets. In addition, the economic evaluation of adoption of improved pastures is carried out for cow-calf operations and not for fattening operations. This is indeed performing a most conservative appraisal, because it is well-known that these type of farms are considerably less profitable, with a slow capital turnover. Finally, the country which is being used for the evaluations (Colombia) presents input-output price ratios which are less favorable than in other countries included in the target area of the Program.

3.51 In general, the results obtained from the ex-ante evaluation of new technology in the Colombian Plains, show that the strategic use of legume-based pastures on cow-calf farms, can be a profitable alternative, when these are used as a protein bank in conjuntion with large areas of native savannas. Results of the sensitivity analyses indicate that the value of the inputs applied to pastures, as well as the frequency of application, affect the profitability levels significantly (see CIAT Annual Report, 1978).

Diagnosis of Current Production Systems

3.52 A joint project of the Animal Management, Economics and Animal Health Sections of the Tropical Pastures Program is the Evaluation of Beef Production Systems (ETES) being conducted in three different locations: (1) the Colombian Plains, (2) Brazil, with the collaboration of EMBRAPA's Cerrado Center (CPAC), and (3) Venezuela, with the collaboration of FONAIAP's Centro de Investigaciones Agropecuarias del Nor-Oriente (CIARNO).

3.53 Phase I of the project consists of a diagnosis of the prevailing beef production systems, which are analyzed and evaluated in technological and economic terms. Within each region, farms representing different technology levels have been selected and monitored in relation to natural resources, physical inputs, production, applied management, animal health and economic conditions. Interdisciplinary teams visit these farms periodically to collect data. Data are then processed and stored in a computerized form, and used for the estimation of the main production parameters. This phase has just been completed in Colombia, is half finished in Brazil, but is only now beginning in Venezuela.

On-Farm Validation of Technology Components

3.54 Phase II of the ETES project consists of technology validation at the farm level. Some farms, representing specific production systems, of particular interest to the Program, are selected for this purpose. The effects of introduced technology on the productivity and profitability of the systems will be studied.

3.55 In Colombia, phase II has just begun on one selected cow-calf farm, with the introduction of the most promising grasses and legumes (Category IV material), to cover approximately 5 percent of farm area. The use of improved pasture will take place following CIAT's recommendation of "strategic use," and following a set of management practices which in Carimagua (at the experiment station) have been shown to produce 350 percent more than with the traditional production system used as control.

I. PRODUCTION POTENTIAL OF IMPROVED TECHNOLOGY

3.56 A comparison between potential productivity in the target area attainable with improved technology and current average productivity levels is presented in Table III-13.

3.57 On the basis of data on total beef cattle stocks, beef production and area in pastures for tropical Latin America, it is possible to estimate average stocking rate, output per hectare and output per head in stock. Assuming, in the optimistic case, an adoption of new technology in 40 percent of total area, but with only 10 percent of farm area (i.e., 4 percent net) in improved

Table III-13 Potential impact of improved technology in beef production in the target area

	Estimated productivity levels 1/				
				Ratio	
	1975	Available improved technology	Potential maximum	Improved /1975	Potential maximum/ 1975
<u>Optimistic adoption:</u>					
-Output per head in stock (kg/year)	25.0	30.60	50.10	1.22	2.00
-Stocking rate (A/ha)	1.0	0.202	0.45	2.02	4.51
-Output per ha (kg/year)	2.5	6.18	22.59	2.47	9.04
<u>Pessimistic adoption:</u>					
-Output per head in stock (kg/year)	25.0	28.10	43.00	1.12	1.72
-Stocking rate (A/ha)	0.1	0.156	0.27	1.56	2.70
-Output per ha (kg/year)	2.5	4.38	11.61	1.75	4.64

1/ Averages for target area of 300 million hectares of savannas pastures, the stocking rate (for the total 300 million hectares) may increase to 0.2 animal units/ha, and production per head may rise to 31 kg/animal unit year. Consequently, production per hectare would increase from 2.5 to 6.2 kg/year. This is explained by the higher carrying capacity and production capacity of the improved pastures which are already available.

3.58 In the pessimistic case, technology adoption is assumed to take place in only 30 percent of the total area with 5 percent of the latter in improved pastures.

3.59 Potential maximum productivity figures with optimistic adoption have been estimated assuming an adoption of 70 percent, with 20 percent of farm area in improved pastures. Production parameters correspond to conservative estimates with a legume-based pasture in an economically feasible production system. In the pessimistic case, there is 60 percent of adoption of new technology, with 10 percent of the farm area in improved pastures.

3.60 The last two colums in Table III-13 present the ratios between the parameters representing improved technology and current levels. In the worst of the situations under consideration, output per hectare may be expected to increase by 75 percent and in the best of cases by 800 percent.

J. SPECIFIC COLLABORATIVE PROJECTS IN LATIN AMERICA

Bolivia

3.61 Two Regional Trials for Forage Adaptation have been conducted, in San Ignacio de Velasco and in Cochabamba, and two Regional Trials for Seed Production, in Santa Cruz and Cochabamba. The Program has trained five professionals from Bolivia.

Brazil

3.62 Fifteen Regional Trials for Forage Adaptation have been established, covering the majority of the ecosystem areas of the Cerrado and the Brazilian Amazon. Four seed production trials have also been established. Studies have been initiated on 15 ranches in the states of Mato Grosso and Goias, to make quantitative assessments for later validation of technology (ETES Project). The three CIAT scientists from the Tropical Forages Program stationed at the Cerrado Center, in Brasilia, and one visiting scientist associated with the ETES Project are well integrated into the technical group at that Center and are working throughout the country. Some 25 Brazilian professionals have been trained during the past two years.

Colombia

3.63 Regional Trials for Forage Adaptation are being done in various locations in six regions of the country. In addition, 20 cattle ranches in the Colombian Eastern Plains are being studied under the ETES Project (see Brazil). Seed of the forage grass Andropogon gayanus CIAT 621 is being produced for possible release by ICA in 1980. During the past two years 20 Colombian professionals have been trained in tropical pastures.

Cuba

3.64 Two Regional Trials for Forage Adaptation are located in Cuba, one at Catalina de Guines, Havana, and the other at the Indio Hatuey Experiment Station, Perido, Matanzas. In addition, this country is introducing a large quantity of genetic material and training personnel in the introduction and evaluation of legumes, development of pastures, seed production, soils, and phosphorus utilization.

Ecuador

3.65 Two Regional Trials have been done in Ecuador, one in the eastern zone and the other in the areas of Santo Domingo de los Colorados. Ten professionals from this country have been trained by CIAT.

Guatemala

3.66 Twenty Guatemalans were trained in a beef production course.

Panama

3.67 Two technicians from the Instituto de Investigación Agropecuaria de Panamá (IDIAP) have been trained and Regional Trials are being planned for several zones of the country.

Paraguay

3.68 Animal health studies are being done in cooperation with the Ministerio de Agricultura and the Universidad Nacional.

Peru

3.69 Regional Trials for Forage Adaptation are underway at Yurimaguas, Pucallpa and Tarapoto. Additional personnel are being trained at Tingo María and seed production for Andropogon gayanus trials are being initiated on the coast, at Piura. Ten professionals from Peru have been trained by the Program.

Nicaragua

3.70 Three technicians from the Instituto Nacional de Tecnología Agropecuaria have been trained and a Regional Trial has been established under jungle conditions in the Nueva Guinea area.

Venezuela

3.71 Twelve cattle ranchers are being studied with the same objectives as those in Brazil and Colombia. Six Regional Trials of Forage Adaptation are established in the states of Zulia, Monagas, Anzoátegui and Delta, and trials for the utilization of rock phosphates, in the state of Monagas. Eight Venezuelan professionals have been trained.

Other Countries

3.72 Contacts have been established in the countries of Surinam, Trinidad, Antigua, the Dominican Republic, Mexico, Honduras, Costa Rica and Guayana. The necessary training is being given for initiating a network of Regional Trials for Forage Adaptation in these countries.

References

FAO, Agricultural Commodity Projections, 1970-80 (Rome: FAO, 1971).

Nores, Gustavo and Rubén Estrada. "Economic evaluation of beef production systems in the Llanos Orientales of Colombia." In Pasture Production in Acid Soils of the Tropics. Eds. P.A. Sánchez and L.E. Tergas. Series 03EG-5, March 1979, Centro Internacional de Agricultura Tropical, Cali, Colombia.

Rivas, L. and G. Nores. "Evolución de la ganadería bovina en América Latina, 1960-74," Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, February 1978 (mimeographed).

Rubinstein, E.M. de and G. Nores. "Gasto en carne vacuna por estrato de ingreso en 12 ciudades de América Latina." CIAT, Cali, 1979 (mimeographed).

Valdés, Alberto and Gustavo Nores. "Growth potential of the beef sector in Latin America - Survey of issues and policies." Paper presented at the IV World Conference on Animal Production, Buenos Aires, August 1978. IFPRI.

CIAT. Annual Report 1977, 1978. Cali, Colombia.

IV. SWINE

4.1 The CIAT Swine Unit has always been one of the smaller units of the Center, with two or three senior staff. Before 1975, the major emphasis was on the development of technological components; after that time emphasis has been shifted towards technology transfer with research efforts being of secondary priority.

4.2 This report summarizes the most important activities accomplished by the Swine Unit during the decade 1969-79 in the following order: (A) Training; (B) International Cooperation; and, (C) Research.

A. TRAINING

Training in Research and Postgraduate Courses in Swine Production

4.3 The objective of swine production training at CIAT has been to form nuclei of professionals who can actively participate in swine production development in their respective countries. The Swine Unit has trained 93 professionals between 1969 and 1978. Table IV-1 shows the total numbers trained during various periods, according to countries. Before 1976, training was oriented towards research aspects; between 1976 and 1978 a total of 67 professionals from Latin America received postgraduate training in swine production. Up to now, three postgraduate courses have been provided: one of six months (1976); one of six weeks (1977) and one of four months (1978).

Workshop/Meeting of Ex-trainees of the Swine Unit

4.4 In October 1977, 35 former trainees of the Swine Unit, who were working in national institutions of 12 Latin American countries, participated in a Workshop on Swine Production in Latin America. The objectives of the workshop were: to review the situations in national programs, emphasizing collaborative projects with CIAT; to explore the factors limiting the development of swine production; and to propose future strategies for their solutions.

4.5 Conclusions and recommendations from the meeting were the following:

- To conduct technical, economic and marketing feasibility studies for integrating swine production into the economic development of the region.

- To offer technical assistance to swine development programs aimed at small- and medium-scale farmers.

Table IV-1 Professionals trained in the CIAT Swine Unit from 1969 to 1978, by period and country

Country	Period				Total
	1969-75	1976	1977	1978	
Argentina	-	-	1	1	2
Bolivia	4	2	2	3	11
Brazil	-	1	2	1	4
Colombia	5	3	9	4	21
Costa Rica	3	1	1	-	5
Ecuador	5	-	1	2	8
El Salvador	-	-	2	-	2
Guatemala	-	1	-	1	2
Honduras	-	1	2	-	3
Mexico	1	4	-	1	6
Nicaragua	1	2	-	-	3
Panama	1	1	1	-	3
Paraguay	1	4	-	2	7
Peru	1	-	4	3	8
Dominican Republic	1	-	-	-	1
Venezuela	-	-	-	2	2
Western Germany	1	-	-	-	1
Thainland	-	-	2	-	2
Nigeria	2	-	-	-	2
Total	26	20	27	20	93

- To create and intensify extension services for the transfer of swine production technology, especially at the small producer level.

- To seek methods of reducing production costs, especially by replacing conventional animal feed products and utilizing agro-industrial byproducts to the maximum.

- To integrate swine production in Latin America, forming a cooperative network with the objective of preventing duplication of efforts and permitting more efficient technology transfer.

Evaluation of the Swine Production Training at CIAT

4.6 At the end of December 1978, 88 Latin American professionals who had received training in the swine production at CIAT were surveyed with the primary objective of evaluating the training each had received. From the 56 surveys returned, the most relevant answers for evaluating the training were the following ones:

- Knowledge and skills acquired during training at CIAT appears to be very applicable to the work of the ex-trainees in their respective countries.

- Ninety-six percent of the trainees have continued working in national institutions dedicated to development, research or education relating to swine production.

- Almost one-half of the trainees dedicate a majority of their time to activities related to swine production -- training, research, administration and extension or promotion.

- In the regions where ex-trainees work, more than 50 percent of the farmers with small and medium farms have pigs, a fact that increases the possibilities of obtaining an appreciable impact on swine development at the regional level.

B. INTERNATIONAL COOPERATION

Collaborative Projects

4.7 The CIAT Swine Unit has maintained collaborative projects in swine development with the following national institutions: the Universidad Boliviana Gabriel René Moreno (UBGRM), Santa Cruz, Bolivia; the Universidad de Costa Rica, in San José; the Instituto Nacional de Investigaciones Agropecuarias (INIAP), in Ecuador; and the Instituto Veterinario de Investigaciones del Trópico y Altura (IVITA), in Pucallpa, Peru. Each of these institutions has swine programs in regions with potential for the development of this enterprise. In Colombia, collaboration exists with the Instituto Colombiano Agropecuario (ICA) especially in research aspects of swine feeding programs. In addition, other countries like El Salvador, Guatemala, Honduras, Nicaragua, Panama and Paraguay have received technical assistance from time to time.

Technical Consulting and Summary Activities of Collaborative Projects

4.8 Technical collaboration on the part of the CIAT to cooperative programs has been through the training of professionals, especially in the courses during 1976 to 1978. These were complemented with periodic visits by CIAT specialists to the national programs. A summary of results obtained by the countries up to the present follows.

4.9 BOLIVIA. During 1975-1978, 10 visits have been made to Santa Cruz and four to Chuquisaca. Collaborating institutions are the Universidad Gabriel René Moreno (El Prado Project), in Santa Cruz, and the Comité de Desarrollo de Chuquisaca/IDB (Monteagudo Project), in Monteagudo.

4.10 The principal results from the cooperative project between CIAT and the Universidad Gabriel René Moreno may be summarized as follows:

- Facilities, equipment and animals were acquired to permit functioning of the Swine Unit, with a capacity of 800-1000 pigs.

- Ten short courses have been conducted in the project area for more than 200 small farmers and producers.

- More than 500 pigs of improved breeds have been distributed for development or promotion programs with regional producers.

- Five research projects have been done to investigate the use of agricultural products and byproducts in swine feeding.

4.11 Principal results obtained in the cooperative project with the Comité de Desarrollo de Chuquisaca may be summarized as follows:

- Consulting was provided in designing development and credit projects for establishing 150 swine-producing farms in the Chuquisaca region.

- A short course for 20 professionals working in various aspects of the project was given in the project area.

- Consulting on swine feeding programs was provided to centers that are multiplying pigs and also to the user level.

4.12 COSTA RICA. During the period 1975-1978, 8 visits made to San Jose and 3 to Guápiles. CIAT collaborates with the Ministerio de Agricultura y Ganadería and the Universidad de Costa Rica, both located in San José.

4.13 Principal activities and results in the cooperative project with the Universidad de Costa Rica are summarized in the following points:

- Consulting was provided in the development and in the plans of work for a Swine Research and Development Center that will be constructed in central Costa Rica.

- A seminar on swine production was conducted in the Universidad de Costa Rica for 100 professionals of various Central American countries.

4.14 The cooperative project with the Ministerio de Agricultura was initiated in 1978; work is specifically with a Swine Production Unit located in the banana growing zone of Guápiles. Principal activities have been the following:

- Collaboration has been provided in the development and in the work plans of the Swine Unit which has the objective of promoting and developing swine production in that region.

- Consulting was furnished in designing the research work that has been initiated, utilizing banana and camote as feed for pigs.

4.15 ECUADOR. During 1975-1978, 6 visits have been made to Ecuador. INIAP has three swine programs in the Experimental Stations at Santa Catalina (near Quito), at Santo Domingo, and at Boliche (Guayaquil).

4.16 Principal activities and results up to the present are as follows:

- Fourteen courses have been provided for swine production training for farmers, ranchers and professionals, especially in the regions under the Santo Domingo and Santa Catalina stations. A total of 700 persons have attended these courses.

- Collaborative work in swine promotion has been done with four agricultural cooperatives (Urauco, San José, El Marco and Tolontag) and two communes (El Marco and Calvario de la Calera) in the Andean region for which the Santa Catalina program is responsible. Similar activities have been initiated in the program at Boliche with the Programa de Desarrollo del Sur del Ecuador (Predesur) and two agricultural cooperatives located between Boliche and Machala. In Santo Domingo, contact has been established with the Chiguelpe commune. These activities are complemented with training for the cooperating farmers and with the management of demonstration herds of swine in the program areas.

- More than 1500 head of foundation stock and boars of improved breeds have been sold and distributed to help upgrade swine production.

- Nine technical bulletins and two extension bulletins have been published on various aspects of swine production.
- Between 1969 and 1978, more than 100 research projects have been done, especially in the area of swine feeding. Among these have been graduate theses projects for 20 veterinarians.

4.17 PERU. In the period 1975 to 1978, 9 visits have been made to Peru, especially to Pucallpa (8) and Tarapoto (2). The region of interest is the jungle area and collaborative work is being done with IVITA at its Estación Principal del Trópico at Pucallpa and, more recently, with the Centro Regional de Investigación Agraria III in Tarapoto.

4.18 The most important results obtained up to now have been:

- Technical consulting has been provided to agricultural colonization cooperatives and to small-scale swine breeders in the Ucayali region, in collaboration with the Ministerio de Agricultura and Alimentación.
- A study of adaptation and performance of improved pigs has been made in the tropical region of Pucallpa. Up to now three years of results have been obtained on the control of reproductive behavior and performance of Yorkshire pigs in the IVITA program.
- Research work has been conducted on management and feeding of swine in tropical climates, with special attention to utilization of cassava, rice polishing and forage legumes (Kudzu) for swine feeding.

Surveys of Swine Production

4.19 A field survey of swine producers in Bolivia, Colombia, Ecuador, Guatemala and Paraguay was done between November 1978 and April 1979. The studies in Bolivia and Paraguay were done in collaboration with the national agencies contacted by CIAT. The study in Guatemala was conducted by a research associate in economics from CIAT. Studies in Colombia and Ecuador were coordinated by the scientific personnel of the Swine Unit. In addition, CIAT economists have statistically analyzed the swine production industry over all of Latin America.

4.20 Data from the surveys were processed at CIAT and the results have been compiled and presented as reports to the Center's Board of Trustees. Afterwards, they will be edited and published.

4.21 The most common characteristics of swine production in the five countries surveyed were found to be:

- The swine enterprise is an integral part of animal agriculture activities which included also cattle ranching, beef fattening and poultry operations.

- The majority of the swine enterprises are found within the small and intermediate strata (1-4 and 5-19 breeding sows per farm, respectively).

- At the small-producer level, native pigs predominate; but, on larger ranches the proportion of crossbred and improved breed sows increases.

- Reproductive efficiency (number of births or litters per sow per year) is the parameter most affected by existing production conditions.

- Small swine enterprises produce the major part of their swine feed, which consists of slop and harvest residues; however, farmers at this level also use maize, cassava, plaintains, potatoes and whey in swine feeding.

- At the small- and medium-producer levels, conventional protein concentrates (soybean meal, cottonseed meal, meat and fish meals) are not used; the majority of the feeds available at the small-farm level do provide appreciable quantities of energy.

- Pigs are normally sold to wholesalers when they are 8-12 months old and weigh 50-70 kilograms.

- Vaccines and wormers are relatively easy to acquire and, in general, the majority of the producers vaccinate their pigs against swine cholera and worm them at least once a year.

4.22 Some differences were observed in certain aspects of swine production between the countries surveyed. The most important differences were the following:

- In Colombia, and to a lesser extent in Ecuador, there are regions where swine enterprises under improved technology are acquiring importance as commercial companies. The central part of Colombia and the western region of Ecuador show this tendency. This situation was not clearly observed in Bolivia, Guatemala and Paraguay. Large swine enterprises (more than 50 breeding sows) were more frequently encountered in Colombia, compared with the other countries studied.

- Small swine enterprises (1-4 sows) are widely distributed in all the countries studied, but the proportion at this level of production was most commonly observed in Guatemala than in the other countries. Although the Paraguayan agricultural system is also based on a high proportion of small farms, the economic focus seems to be oriented towards a commercial type of production, more so than to a subsistence level of exploitation.

- No marked division was found between breeding, growing and fattening enterprises. Colombia is the main country where some degree of specialization was observed in swine production.
- Estimations of the energy/protein relationship in feeding systems suggest differences between the countries studied and between regions within the same country. Also, differences were observed between the production strata analyzed which are associated with the level of technology.

C. RESEARCH

4.23 For the economic importance that feed represents in swine production costs, the majority of the research work at CIAT has been oriented towards evaluating feeding programs in which cereal grains (maize or sorghum) are replaced by non-conventional feeds. On this basis, feed products such as cassava roots, waste banana, rice polishing and sugar cane molasses have been studied. In addition, before 1976, several experiments were done to evaluate high-lysine maizes in swine feeding. Some of this experimental information is now being tested in the Chuquisaca region of Bolivia and in the Andean Zone of Ecuador.

4.24 Details of the experimental projects have been presented in the various Annual Reports of CIAT. What is the degree of adoptation of these experimental results? The answer that we have arrived at in recent years is that it has been limited, for the following four reasons.

4.25 First, lack of basic information exists on the normal conditions of swine enterprises, especially in tropical regions. In general, more than 50 percent of the swine producers surveyed are small producers and the use of balanced feeds or protein supplements is almost nil. Cassava roots, bananas and maize are widely used and are produced on the farm. Other feed sources available are garbage or slop, grasses and whey. The swine production survey is furnishing part of the information for conditions at the regional level.

4.26 Secondly, protein supplements and agro-industrial byproducts are not available to the average swine producers and are in the dominion of commercial plants processing balanced feeds. Apparently, utilization of these inputs is oriented to poultry enterprises and dairies. Thus, limitations exist on the accessibility and profitability of employing certain ingredients that would permit adoption of improved technology.

4.27 Thirdly, economic factors are of vital importance for enterprises with limited financial resources; generally, these enterprises are not considered for this type of help by credit agencies.

4.28 Finally, another of the limiting factors has been the lack of professionals sufficiently prepared to help adapt CIAT technology at the field level; also, before 1975, the majority of the professionals trained at CIAT dedicated all of their time to research and very little to direct contact with farmers. Since 1976 training in production aspects has been emphasized at CIAT, as has the intensification of demonstration trials at the farm level and extension work and swine promotion at the regional scale by the various national programs. In this sense, up to the present the group of swine specialists shown in Table IV-2 has been prepared to do research and transfer technology at the regional level.

Table IV-2 Swine specialists trained at CIAT who are working in countries and institutions where cooperative swine development programs exist

Country	Institution	Number of specialists trained at CIAT
Bolivia	UBGRM	5
	Monteagudo Project	4
	Other institutions	2
Colombia	ICA	2
	Universities	10
	Other institutions	9
Costa Rica	Univ. de Costa Rica	2
	Minist. Agric. y Ganadería	2
	Other institutions	1
Ecuador	INIAP	7
	Minist. Agric. y Gan.	1
Perú	IVITA	3
	Universities	2
	Minst. Agric. y Aliment.	2
	Other institutions	1

4.29 In order to establish a beginning in countries with regions having potentials for swine production and where there are as yet no specific collaborative projects, nuclei of swine specialists have been formed as shown in Table IV-3.

Table IV-3 Swine specialists trained at CIAT who are working in countries and institutions where cooperative swine development programs do not yet exist

Country	Institution	Number of specialists trained at CIAT
Mexico	INIA	1
	Universities	4
	Other institutions	1
Paraguay	Minist. Agric. y Gan.	6
	Universities	1
Other Central American countries	Agricultural ministries	12
	Universities	2

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V. RICE

A. INTRODUCTION OF IMPROVED RICE VARIETIES TO LATIN AMERICA

5.1 In the mid-60s, a new rice type was developed in Asia whose architecture was characterized by (a) a reduced plant height that helped to prevent the plant from lodging; (b) erect leaves that assured higher levels of light absorption at the same time that they allowed more light penetration to lower leaves; and (c) a capacity to make more efficient use of nitrogen fertilizers. At the time that CIAT was inaugurated (1968), the improved rice variety IR 8 from the International Rice Research Institute (IRRI) in the Philippines had just become available. This moment marked the beginning in Latin America of the search for dwarf rice plants that would also be resistant to insect pests, diseases, soil deficiencies and stressful climatic situations. (The above mentioned IR 8 variety which incorporated most of these characteristics did not find wide acceptance in Latin America due to its short grain, its low quality, and taste preferences of the Latin American consumer.)

5.2 In 1970, CIAT, in collaboration with the Colombian Agricultural Institute (ICA) released two new varieties: CICA 4, which had been produced in Palmira, and IR 22 which came from IRRI but had been selected in Colombia for Latin American conditions. There was an immediate, wide acceptance of these two improved varieties throughout Latin America--especially in Colombia.

5.3 In 1974, the variety CICA 6 was released; it incorporated the successful characteristics of CICA 4 and IR 22, at the same time that it demonstrated improved cooking and milling qualities. In 1976, the varieties CICA 7 and CICA 9 were released; their plant size was slightly taller and their fertilizer requirements were slightly less than the earlier varieties. Finally, in February of 1978, CIAT and ICA released CICA 8, a variety that had a still higher production capacity at the same time that it incorporated resistances to a wide range of pests and diseases. Beginning in 1970, the improved CICA and IR varieties had started to gradually displace the traditional varieties with their tendency to lodge and their pest and disease susceptibility.

B. RICE PRODUCTION CONSTRAINTS IN LATIN AMERICA AND RELATED CIAT EFFORTS

5.4 Weeds constitute the most severe rice production problem in Latin America. Ever since the inception of the CIAT Rice Unit, it has dedicated considerable efforts for the development of improved, low-cost, and integrated weed control methods. As a result of these efforts, efficient weed control methods are available and are being disseminated to cooperating national institutions.

5.5 Rice diseases constitute the second most important constraint. Of considerable importance is the "mancha lineal" caused by Cercospora oryzae, "mancha parda," cause by Helminthosporium oryzae, and the viral disease "hoja blanca" which is transmitted by the insect Sogatodes oryzicola. The most pervasive and economically important disease, however, is rice blast caused by the fungus Pyricularia oryzae. Its control has proved to be overly difficult and costly. The most economical control to this disease is the development of resistant varieties. However, due to the speed at which the fungus is able to mutate, the problem of finding stable resistance to rice blast is exceedingly difficult to resolve. The CIAT Rice Program combats rice diseases on two fronts: firstly, through its breeding efforts, it attempts to find stable sources of resistance for incorporation into improved varieties; and, second, it works on low-cost chemical control methods that can contain selected outbreaks within limits.

5.6 Next in line in terms of importance are insect problems, the most severe of which is Sogatodes oryzicola. Its control has largely been brought about by the incorporation of resistance to the insect into improved varieties. A great many other insects can cause considerable yield losses. Chemical control methods are available, but they are costly.

5.7 Soil deficiencies and/or soil toxicity problems constitute a fourth family of rice production constraints in Latin America. While it is possible to combat some of these problems by a combination of chemical interventions and appropriate cultural practices, others are sought to be countered on a permanent basis by developing varietal resistance to selected adverse soil conditions.

5.8 Other rice production constraints are: (a) the non-availability of sufficient amounts of certified seed that would eliminate such problems as wild rice and weed seed transmission; (b) the lack of technical personnel specifically trained in rice production; and (c) lack of mechanization. With respect to manpower development, CIAT has trained nearly 200 professionals from Latin America in rice production. And with regard to mechanization, CIAT developed a variety of low-cost implements that facilitate many phases of the rice production process; also, it has successfully adapted the Asian-developed continuous rice production system to Latin American conditions. This system has proved of utmost economical viability and already has been adopted by many rice growers in the region.

C. RELATIONSHIP BETWEEN IRRI AND CIAT

5.9 Within the International Agricultural Research Center system, IRRI has been assigned principal responsibility for the development of improved rice production technology. Given the fact that IRRI is based in Asia where fully 90 percent of the world's rice production is grown (i.e., more than 300 million tons per year), it is obvious that IRRI places its major emphasis on the Asian continent. As far as the Latin American region is concerned, CIAT has accepted the responsibility to act in a relay capacity for IRRI, evaluating IRRI's technology under Latin American conditions and adapting this technology to regional requirements. One of the most substantial contributions of IRRI to Latin America has been the dispatching of improved germplasm to the countries of the region through CIAT.

D. INTERNATIONAL RICE TESTING PROGRAM FOR LATIN AMERICA

5.10 In 1976, CIAT and IRRI formalized the International Rice Testing Program for Latin America. Under this program, CIAT evaluates at the Center IRRI materials with respect to yield, resistance to blast, sheath blight, plus environmental and soil problems. From these nurseries, appropriate material is distributed to Latin American countries.

Nurseries Distributed in Latin America

5.11 In 1976 and 1977, rice workers from throughout Latin America were invited to CIAT to identify specific nurseries types that would be of interest and relevance to the region. These conferences resulted in the eight nursery types as listed in Table V-1. This table also shows the number of entries in each nursery and the number of sets as they were dispatched by CIAT in 1977 and 1978. The source of germplasm included in the various nurseries originated from the 1976 and 1977 IRRI nurseries planted at CIAT for evaluation and seed multiplication.

5.12 At CIAT, the germplasm had been evaluated, under field conditions, for plant type, maturity, lodging resistance and yielding ability and, under laboratory conditions, for plant hopper (Sogatodes oryzicola) resistance, grain type and quality. Only those entries combining good plant type (semidwarf and intermediate in height, resistance to lodging), resistance to Sogatodes, early and medium duration, long and medium grain size with good milling and cooking qualities, and good yield were included in the specific nurseries for Latin America.

Results of Nurseries Distributed in 1977

5.13 The type and number of nurseries distributed in 1977 as well as returned data are indicated in Table V-2. Returned data are rather high if it is considered that it is the first cooperative year of the IRTP trials in the region. It is expected that this cooperative network would greatly increase as national programs become more conscious of its benefits.

Table V-1 IRTP nurseries for Latin America distributed in 1977 and 1978

Nursery[1]	Number of Entries		Number of Sets	
	1977	1978	1977	1978
VIRAL-P	10	--	28	--
VIRAL-T	15	14	28	26
VIRAL-S	14	19	22	31
VIRAL-F	8	8	5	5
VIOAL	--	60	--	37
VIPAL	--	185	--	31
VIAVAL	21	20	9	11
VIOSAL	37	25	4	7
TOTAL	105	331	96	148

[1] VIRAL-P = International Rice Yield Nursery - Early
VIRAL-T = International Rice Yield Nursery - Medium
VIRAL-S = International Rice Yield Nursery - Upland
VIRAL-F = International Rice Yield Nursery - Deep Water
VIOAL = International Observational Nursery
VIPAL = International Rice Blast Nursery
VIAVAL = International Rice Sheath Blight Nursery
VIOSAL = International Rice Salinity and Alkalinity Observational Nursery

Table V-2 Data returned of IRTP nurseries for Latin America distributed in 1977

Nursery[1]	Number of Sets		Percentage of data received
	Dispatched	Returned	
VIRAL-P	28	18	64
VIRAL-T	28	17	61
VIRAL-S	22	13	59
VIRAL-F	5	--	--
VIAVAL	9	9	100
VIOSAL	4	--	--
TOTAL	96	57	59

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[1] See names of nurseries on Table 1

5.14 The average yield and growth duration of VIRAL-P, VIRAL-T and VIRAL-S germplasm are summarized in Tables V-3, V-4 and V-5, respectively.

5.15 The VIRAL-P was planted in 15 locations (Fig. V-1), four (Guatemala, El Salvador, Costa Rica and Campinas, Brazil) which were under upland culture but with good rain distribution. The average yield of all entries, except one was over 5.0 t/ha under irrigated conditions. Similarly, all except one yielded 4.0 t/ha or more, under upland culture. The growth duration of all entries was similar under both irrigated and upland culture.

5.16 The average yield of germplasm of VIRAL-T planted on 13 locations (Fig. V-2) was high under irrigated conditions. It varied from 5.3 t/ha for line IR 2823-399 to 6.6 t/ha for line IR 2588-19. The average yield for the upland culture with good rain distribution (Costa Rica, Guatemala, El Salvador, Honduras, (Guaymas) and Panama), varied from 3.0 t/ha for line IR 2070-423 to 4.9 t/ha for line IR 2823-399.

5.17 The germplasm of VIRAL-S was planted in 9 localities (Fig. V-3), 3 of which (Uberaba, Brazil; Chiapas, Mexico; La lujoa, Honduras) had drought periods during the growing season. In the other localities there was a good rain distribution. Under upland culture with water stress, yields were below 3.0 t/ha. But, in localities with good rain distribution, average yields were over 3.0 t/ha. Under these conditions 4 entries from IRRI (IR 1529-430-3, IR 36, IR 2061-522-6-9 and IR 3880-13) and one line from CIAT-ICA (P918-15-1-4-2-3-1B) yielded 4.0 t/ha.

5.18 The other trial distributed in 1977 was the Sheath Blight Nursery. This nursery was requested by seven countries and was planted in nine localities (Fig. V-4) where this disease is considered as a potential serious problem. The nursery was planted under irrigated conditions in CIAT, Colombia; Boliche, Ecuador; and Rice Board Station, Guyana. In the other localities the nursery was grown under upland culture and had good rain distribution.

5.19 Sheath Blight incidence was registered at CIAT (Colombia), Guaymas (Honduras), Cañas (Costa Rica) and Tocumen (Panama). Incidence was severe in Tocumen and moderate in the other localities, and did not affect the yield. Table V-6 lists the highly resistant lines as observed at Tocumen. The yield of susceptible varieties was severely affected in Tocumen and production of the susceptible check (IR1487-194) was nil.

Table V-3 Average yield and growth duration of germplasm of VIRAL-P, 1977 planted in 15 localities of Latin America

Entry N°	Designation	Yield (t/ha)		Maturity (Days)	
		Irrigated 1/	Upland 2/	Irrigated 1/	Upland 2/
1	BR51-46-1-C1 IR 20/IR5-114-3-1	5.4	5.1	127	130
2	IET 2881 (RP319-34-8-1-3) T 141/IR661-1-175-3	6.4	4.0	122	123
3	IET 3262 (RP633-9-5-8-1) IR 8/BJ 1-43//IR 22	5.5	4.1	121	120
4	IET 3127 (RP6-516-31-4) TKM 6/IR 8	5.5	3.1	119	120
5	B541b-Pn-58-3-3-1 Pelita I-1/IR 1108-2	6.2	4.5	125	128
6	IR 2070-414-3-9 IR 20*2/O.n.//CR 94-13	5.1	5.2	127	130
7	IR 2071-625-1-252 (IR 36) IR1561-228//IR24*4/O.n.///CR94-13	5.2	4.7	120	118
8	IR 2307-84-2-1-2 CR 94-13/IR 1561-228	4.9	4.9	124	124
9	IR 1561-228-3-3 (check) IR 8/Tadukan//TKM6*2/TN1	5.7	4.0	118	120
10	CICA 7	5.3	5.5	127	131

1/ Average of 11 localities

2/ Average of 4 localities with good rain distribution

Table V-4 Average yield and growth duration of germplasm of VIRAL-T, 1977 planted in 13 localities of Latin America

Entry No.	Designation	Yield (t/ha)		Maturity (days)	
		Irrigated 1/	Upland 2/	Irrigated 1/	Upland 2/
1	BR51-46-5 IR20/IR 5-114-3-1	5.6	4.0	137	134
2	BR 51-74-6 IR 20/IR 5-114-3-1	5.8	4.7	141	137
3	BR 4 (BR 51-91-6) IR 20/IR 5-114-3-1	5.8	4.3	142	140
4	IET 1785 (RP 84-39-1)	6.4	4.4	135	135
5	B541b-Kn-58-5-3 Pelita I/1-IR 1108-2	5.5	3.3	134	132
6	B 542b-Pn-68-9-2-2 Pelita I/I-IR 532 E 576-4	6.5	3.6	140	135
7	IR 2070-423-2-5-6 IR 20*2/O.n.//CR 94-13	5.9	3.0	139	138
8	IR 2071-586-5-6-3 IR 1561-228/IR24*2/O.n.///CR94-13	5.6	4.2	144	144
9	IR 2823-399-5-6 CR94-13/IR1529-680///IR24*3/O.n.//IR1416-131-5	5.3	4.9	139	135
10	IR 2863-38-1-2 IR1529-680-3/CR94-13//IR480-5-9-3	5.7	3.2	140	143
11	Bg 374-1 (75-311) Bg 66-1/IR20	5.8	3.5	139	135
12	Bg 375-1 (75-404)	6.2	4.5	139	136
13	IR 2588-19-1-2-2 IR 1544-238/IR 1529-680-3	6.6	4.6	140	137
14	Taichung Sen Yu 195 Bin-Tang-Chien/IR 661	6.2	3.8	135	136
15	CICA 9	5.7	4.8	135	136

1/ Average of 9 localities

2/ Average of 4 localities with good rain distribution

Table V-5 Average yields and growth duration of germplasm of VIRAL-S, 1977 planted in 9 localities of Latin America

Entry No.	Designation	Yield (t/ha)1/		Maturity (days)	
		A	B	A	B
1	IRAT 13				
	63-83 (Mutante)	2.5	3.0	127	121
2	IR 2071-625-1-252 (IR 36)				
	IR 1561//IR 24*4/O.n///CR 94-13	2.6	4.0	124	119
3	IR 1529-430-3				
	IR305/IR661-1-140	2.3	4.3	132	127
4	IR 1750-F_5-B-5				
	E425/IR 22	2.3	3.7	125	117
5	IR 2061-522-6-9				
	IR 833//IR 1561/IR1737	2.1	4.0	129	116
6	IR 3880-13				
	IR841/C22-2b//Bbt50/IR1529-689	1.3	4.0	129	123
7	IR3880-17				
	IR841/C22-21/Bbt50/IR1529-689	1.7	3.6	130	124
8	Kn361-1-8-6				
	Jerak/IR8	2.4	3.3	121	118
9	MRC 172-9	1.8	3.1	129	125
10	Se 302G	2.0	2.4	122	96
11	BPI76-9/Dawn	2.2	3.2	120	123
12	CICA 9				
	IR665 (IR841/C46-15)	2.4	3.6	128	124
13	P918-25-1-4-2-3-1B (4440)				
	CICA 4 (IR665/Tetep)	2.8	4.2	130	127
14	P918-25-15-2-3-2-1B (4444)				
	CICA 4 (IR 665/Tetep)	2.1	3.7	133	127

1/ A = Average yield and maturity of 3 localities with water stress

2/ B = Average yield and maturity of 6 localities with good rain distribution

Figure V-1 Localities where the VIRAL-P, 1977 was planted

Figure V-2 Localities where the First VIRAL-T, 1977 was planted

Figure V-3 Localities where the First VIRAL-S, 1977 was planted

Figure V-4 Localities where the First VIAVAL, 1977 was planted

Table V-6 Highly resistant lines to Sheath Blight
at Tocumen, Panama

Designation	Origin	Infection type	Yield (t/ha)
BR 1-30-1-5-1	Bangladesh	1.0 (Resistant)	5.0
IR 1514A-E666	IRRI	1.0 "	2.8
IR 2070-747-6-3	IRRI	1.0 "	2.3
IR 2053-160-3	IRRI	1.0 "	1.2
Pankaj (Resistant Chech)	India	1.0 "	1.1
IR 1487-194 (Susceptible Check)	IRRI	7.0	0.0

5.20 The results of this cooperative effort indicate that among the germplams included in these 4 nurseries there are several entries with good adaptation and high yield potential for both irrigated and upland cultures with good rain distribution, which can be selected by rice scientists of the region for further tests, seed multiplication and eventually for release in the form of new varieties to farmers in a short period of time.

5.21 Demonstrating the importance of this network, several promising lines from the nurseries distributed in 1977 have been advanced for yield trials and regional tests by national programs. Table V-7 indicates the number of entries selected from the various nurseries.

E. INTERNATIONAL SEED SHIPMENTS

5.22 Beyond the dispatching of seed packages for the International Rice Testing Program, CIAT also is engaging in the international shipping of rice seed. These shipments contain seed of already released improved varieties and/or of lines that are about to be released. In the period 1976-1978, CIAT had dispatched close to 5,000 kg of 15 varieties and lines to a total of 19 Latin American countries.

F. ACCEPTANCE OF NEW RICE VARIETIES FROM CIAT

5.23 The name "CICA" constitutes a merger of the acronym for Centro Internacional de Agricultura Tropical (CIAT) and for the Instituto Colombiano Agropecuario (ICA). Normally, promising lines are sent out by CIAT under the name of CICA. As Table V-8 shows, these lines not only have been accepted by collaborating countries in Latin America, but they have

Table V-7 Entries selected by national programs for further regional tests from nurseries distributed in 1977 in Latin America

Country	Source of Nursery	Entry Numbers
Argentina	VIRAL-T, 77	8, 9, 11, 13, 14
	VIRAL-P, 77	7, 10
	VIAVAL, 77	10, 11, 12, 14, 20
Bolivia	VIRAL-S, 77	3, 7, 9, 12
Colombia	VIRAL-F, 77	2, 4, 7, 8, 9, 10
	VIRAL-T, 77/78	5, 4/, 3, 7, 9
	VIRAL-S, 77/78	2, 3, 8/, 6, 9
Cuba	VIRAL-S, 77	3
Ecuador	VIRAL-F, 77	1, 10
Honduras	VIRAL-S, 77	3
	VIRAL-P, 77	9
	VIRAL-T, 77	13, 14
Nicaragua	VIRAL-P, 77	2, 4, 5, 6, 9
	VIRAL-T, 77	3, 4, 6, 10, 11, 12, 13, 14
Panama	VIRAL-P, 77	10
	VIRAL-S, 77	13
Peru	VIRAL-P, 77	1, 8
	VIRAL-T, 77	2, 5, 9

been nationally re-named for their commercialization.

Table V-8 Examples of CIAT developed lines and their commercial names in selected Latin American countries

Country	Lines			
	4422	4444	4421	4440
Guatemala	Tikal 2			
Ecuador		INIAP7		
Dom. Republic		ISA 44		
Venezuela			Ciarllacen-1	
Colombia			CICA 9	CICA 8
Paraguay				Adelaida 1

G. NEW HIGH YIELDING RICE VARIETIES IN RELATION TO RICE PRODUCTION IN LATIN AMERICA, WITH PARTICULAR EMPHASIS ON COLOMBIA[1]

5.24 In 1976, Latin American rice production reached 20,561,000 metric tons. This production amounted to 5.9 percent of total world rice production. In Latin America, rice provides one-third of the calory intakes of the population. Hence, rice constitutes one of the most important food staples in the region.

5.25 The principal rice producers in Latin America and their respective share of production in 1965 and 1974 are represented in Table V-9.

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[1] For a more complete treatment of this topic, the reader is referred to the publication attached to this report: Grant M. Scobie and Rafael Posada T. The Impact of High-Yielding Rice Varieties in Latin America. CIAT, 1977.

Table V-9 Principal rice production countries in Latin America and their respective share of production in 1965 and 1974

Country	1965	1974
Brazil	72 %	56 %
Colombia	6 %	13 %
Peru	3 %	4 %
Mexico	3 %	3 %
Others	16 %	24 %
	100 %	100 %

5.26 In the past 15 years, rice production in Latin America has increased at an annual rate of 2.8 percent, equal to the population growth rate. In general, one-third of the increases in production can be attributed to increases in yield. The remaining two-thirds were due to increases in the area planted to rice. This proportion, however, has varied from country to country. In Colombia, Ecuador, Panama, Belize, Haiti, and Trinidad & Tobago, most of the increases were due to yield increases. In contrast, recorded production increases in Brazil, Cuba, Argentina, Bolivia, Paraguay, and Guatemala were mostly due to area increases. The estimated contribution of the newer, high-yielding varieties to production in Latin America up to 1974 is shown in Table V-10 (from Scobie and Posada).

5.27 Overall, gross imports to Latin America have increased from approximately 385,000 tons per year in the period 1963-1965 to some 470,000 tons per year in the period 1973-1975. As a result of increased exports from some countries, notably Colombia, Venezuela, Uruguay and Surinam, net regional imports have ramained at around 150,000 tons per year.

5.28 Presented below is a discussion of the role that improved rice varieties and new rice production technology play in Colombia. Related information for the remaining Latin American countries will be obtained by CIAT through (a) a conference scheduled for early June of this year to be held at CIAT which will be attended by rice researchers from throughout Latin America; and (b) the work of an agricultural economist who is budgeted starting in 1980; this economist will survey all important rice growing areas in Latin America and will monitor developments on a continuing basis.

Table V-10 Estimated contribution of high-yielding rice varieties in Latin America, excluding Brazil; by regions (1974)(from Scobie and Posada).

Item	Mexico and Caribbean	Central America	South America	Colombia (irrigated)	Latin America (Excluding Brazil)
1. Total area ('000 ha)	452.0	257.1	1,088.0	273.0	1,797.0
2. Total production ('000 m.t.)	1,022.0	472.2	3,647.1	1,420.1	5,141.4
3. Yield (tons/ha)	2.261	1.837	3.352	5.203	2.861
4. HYV area ('000 ha)	264.0	105.3	438.5	270.2	807.8
5. Traditional area ('000 ha)	188.0	151.8	649.5	2.7	989.2
6. Traditional yield (tons/ha)	1.779	1.284	2.399	3.100	2.040
7. Traditional prod. ('000 m.t.)	334.5	194.9	1,558.2	8.4	2,018.0
8. HYV production ('000 m.t.)	687.5	277.3	2,088.9	1,411.7	2,123.4
9. HYV yield (tons/ha)	2.604	2.633	4.764	5.225	3.867
10. Yield margin (tons/ha)	0.825	1.349	2.365	2.125	1.827
11. Additional prod. ('000 m.t.)	217.8	142.0	1,037.1	574.2	1,475.9
12. Additional prod. (%)	27.1	43.0	39.7	67.9	40.3

Derivations:

5 = 1 - 4

6 = Average yield 1950-1964
7 = 5 x 6
8 = 2 - 7

10 = 9 x 6
11 = 10 x 4
12 = 11/2 - 11 x 100

Improved Rice Technology in Colombia

5.29 Before 1961, Colombian rice production was not sufficient to meet national demand. Since then, however, rice production has increased to such an extent that Colombia has become a net exporter of this staple. Table V-11 presents data on the areas planted to rice during the 1961 and 1977 period.

Table V-11 Areas planted to irrigated and upland rice in Colombia between the period 1961-1977

Year	Irrigated (ha)	Upland (ha)	Total (ha)
1961	105,000	132,100	237,100
1965	130,000	244,750	374,750
1969	115,000	134,570	250,460
1973	192,020	98,840	290,864
1977	230,100	95,000	325,100

5.30 As is evident, the area planted to irrigated rice has been greatly increased over the years. At the same time, upland rice cultivation has decreased dramatically, going from 245,000 ha in 1965 to 95,000 ha in 1977. Starting in 1974, the total area devoted to rice (irrigated and upland) has been higher than 320,000 ha.

5.31 Table V-12 presents the yield per hectare between the years 1961 and 1977. Note that the productivity of irrigated rice jumped from 2.6 tons per hectare in 1961 to 5.1 tons in 1977. At the same time yields of upland rice have remained stable at around 1.5 t/ha. During the past six years, the overall national average (including both irrigated as well as upland rice) has been around 4.0 t/ha. In irrigated rice, small increases in the 1960s were primarily due to new technology for weed control and other agronomic practices. The significant increases in 1970 were due to new varieties with higher yielding capacity, complemented by already existing improved agronomic practices.

Table V-12 Average yield per hectare of irrigated and upland rice in Colombia between the period 1961-1977

Year	Irrigated (t/ha)	Upland (t/ha)	National Average (t/ha)
1961	2.6	1.5	2.0
1965	3.0	1.1	1.8
1969	4.1	1.6	2.8
1973	5.3	1.6	4.1
1977	5.1	1.5	4.0

Experimental and Commercial Yields of Improved Varieties

5.32 Commercial vs. experimental yields in Colombia of the improved varieties have been reported by FEDEARROZ as listed in Table V-13.

Table V-13 Mean commercial and experimental yields of improved rice varieties in Colombia

Variety	Commercial Yield (t/ha)	Regional Trials[1] (t/ha)
CICA 4	5,680	6,196
CICA 6	5,450	5,657
CICA 7	5,930	5,513
CICA 9	6,340	6,730
IR 8	6,120	6,032
IR 22	5,210	5,360

[1] Mean for 41 regional trials carried out between 1975-1977

Utilization of Improved Varieties in Colombia

5.33 During the last 20 years, more than 20 rice varieties have been cultivated in Colombia. Table V-14 lists the percentage distribution of the varieties occupying one percent or more of the area planted to rice during the period 1965-1976. The latter seven constitute the "traditional" varieties, characterized by their tallness, low yielding ability, and susceptibility to pests and diseases; the first represent semi-dwarf, high-yielding varieties that have a good response to fertilizer applications and are tolerant to most important pests and diseases of the region.

5.34 Bluebonnet 50, released in Texas in 1950, was widely planted in the country for 15 years. However, when the improved varieties appeared in the 1970s, its importance decreased. By 1976, virtually all rice grown in Colombia was of the improved type coming from IRRI and CIAT.

Table V-14 Percentage distribution of rice varieties grown in Colombia during the period 1965-1976

Variety	1965	1969	1973	1976
CICA 6	-	-	-	24.8
CICA 4	-	-	17.8	37.1
IR 22	-	-	38.8	27.7
IR 8	-	5.5	41.2	10.0
Bluebonnet 50	86.6	50.1	2.2	0.8
Guayaquil	1.0	0.1	-	-
Tapuripa	-	36.2	-	-
Bluebelle	-	6.9	-	-
Rexoro	5.5	-	-	-
Century	1.3	-	-	-
Napal	4.9	-	-	-

Benefits of Increased Rice Production in Colombia

5.35 The primary beneficiaries of increased rice production in Colombia have been the low income consumers. As rice production increased, its relative price in relation to other staples decreased (Table V-15)[1]

Table V-15 Kilograms of rice which could be bought with one kilogram of other selected products in the wholesale market of Bogota; selected years

	Kilograms of rice bought with 1 kg of			
Year	Beans	Cassava	Maize	Potatoes
1960	1.99	0.16	0.36	0.37
1965	1.82	0.34	0.36	0.37
1970	2.38	0.48	0.45	0.29
1974	3.47	0.79	0.51	0.55

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[1] A detailed analysis of the distribution of net benefits of the technological change in the Colombian rice industry is contained in the above cited publication by Scobie and Posada (1977), pp. 69-85.

H. TECHNICAL ASSISTANCE/COOPERATION BY CIAT RICE PROGRAM SCIENTISTS TO COLLABORATING NATIONAL INSTITUTIONS IN LATIN AMERICA

ARGENTINA

Annual visits: 1

Institutions: Instituto Nacional de Tecnología Agropecuaria (INTA), Rice Program headquarters in Corrientes

Results: On CIAT's recommendation, a new rice variety was adopted for cultivation in Argentina. The rice program at Corrientes is now working in cooperation with scientists from other national institutions to further disseminate improved rice technology. One technician from this country participated in a training course held at CIAT.

BOLIVIA

Annual visits: 2

Institutions: Centro de Investigación Agrícola Tropical (CIAT), Experimental Stations in Saavedra and Santa Cruz.

Results: Three technicians from Bolivia came to CIAT for training in rice production, as part of this Center's program to transfer improved technology to other countries. Three or four promising lines from IRTP nurseries were selected in Bolivia for seed increase.

BRAZIL

Annual visits: 2

Institutions: Instituto Riograndense do Arroz (IRGA), Rio Grande do Sul,
Centro Nacional de Pesquisas do Arroz e Feijao (CNPAF), Goiania, and
Instituto Agronomico do Campinas (IAC), Sao Paulo

Results: Following CIAT's recommendations, IRGA is promoting a new rice variety to be cultivated in the Rio Grande do Sul region. IAC and CNPAF scientists are working through EMBRATER on a gradual change from upland to irrigated rice.

COLOMBIA

Annual visits:[1] 40

Institutions: Instituto Colombiano Agropecuario (ICA) and Federación de Arroceros (FEDEARROZ).

Results: CIAT-developed technology for irrigated rice has been adopted by farmers in this region, who are obtaining average yields of 5.3 t/ha. Of the irrigated rice area, 99 percent is being cultivated with high-yielding varieties.

COSTA RICA

Annual visits: 10

Institutions: Ministerio de Agricultura, Experimental Station Enrique Jiménez Núñez.

Results: Starting in late 1977, CIAT posted a regional services senior staff member in Costa Rica in order to serve Central America and the Caribbean by contributing to the inter-institutional transfer of improved rice production technology.

In 1976, Costa Rica commercialized the variety CR-1113, which was selected from materials sent from CIAT.

CUBA

Annual visits: 4

Institutions: Ministerio de la Agricultura

Results: Based on CIAT's recommendations, better crop management through the use of chemicals for weed control have been achieved. As part of the cooperation activities of the IRTP, six tech-

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[1] Includes activities of CIAT-based scientists in the course of their own experimental work in addition to visits to national programs by the Regional Coordinator for Central America in cases of those countries.

nicians received training in rice production, two at CIAT and four at IRRI. Also, in 1978, a new variety, named IR 1529, was released as a result of IRTP cooperation.

DOMINICAN REPUBLIC

Annual visits: 4

Institutions: Ministerio de Agricultura (Rice research program in Juma) and,
Instituto Superior de Agricultura (ISA)

Results: Materials from the CIAT-ICA program (e.g. lines 4440 and 4421) have been recommended for commercial planting, under the names of ISA 40 and ISA 21. Also, several promising lines, tolerant to soil salinity, were selected and are now being tested further in yield trials.

ECUADOR

Annual visits: 5

Institutions: Instituto Nacional de Investigaciones Agropecuarias (INIAP)

Results: As a result of cooperative activities, several lines resistant to the "hoja blanca" virus, were identified. The rice variety INIAP 7 has been selected from the IRTP trials and recommended for commercial plantings. Two floating rice varieties are under seed multiplication.

EL SALVADOR

Annual visits: 5

Institutions: Ministerio de Agricultura
Centro Nacional de Tecnología Agropecuaria (CENTA)

GUATEMALA

Annual visits: 5

Institutions: Instituto de Ciencia y Tecnología Agrícolas (ICTA), especially its rice program in Cuyuta

Results: As a result of exchange of materials between CIAT and ICTA and through recommendations made by CIAT scientists during individual visits, the varieties ICTA 6 and TIKAL 2 are being grown commercially.

GUAYANA

Annual visits: 2

Institutions: Rice Research Board, Georgetown

Results: As a first step of CIAT's effort to contribute to improved rice production in this country, two scientists from Guayana received training at CIAT on improved rice technology.

HONDURAS

Annual visits: 10

Institutions: Ministerio de Agricultura, Experimental stations in Guaymas and La Lujosa

Results: CIAT rice scientists have recommended that this country gradually change its rice production system from upland to irrigated. Suitable CICA high-yielding varieties are being recommended as part of this plan. In addition, four lines have been selected from the IRTP for further testing in regional trials. CIAT scientists helped organize a short course for producers.

MEXICO

Annual visits: 5

Institutions: Instituto Nacional de Investigaciones Agrícolas (INIA), especially its rice research efforts in

Morelos, Sinaloa, Tabasco, Campeche, Veracruz, and Tierra Caliente.

Results: CIAT cooperation activities with Mexico have been very fruitful: (a) Two or three promising lines have been recommended for seed increase and the best will eventually be released to the farmers; (b) several promising lines were identified at Tierra Caliente as being tolerant to alkalinity and iron deficiency. These materials were included in observational and yield nurseries for further tests in Latin America; and, (c) five or six rice growing technicians were selected to receive short training courses at CIAT. Another technician will receive MS level training at IRRI.

NICARAGUA

Annual visits: 5

Institutions: Ministerio de Agricultura, Experimental Stations in Altamira and Sebaco.

Results: Thirteen promising lines, selected from the IRTP nurseries, were further tested in yield and regional trials.

PANAMA

Annual visits: 5

Institutions: Instituto de Investigación Agropecuaria de Panamá (IDIAP), and
Facultad de Agronomía, Universidad de Panamá, Tocumen

Results: CIAT has recommended for commercial planting the varieties CICA 7 and CICA 8, while Bg 90-2 is in the process of seed multiplication. Furthermore, several lines, resistant or tolerant to leaf scald and sheath blight diseases, were identified in the IRTP nurseries and included in yield trials to observe their performance in this country.

In cooperation with IDIAP, the Facultad de Agronomía and several technicians from Costa Rica, CIAT organized a short course on rice production which was held in Panamá.

PARAGUAY

Annual visits: 1

Institutions: Ministerio de Agricultura, Rice Program in Caacupe.

Results: CIAT's activities in Paraguay resulted in the commercialization of the varieties CICA 6, 7, and 8 (there known as Adelaida 1) which have shown excellent performance.

PERU

Annual visits: 3

Institutions: Ministerio de Alimentación, CRIA II, and Universidad Pedro Ruiz Gallo.

Results: CIAT's cooperative activities resulted in the selection by national programs of several promising lines for further testing on regional yield trials. In addition, six Peruvian scientists received short-course training at CIAT on rice production technology.

SURINAM

Annual visits: 1

Institutions: Ministerio de Agricultura, Rice Program in Paramaribo.

Results: CIAT's technical assistance activities in Surinam have resulted in strengthening the SLM rice program which is now testing IRTP early materials and using the best ones in hybridization programs in their country.

VENEZUELA

Annual visits: 2

Institutions: Fondo Nacional de Investigaciones Agropecuarias (FONAIAP), Experimental stations in Acarigua and Calabozo.

Results: Varieties tested and developed by CIAT, such as CICA 7 and CICA 8 are grown here commercially, and CICA 9 (known as CIALLARCEN 1) is being recommended for cultivation in the lowland areas of Calabozo.

VI. TRAINING AND CONFERENCES

A. INTRODUCTION

6.1 Training and Conferences are integral parts of the International Cooperation activities of CIAT and are, at the same time, intimately related to the research activities of the Center's commodity programs. Together with new technologies, trained scientists are a product of the Center.

6.2 Training was one of the first and has remained one of the most active areas of activities in CIAT. It has been dynamic in that the types of professionals considered for training and the nature of training activities have been progressively modified during CIAT's development and evolution, to take into account the changing nature of CIAT's commodity programs, the amount and kind of technology generated and the evolving needs of the national programs concerned.

B. OBJECTIVES

6.3 Training is offered at the post-graduate or professional level, and together with conferences, has the following objectives:

(a) To contribute to developing and operating in national programs of client countries a network of research scientists on each of CIAT's commodities, for the primary purpose of validating and transfering technology that has been generated by the Center or by CIAT in cooperation with national research organizations.

(b) To help strenghten the research capabilities of national programs dealing with CIAT's commodities, so that these programs may become fully capable of conducting, cooperatively or independently, validative, adaptive and applied research.

(c) To facilitate through conferences the exchange of scientific and technological information, and the planning and application of strategies and tactics for the generation, validation and transfer of new high-yield technologies.

C. TYPES OF TRAINING

6.4 To accomplish these objectives the Center offers three types of training that are available for various lengths of time.

Disciplinary research training

6.5 Individualized in-service training in one commodity and discipline. (e.g., beans-breeding.) This has been and continues to be the most important category. It includes non-degree internships and also M.S. or Ph.D. thesis research in combination with academic studies of selected universities. Figure VI-1 shows the numbers of participants in this and other categories of training since 1969.

Production-oriented training

6.6. Multidisciplinary in scope, it intends to familiarize the participant with the various disciplines and technologies contributing to the yield improvement of a given commodity. A series of six courses (four IDB financed) that had started in 1970 on crop production, (the so-called CPSTP* courses) and four courses (three IDB financed) on livestock production (the so-called LPSTP* courses) was conducted.

6.7 Since 1976, production training has proceeded on a single commodity basis. It is conducted mainly through short (four to six weeks), intensive, multidisciplinary courses in beans, cassava and seed technology; beef (forages), swine, and rice have maintained longer-term courses (six months each).

Research support training

6.8 On a limited basis, CIAT is continuing to provide training not related to a specific commodity. In this area, training is offered in the management of experiment stations, in biometrics, in documentation and in communication skills.

D. ASSISTANCE TO IN-COUNTRY TRAINING

6.9 The LPSTP courses had a number of spin-offs in the form of within-country courses, such as in Ecuador, the Dominican Republic, Panama, Colombia, Paraguay and Guatemala. In the latter country, the modelling influence of the CIAT courses has been particularly pronounced as the Instituto de Ciencia y Tecnología Agrícolas (ICTA) has institutionalized a similar type of training program. The Instituto Nacional de Investigaciones Agropecuarias (INIAP) in Ecuador has followed the same pattern. More recently, 1977 to present, CIAT has helped organize and conduct single commodity short courses on rice in the Dominican Republic, Ecuador, Panama and Honduras. CIAT has helped organize and conduct a total of 17 courses in countries.

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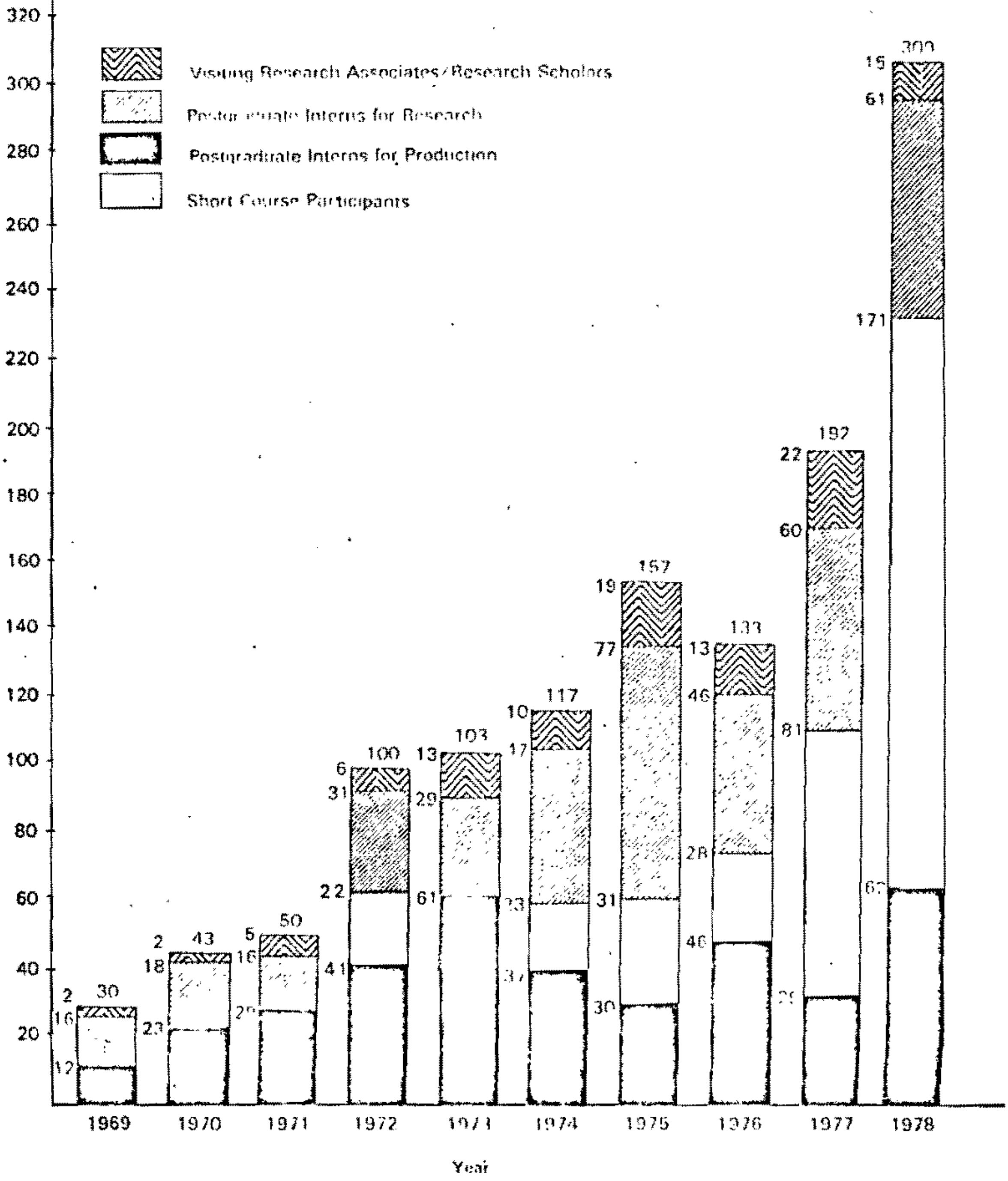
* CPSTP = Crop Production Specialists Training Program
LPSTP = Livestock Production Specialists Training Program

Figure VI-1 Number of CIAT Training Participants by Training Categories, 1969-78



Linkages with extension

6.10 Because of its nature as a research organization, CIAT has to concentrate on the training of researchers. However, there is a great demand on the part of national institutions to train professionals in extension organizations. While CIAT does not plan to train extension workers per se, it does try to bridge the gap between extension and research by training professionals in the on-farm validation of technology, chiefly by assisting countries to develop such training programs at the national level. The training of personnel from extension organizations in the conduct of varietal and agronomic verification trials with CIAT commodities will also go a long way towards eliminating the traditional distinction between "research" and "extension."

E. CONFERENCES

6.11 CIAT organizes various types of conference events that serve one or more of the following objectives:

(a) Consultation with a pool of experts on program strategies;

(b) establishment/maintenance of networks of collaborating researchers on a given commodity, and,

(c) presentation of information on new technologies, and planning for their testing and dissemination.

6.12 Since 1971, 47 conferences attended by 2769 scientists from Latin America have been sponsored or co-sponsored by CIAT. These are listed in Appendix VI-A. In addition, CIAT has hosted 38 conferences sponsored by others and has held 117 internal seminars.

F. ACCOMPLISHMENTS OF TRAINING

6.13 During the period 1969 to 1978 a total of 1246 professionals received training at CIAT. The large numbers involved and the very practical learn-by-doing philosophy which has characterized training activities are such that a critical mass of agricultural scientists oriented to the generation and transfer of practical agricultural production technology is now developing in CIAT's area of responsibility. A visitor to almost any national agricultural research or extension organization in tropical America is likely to find CIAT graduates holding positions of responsibility. Thus, a major contribution has been made towards the strengthening of the capacity of local organizations to better play their key role in the technology generation/adoption/transfer process. When the CIAT commodity programs were still in the formative stages, much of the training activities were of a broader, cross-commodity nature. With the growing capacity of these programs the training activities have been integrated into the commodity programs so that the returning trainees represent an increasingly important link to their colleagues in CIAT in the adaptation, validation and transfer of CIAT-generated, commodity-specific technology at the national and local level. Figure VI-1 provides a breakdown by year and training category of the professionals referred to above. Of these, 88 percent were from the Latin America and Caribbean region. Of the 1246 professionals trained at CIAT, 62 percent were supported from core budget funds, including those provided by the IDB. IDB funds (core and special project) have been exclusively applied to participants from lesser developed countries in the Americas.

6.14 Shown in Table VI-1 are the numbers of professionals trained at CIAT for each country and their distribution by commodity or area of training. Detailed listings of their names and organizations are given in the reports submitted to IDB on the production courses in 1972 to 1973 and 1974 to 1975, and in CIAT's Annual Reports starting in 1973.

6.15 With the exception of rice in Colombia, Ecuador, Panama and Central America, and of swine in various countries, the technology emerging from the main programs, (beef, beans, and cassava)--although already in the hands of national programs-- is still, at this date, in the stages of validation and adaptation to local conditions and one or two steps short of release and diffusion to producers in the form of new high-yielding varieties or cultivars and associated management practices. Therefore the impact of CIAT's training through the work of former trainees can not yet be measured by increases in yields. At the present, besides the numbers of professionals trained, the results of training are typified and a assessed by the presence and role of former trainees in the national commodity research programs.

6.16 A detailed follow-up evaluation of the present activities of those trained at CIAT and their contributions to national programs is planned for late 1979 and 1980. Mentioned below are only a few specific examples.

6.17 In Brazil: Practically all the members of the cassava research team at the Centro Nacional de Pesquisas de Mandioca y Frutales at Cruz das Almas have been trained at CIAT and are actively engaged in validating and developing technology for this important crop in Brazil.

6.18 In Mexico: All ten members of the INIA-ISAT multidisciplinary team for support of cassava research have been trained at CIAT. They are initiating a research effort in cassava for the humid tropics of that country, in an attempt to help satisfy that country's feed energy needs for domestic animals.

Table VI-1

DISTRIBUTION OF PARTICIPANTS IN CIAT'S TRAINING BY COUNTRIES AND COMMODITIES OR AREA OF TRAINING
1969 THROUGH 1978

	Beans	Beef	Cassava	Maize	Rice	Swine	Crop Production	Others	Total	Grand Total
LATIN AMERICA										1102
Argentina	4	2	0	0	2	2	0	3	13	
Belize	1	0	0	0	2	0	0	1	4	
Bolivia	5	13	1	0	3	9	3	14	48	
Brazil	33	20	54	0	37	4	0	16	164	
Chile	10	2	1	0	1	0	5	5	24	
Colombia	34	71	30	15	7	22	30	106	315	
Costa Rica	10	1	5	0	5	5	0	4	30	
Cuba	2	1	2	0	3	0	0	2	10	
Dominican Rep.	7	9	3	0	4	0	8	14	45	
Ecuador	10	10	3	2	17	9	15	26	92	
El Salvador	9	4	1	0	2	2	1	4	23	
Guatemala	12	15	0	0	4	3	11	12	57	
Guayana	0	1	3	0	2	0	0	0	6	
Haiti	0	0	0	1	0	0	0	0	1	
Honduras	19	3	3	0	7	3	2	6	43	
Jamaica	0	0	0	0	1	0	0	1	2	
Mexico	8	6	17	0	5	6	1	4	47	
Nicaragua	4	3	1	0	1	3	1	1	14	
Panama	4	4	4	0	1	3	5	6	27	
Paraguay	0	16	1	0	3	7	4	1	32	
Peru	12	9	6	0	11	9	3	14	64	
Puerto Rico	1	0	0	0	0	0	0	0	1	
Trinidad Tobago	0	0	1	0	0	0	0	0	1	
Uruguay	0	1	0	0	0	0	0	0	1	
Venezuela	11	7	10	0	3	2	0	5	38	
ASIA										41
India	0	0	5	0	0	0	0	0	5	
Indonesia	0	1	5	0	0	0	0	0	6	
Japan	2	0	1	0	0	0	0	0	3	
Malaysia	0	0	8	0	0	0	0	0	8	
Nepal	0	0	0	1	0	0	0	0	1	
Philippines	0	0	4	0	0	0	0	0	4	
Thailand	0	0	12	0	0	2	0	0	14	
AFRICA										11
Camerun	0	0	3	0	0	0	0	0	3	
Ghana	0	0	0	0	0	0	0	1	1	
Nigeria	0	0	2	0	0	2	0	0	4	
Rep. Seychelles	0	0	1	0	0	0	0	0	1	
South Africa	0	0	1	0	0	0	0	0	1	
Tanzania	0	0	1	0	0	0	0	0	1	
OTHER COUNTRIES	24	33	11	0	9	2	0	13	92	92

6.19 In Guatemala: The main researchers from ICTA, the national research institute founded in 1974, have been trained at CIAT and staff the core of the bean and rice programs. Most of the personnel engaged in on-farm testing and transfer of technology have been trained in Guatemala in courses that received the assistance of CIAT.

6.20 In Honduras: In cooperation with the PROMYF project of the Secretaría de Agricultura, CIAT trained 12 members of the project's staff and of the SRRNN Bean research program. They are now actively engaged in field testing of new varieties, selections, and improved practices. All five of the country's rice research team were also trained at CIAT and are responsible for the testing and spread of new high yielding rice varieties: CICA 4, CICA 6, and CICA 9.

6.21 In El Salvador: All of the bean research group of CENTA, the national research institute, have been trained at CIAT and are now actively working in validation of varieties with resistance to Golden Mosaic, an endemic disease in that country that severely limits bean yields.

6.22 In Bolivia: Three professionals trained at CIAT constitute the bean research group of the regional research center at Santa Cruz.

6.23 In Brazil, Venezuela, Ecuador, Peru, and Nicaragua: Professionals trained in the production and utilization of pastures now make up a network that is coordinated by CIAT and is designed to test new germplasm selections for adaptation to local acid soil conditions.

6.24 In Ecuador: All scientists working with *Phaseolus* bean research have been trained at CIAT and are initiating a new bean program in the middle highlands.

6.25 Most of the researchers of INIAP's rice program are CIAT graduates. They are responsible for the testing and release of local varieties INIAP 2 and INIAP 6 developed from CIAT's selections.

6.26 In the Dominican Republic: In spite of frequent turnovers, most of CIAT's trained young scientists are still in their jobs in the beans and cassava programs of CNIA and CENDA.

APPENDIX VI-A

LIST OF CONFERENCES

SPONSORED AND CO-SPONSORED CONFERENCES

HELD AT CIAT, 1971-1979

		Number of Participants	Participants from L. America
1971	Seminar on horizontal resistance to the blast disease of rice	104	90
	Seminar on rice policies in Latin America	196	190
	IV Andean Maize Workshop	43	43
1972	Cassava Program Review Conference	27	15
	Rice research workers' workshop	49	46
	Seminar on swine production in Latin America	81	75
1973	Symposium on the potential of the lowland tropics	120	80
	Seminar on the potential of field beans and other legumes in Latin America	153	140
1974	Seminar on the potentials for increasing beef production in the American Tropics	150	120
	Panel on hemoparasite diseases of cattle	12	4
	Workshop on the economics of beef production	16	8
	Seminar on soils management and the development process in tropical America	150	125
	Workshop on research on bean rust	44	--
	Symposium on communication strategies in rural development	58	40

		Number of Participants	Participants from L. Americ
	Workshop on methods used to allocate resources in applied agricultural research in Latin America	40	25
	Seminar on advances in research at CIAT	80	70
1975	Workshop on the epidemiology and control of anaplasmosis and babesiosis in Latin America	59	45
	Workshop on the ecology and control of external parasites of cattle of economic importance in Latin America	81	70
	Workshop on the characterization of the cattle industry in selected countries	25	21
	Workshop on the genetic improvement of dry beans and germplasm resources	68	55
	Workshop on bean protection	130	110
	Meeting of cassava advisory committee and testing program workshop	30	12
	Workshop on nature and organization of CIAT agircultural systems	20	15
	Workshop on economic analysis in the design of new technology for small farmers	37	28
	Seminar on advances in research at CIAT	80	79
1976	VIII Latin American meeting on <u>Rhizobium</u>	59	55
	Conference on root-knot nematodes	25	19
	IV Symposium of the International Society for Tropical Root Crops	114	60
	Meeting on IRRI-CIAT rice trials in Latin America	43	35

		Number of Participants	Participants from L. America
	Workshop on training at CIAT	60	50
	Seminar on advances in research at CIAT	80	75
	Regional meeting on weed/crop/insect interaction	80	80
1977	Workshop on cassava plant protection	36	28
	Workshop on the strategies to improve rice production in Latin America	34	30
	IRRI-CIAT meeting on international rice testing program for Latin America	35	30
	Workshop for swine production specialists	35	35
	Seminar on advances in research at CIAT	117	95
1978	Workshop on international bean breeding trials in Latin America	54	50
	Workshop on coordinating and planning for the collection, preservation, distribution and characterization of germplasm resources of tropical forages	115	100
	Seminar on the production and utilization of forages in tropical acid and infertile soils	185	160
	Workshop on cassava harvesting and processing	21	16
	Workshop to review the Latin American agricultural economics documentation center	25	25
	Seminar on advances in research at CIAT	130	115
1979	III conference on international rice trials program for Latin America-IRRI/CIAT	50	45
	Workshop on tropical pastures research network	60	40

	Number of Participants	Participants from L. Americ
Workshop on bean anthracnose, angular leaf spot and common bacterial blight	60	50
Seminar on advances in research at CIAT	80	70
Total participants	3351	2769

Furthermore, CIAT has lent its facilities for conferences held on topics compatible with its objectives. From 1971-1978, 38 major events of this nature were held.