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Highlights of Activities in 1980

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Contents

The Consultative Group for International Agricultural Research (CGIAR)

The Consultative Group for International Agricultural Research (CGIAR) was formed in 1971 to provide a mechanism for mobilizing financial support to the various international agricultural research centers and organizations. The creation of the CGIAR indicated the desire of donor agencies to provide long-term support for agricultural development in the Third World.

Acting on the advice of the Technical Advisory Committe — a panel of top-level scientists which oversees the research programs of the Centers — the CGIAR is able to assure financial donors that their resources are being utilized to achieve maximum benefits. The soundness of this system is evidenced by the fact that donor membership in the CGIAR has grown from 15 in 1972, who contributed about US$20 million, to 35 in 1980, with a total contribution of about US$126 million.

Each center or organization in the CGIAR system is autonomous, with its own Board of Trustees or other governing body. Each develops its own budget consistent with the overall goals of the CGIAR system. Individual center budgets are submitted annually to the International Centers' Week, during which each center presents a short review of its programs and accomplishments before the body of CGIAR donors and other representatives. Funds are provided for each center's budget, consistent with the total money pledged to be available for the coming year and the center's program in relation to the goals of the system.

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

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

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

- Centro Internacional de Mejoramiento de Maíz y Trigo, CIMMYT, in Mexico: maize and wheat.

- Centro Internacional de la Papa, CIP, in Peru: potato.

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

- International Board for Plant Genetic Resources, IBPGR, in Rome, Italy.

- International Crops Research Institute for the Semi-Arid Tropics, ICRISAT, in India: chickpea, pigeonpea, pearl millet, sorghum, groundnut, and farming systems.

- International Livestock Center for Africa, ILCA, in Ethiopia: livestock production systems.

- International Rice Research Institute, IRRI, in the Philippines: rice.

- International Institute of Tropical Agriculture, IITA, in Nigería: farming systems, maize, rice, roots and tubers (sweet potatoes, cassava, yams), and food legumes (cowpea, lima bean, soybean).

- International Laboratory for Research on Animal Diseases, ILRAD, in Kenya: trypanosomiasis and theileriosis of cattle.

- West Africa Rice Development Association, WARDA, in Liberia: rice.

- International Service for National Agricultural Research, ISNAR, in the Netherlands.

- International Food Policy Research Institute, IFPRI, in Washington, D.C.: analysis of world food problems.

Centro Internacional de Agricultura Tropical (CIAT)

CIAT started operations in 1969 in Colombia. The objective of the center is to generate and deliver, in collaboration with national institutions, agricultural technology which will contribute to increased production productivityand quality of specific basic food commodities in the tropics, principally in countries of Latin America and the Caribbean. In this manner, CIAT seeks to help improve the economic situation of the agricultural producers and raise the nutritional levels of both rural and urban populations.

In the course of its activities, the Center has made use of its comparative advantage in international research and training and has focused its resources on three important food crops in the region: dry beans, cassava and rice, and on the development of improved pasture technology on acid infertile soils where beef and milk production can be expanded. The primary goal with beans, rice and cassava is to increase their productivity on lands presently under cultivation. In the case of tropical pastures, and again in cassava, the Center is developing improved technology that will enable increased production of both crops on lands where other species cannot be economically produced.

Each international agricultural research center has its own clearly defined areas of responsibility. In the case of CIAT, they are the tropical areas in the Western Hemisphere, but the Center also works in other regions. Among the centers, CIAT has worldwide responsibility for research on *Phaseolus* beans and responsibility in all regions, except Africa, for improvement of cassava. Rice improvement is restricted to Latin America, with the cooperation of the International Rice Research Institute (IRRI), in the Philippines. While not a part of CIAT's basic program, the Center furnishes a base location for maize improvement in the Andean region under the responsibility of the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) in Mexico.

CIAT is a member of the CGIAR system, and as such it has its research responsibilities and financial support coordinated in accordance with the overall goals of the system. The following CGIAR members contributed funds to CIAT's core budget in 1981: The Rockefeller Foundation,the Ford Foundation, the International Bank for Reconstruction and Development (IBRD) through the International Development Association (IDA), the Inter-American Development Bank (IDB), the European

Economic Community (EEC), the International Fund for Agricultural Development (IFAD), the International Development Research Center (IDRC), and the foreign assistance agencies of the governments of Australia, Belgium, Canada, the Federal Republic of Germany, Japan, Mexico, the Netherlands, Norway, Spain, Switzerland, the United Kingdom, and the United States. In addition, special project funds are supplied by various of the aforementioned donors, plus the Kellogg Foundation, and the United Nations Development Programme (UNDP).

CIAT collaborates with many national and regional institutions in the Hemisphere in the adaptation and evaluation of improved technology and with training of their professional personnel.

Foreword

Last year we compared the movement of germplasm through the various stages of crop improvement with the flow occurring in a pipeline. In this Report, exciting new examples are documented of an increasing volume reaching the discharge end of the pipeline as more national programs have named new varieties based on CIAT developed lines, and some cases of measurable impacts on national production are beginning to be noted. The naming of new, more productive and disease resistant bean varieties in several Central American countries, and the naming of **Andropogon gayanus** *as a highly promising new grass variety in Colombia and Brazil, are examples of the flow passing from CIAT through the important "check valves" of national programs to farmers and ranchers.*

The dramatic increase in yields and national production of rice in Colombia has for several years been the chief example of the collaborative efforts between CIAT and the Instituto Colombiano Agropecuario (ICA). New data compiled in this report shows that a large number of other countries have also greatly increased their rice yields as a result of new varieties coming out of these efforts. The expectation that other CIAT programs will soon be able to report major increases in national production and productivity for their crops is enhanced by preliminary reports of large cassava yield increases in Cuba as a result of adoption of CIAT generated technology.

Such encouraging results are possible only when national research and extension programs are able to play their key role in the evaluation, adaptation and transfer of new production technology. It is encouraging, therefore, to note in this Report the many ways in which the collaboration between CIAT's programs and national programs is being strengthened. Examples include: the expansion and refinement of cooperative testing of promising forage materials; the further fine-tuning of bean *nurseries to national program requirements to avoid overloading cooperators with materials unsuited to local environments or consumer preferences; the increased use of a combination of short courses in production research for the various crops followed by disciplinary in-service training to individualize training programs for specific needs; the expansion of the number of audio tutorial units and the increased use of these in national training programs; the full development of the Seed Unit to train seed specialists and help promote a productive seed industry in this continent.*

The results reported here also continue to support the validity of CIAT's low input philosophy at the same time as world concern grows over the feasibility of technology overly dependent on high energy use. Many examples are given of progress in our attempts to reduce dependence on high level inputs through resistance to insects and diseases; adaptation to adverse soil conditions; tolerance to drought; greater intrinsic efficiency in the uptake and utilization of nutrients; and reduced tillage requirements. These confirm the possibility of producing technology which will increase production and productivity while responding to cost and energy constraints. Potential inequities in access to the benefits of the new technology will also be substantially reduced by this philosophy and these achievements.

At the same time the results reported here were being achieved, scientists and administrators at CIAT were developing a long-range plan for the Center for the decade of the eighties. This plan will be published in mid-1981. Studies conducted to provide a socio-economic context for this plan demonstrate the urgency of increasing food production in the Latin American tropics. Statistics compiled from various sources reveal the extent to which increased production is lagging behind increased demand for the commodities in CIAT's mandate. Information on the percentages of the populations of various countries receiving less than minimum requirements of calories and protein, as well as data on the percentage of income spent on food, highlight the human impact of the supply/demand statistics. The "bottom line" of CIAT's efforts is to make a contribution to the solution of these serious problems of malnutrition and poverty.

I wish to thank my colleagues for their dedication and industry, and the progress they have made in this noble task. I wish to thank the growing number of donors who *continue to make this work possible. In 1980 Mexico joined the list of the contributors to CIAT's core budget. This expression of support from a country in the region CIAT serves, as well as an increased level of support by many donors in the face of severe budget constraints, encourage us greatly. My colleagues and I are grateful and hope the readers of this Report will share our sense of excitement over the results being achieved.*

Director General

Bean Program

Highlights

In 1980 the Program continued to make progress in incorporating resistance to bean common mosaic virus (BCMV) in all improved bean lines; high levels and frequency of resistance to common bacterial blight (CBB) were achieved in the Bean Team Nursery (VEF), as well as advances in multiple-disease resistance breeding. More selective use of different sources of resistance, and a greater emphasis on breeding by color and size to produce improved lines that meet local consumer preferences help the International Bean Yield and Adaptation Nursery (IBYAN) provide national programs with only those experimental lines that satisfy local requirements.

Cuba has made solid advances using IBYAN materials; some 20,000 hectares were planted in this country with the ICA-Pijao variety; Nicaragua released variety BAT 41 under the name "Revolución 79"; Bolivia planted BAT 10 and BAT 76; Honduras named Acacias 4, and Costa Rica the Talamanca variety. The three BGMV-resistant varieties released by Guatemala at the end of 1979 are being multiplied for distribution of certified seed. Further improvement of such lines is likely to be helped by the acquisition in 1980 of a new experimental substation named CIAT-Popayán, leased by the Fundación para la Educación Superior (FES), where the intermediate altitude and climate and low soil phosphorus enhance research selection and screening possibilities of the Program.

Another highlight in 1980 is the initiation of cooperative efforts with bean-producing nations in Eastern Africa - the second most important bean producing area in the tropics after Latin America.

The agroclimatic study of the Bean Program target area continued with the objective to characterize the climate, cropping systems, and factors limiting production in different areas, and to better define the global importance of specific constraints. Thus in 1980 it was able to list areas susceptible to anthracnose and to show that 57% of the target area production, equivalent to approximately two million tons of beans, is subject to this pathogen.

Background and Objectives

The common bean, an important food crop in tropical zones, is produced by small farmers primarily in association with maize, in poor soils and with limited inputs. Bean production has not kept pace with the rising demand for this product; it is limited by the plant's susceptibility to diseases and pests, its physiological defects and the periods of drought. Thus, from the outset, the Bean Program has sought, in conjunction with national bean programs, to increase the yield of the common bean through the development of improved varieties; these improvement efforts have concentrated initially on disease resistance, commercial acceptability and adaptability to bean producers' cropping systems.

Figure 1. *Bean production regions in target area.*

Activities in 1980

Germplasm Screening and Improvement

The Bean Team is developing experimental lines resistant primarily to BCMV, rust, CBB, anthracnose, angular leaf spot and *Empoasca;* it seeks also to improve plant architecture mostly as a disease -avoidance mechanism, to increase yield, atmosphere nitrogen fixation, and tolerance to drought and low soil phosphorus. Table 1 reflects the Program's tendency to adjust to the specific varietal needs of the various countries, as expressed in the grouping of IBYAN entries by colors.

The bean germplasm collection managed by the CIAT Genetic Resources Unit currently contains more than 30,000 accessions of *Phaseolus* beans, 27,000 of which belong to *P. vulgaris*. Approximately one half of them have been multiplied and evaluated, and 10,000 have been catalogued for information and distribution purposes; computer files on the complete collection, and information on 32 descriptors related to the four cultivated species *(P. vulgaris, P. lunatus, P. coccineus* and *P. acutifolius)* are available.

Climbing bean improvement projects were divided among different climatic locations at CIAT-Palmira, CIAT-Popayán, ICA-La Selva, and ICA-Obonuco, the latter two stations having mean temperatures of 17°C and 13°C, respectively. Genetic improvement in these two stations requires more time because only one, or two generations at most, are produced annually. Field selections are done under relay cropping or in association with maize — the most widely used cropping systems in the region. It is possible to select for high yields, both in maize and its associated bean lines, as shown in a trial carried out at CIAT-Palmira. It tested the efficiency of the early generation selection methodology used to maximize bean

Table 1. **Evolution of international bean nurseries in response to regional variation in commercial seed requirements.**

Year	Growth Habit	No. Trials	Color
1976	bush	one	all colors
1977 1978	bush	two	black non-black
1979	bush	five	black non-black
	climbers		black, red large colored
1980	bush	eight	small black red white cream large red
	climbers		red black large colored

Yield trial of bean and maize in association.

yields while minimizing losses in maize as a result of competition. The Suwan-1 maize variety was used, and a high correlation was obtained between F_3 family yield and the yield of selected F_4 lines.

Breeding for virus resistance continued with primary emphasis on identification and selection for bean common mosaic virus (BCMV) and bean golden mosaic virus (BGMV); being studied with lower emphasis are bean yellow mosaic virus (BYMV), the epidemiology of soybean mosaic virus (SMV), and the bean chlorotic mottle virus.

The BCMV screening methodology developed by the Program seeks to introduce the dominant necrosis gene (I) into susceptible germplasm; this dominant gene prevents systemic infection, which means that the virus cannot be seed-transmitted. As additional protection against certain strains of the virus, the Program is incorporating, through collaboration with IVT, Holland, recessive genes into gene I materials, whose F_3 generations had already been tested at CIAT. The evaluation done this year for bean common mosaic involved an average of 2000 plants inoculated and evaluated per work day (more than 250,000 plants in all).

Cases of bean cultivars infected with some strains of the common soybean mosaic virus (SMV) have been reported in Brazil. At CIAT, several isolates of SMV were tested on the BCMV differential cultivars, and results indicated that the genetic interaction between *Phaseolus vulgaris* and BCMV differs with respect to SMV. This should be taken into account whenever beans are grown near soybean fields.

Test to detect necrosis in gen I materials under high temperatures and humidity.

Chile is the country most affected by bean yellow mosaic virus (BYMV). Resistant cultivars are being developed with the cooperation of scientists from the Chilean Institute of Agricultural Research (INIA).

The bean golden mosaic virus (BGMV) project in 1980 focused on incorporating resistance in non-black grain types; efforts had previously concentrated on black-seeded types, which resulted in the release of three varieties by ICTA (Guatemala) which show excellent levels of resistance. Beginning in 1980, work is being done to combine BGMV resistance in red and Carioca materials consumed in Central America and Central and Southern Brazil.

As to fungal and bacterial diseases, primary emphasis continued on identification and selection for resistance to rust, anthracnose, angular leaf spot, and common bacterial blight - all diseases receiving high priority attention in CIAT. Advenced materials were also evaluated for their resistance to pathogens causing so called lower priority diseases such as powdery mildew, halo blight, white leaf spot, root rots and nematodes.

Pathogenically, rust and anthracnose are highly variable, making the identification of improved germplasm with stable resistance difficult. Consequently, the CIAT Program is following the strategy applied for other diseases which involves regional and sequential evaluation to expose germplasm to a wide local variety of pathogen populations; the trials carried out in Palmira are to detect resistance to rust and common bacterial blight, and in

Lines showing resistance or susceptibility to angular leaf spot.

Comparative resistance to common bacterial blight in BAT 1113 (resistant) and Porrillo sintético (susceptible).

Popayán to anthracnose and angular leaf spot. Materials resistant to these diseases in Colombia then undergo further international testing as in the International Bean Rust Nursery (IBRN) and the International Bean Anthracnose Nursery (IBAN).

The breeding program is using sources with higher anthracnose resistance than that of Cornell 49-242; in 1980 bush bean crossing was expanded to include resistance in materials intended for Argentina and the Andean highlands, in addition to lines being developed for Brazilian and Mexican conditions. The backcrossing program initiated in 1979 to incorporate resistance to both anthracnose and BCMV into high yielding climbing bean accessions was extended to include Peruvian varieties and red-seeded ICA lines adapted to the highlands. Cornell 49-242 has been replaced as double-resistance donor for BCMV and anthracnose by three climbing bean breeding lines (V7917, V7918 and V7920).

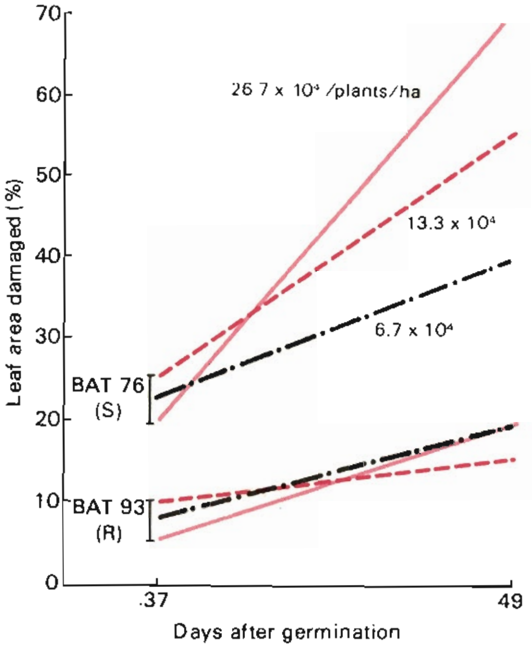


Figure 2. *Effect of density on bacterial blight development in a resistant and a susceptible bean variety*

Empoasca kraemeri (leafhopper) continued to receive preferential attention in the search for resistance and tolerance to insect pests. Almost 4000 materials from the various Program nurseries were evaluated as part of this work, and one third rated as resistant. The International Empoasca Resistance Nursery (IERN) was sent to Mexico, Honduras, Guatemala, Brazil and Peru. Percentage yield reduction is a better selection criterion for *Empoasca* resistance in breeding nurseries than visual damage score; consequently, the following modifications were introduced into the selection procedures: the elimination of susceptible materials using the visual damage score, and selection for high resistance based on reproductive adaptation under leafhopper stress, and relative yield losses.

Besides leafhoppers, screening for resistance included red spider mites and bruchids.

Two architectural traits of the plant are highly associated with bean bush yield: the number of pods and the number of seeds per plant. Work is underway to modify them by reducing foliage size, internode length and pod size. In some BCMV resistant lines it has been possible to transfer the principal traits mentioned. These lines could be used as parents in crosses with high yielding commercial cultivars.

Tolerance to moderately acid soils is another factor sought in breeding and genetic improvement. Plants that are efficient in using low soil phosphorus are not necessarily tolerant to moderate aluminum and manganese toxicity; however, black and color - seeded materials like EMP 28, BAT 458 and Carioca combine efficiency in low soil phosphorus use with tolerance to moderately acid soils. In preliminary studies, the latter appeared to be based upon the efficient use of absorbed P, not on its efficient extraction (Table 2). Crosses carried out in 1980 seek lines combining tolerance to moderately acid soils with resistance to anthracnose, angular leaf spot and common bacterial blight.

Selection of varieties tolerant to water stress uses two criteria: the percent yield reduction associated with drought stress and the summation of the canopy temperature differential during the stress period. Table 3 presents the lines of *P. vulgaris* showing the highest levels of drought tolerance in terms of the above criteria. At CIAT-Palmira, an experiment conducted to determine the causal factors associated with yield reduction due to drought stress showed

Table 2. **Yield and P absorption of one efficient and three inefficient accessions in using P under different P fertilizer levels.**

	Applied P (kg/ha)	Efficient accession	Inefficient accessions
Yield, g/m²	0	67	58
	11	77	71
	33	111	95
	349	214	174
P absorption, mg P/25 plants	0	38	46
	11	44	51
	33	53	59
	349	86	83

that water stress affects photosynthetic efficiency and such morphological factors as the number of pods having seeds, grain growth rate and seed weight.

Breeding for increased nitrogen fixation in bush bean cultivars was initiated in 1978; in 1980, 200 new crosses were made in the glasshouse, and field evaluation of F_2, F_3 and F_4 materials was initiated in Popayán and Santander de Quilichao.

The evaluation of bean quality done by the Nutrition and Food Quality Laboratory monitors nutritional quality in genetic improvement programs. The current aim is to see to it that new lines maintain nutritional value while resistance and yield are increased. The

P absorption of inefficient and efficient accessions.

Table 3. *P. vulgaris* **lines exhibiting drought tolerance according to percent yield reduction and the accumulated sum of the canopy temperature differential (ΣΔT,°C).**

	Yield (kg/ha)		Percent reduction		Rank	
Variety	Control	Drought	Yield	ΣΔT,°C[1]	% Reduc.	ΣΔT,°C
G 5743	2389	2310	3.3	28.9	1	3
A 54	2644	2292	13.3	32.7	2	8
BAT 336	2519	2028	19.5	38.6	7	10
BAT 258	2411	1844	23.5	31.0	12	7
A 27	2987	2126	28.8	27.9	18	2
BAT 131	1932	1391	28.0	25.5	19	1
Rank			3.3-93.7	25.5-123.1	1-216	1-216
LSD (0.01)			25.6	31.4		

[1] Summation for 23 days of stress.

laboratory evaluates beans for protein content, water absorption, cooking time, broth thickness, flavor, storability and consumer acceptance. Studies on storage and seed coat hardening showed that EP 1980 selections were neutral in terms of seed protein content; the selection for IBYAN-1980 materials was neutral in terms of protein content and cooking time but showed a strong tendency against hardening of seed coat.

General view of the new station CIAT-Popayán.

Uniform Evaluation of Promising and Improved Materials

Promising lines or cultivars which are genetically uniform and resistant to BMCV are evaluated in three stages: The Bean Team Nursery, VEF; the Preliminary Yield Trials, EP; and the International Bean Yield and Adaptation Nursery, IBYAN.

The Bean Team Nursery (VEF) is a multidisciplinary evaluation of materials in terms of their resistance to priority diseases and their adaptability; it covers CIAT lines and materials from national programs and the germplasm bank. In 1980 the VEF nursery comprised 166 climbing and 391 bush bean entries. There was a notable increase in CBB (Fig. 3) and anthracnose-resistant lines.

The Preliminary Yield Trials (EP) evaluate promising VEP materials which in addition to BCMV resistance, are resistant to at least one other disease or pest and show adaptation at CIAT-Palmira and/or CIAT-Popayán. Newly developed lines are evaluated for yield, nitrogen fixation, nutritional quality and resistance to a range of diseases, drought and low soil P. A total of 91 advanced bush bean lines and 14 climbing bean lines selected from the 1979 VEF were evaluated for those traits at several locations in Colombia and Costa Rica, and in the United States, the Netherlands and Tanzania for protein content, for resistance to races of anthracnose not found on CIAT testing sites, and for bean fly.

Yield trials were conducted at CIAT-Palmira and CIAT-Popayán under moderate fertilization similar to small farm conditions and both with and without chemical protection against diseases and pests. Each group of entries was compared with commercial varieties and international and elite checks of similar color and growth habits. All entries outyielded the controls (the ten best by 500 kg/ha) even though some of the controls were such well known commercial varieties as Carioca and Aroana (Table 4). All entries evaluated were of commercial colors or very close to them. Like the

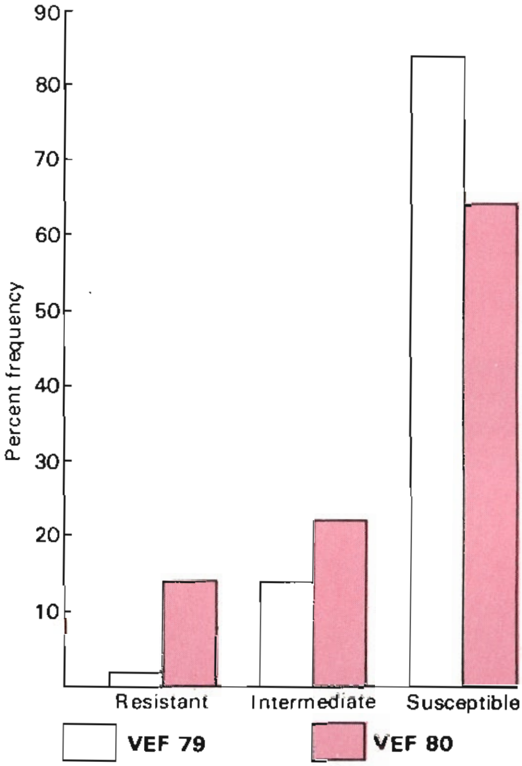


Figure 3. *Frequency of resistance and tolerance to CBB in the evaluation nurseries, VEF 1979-1980.*

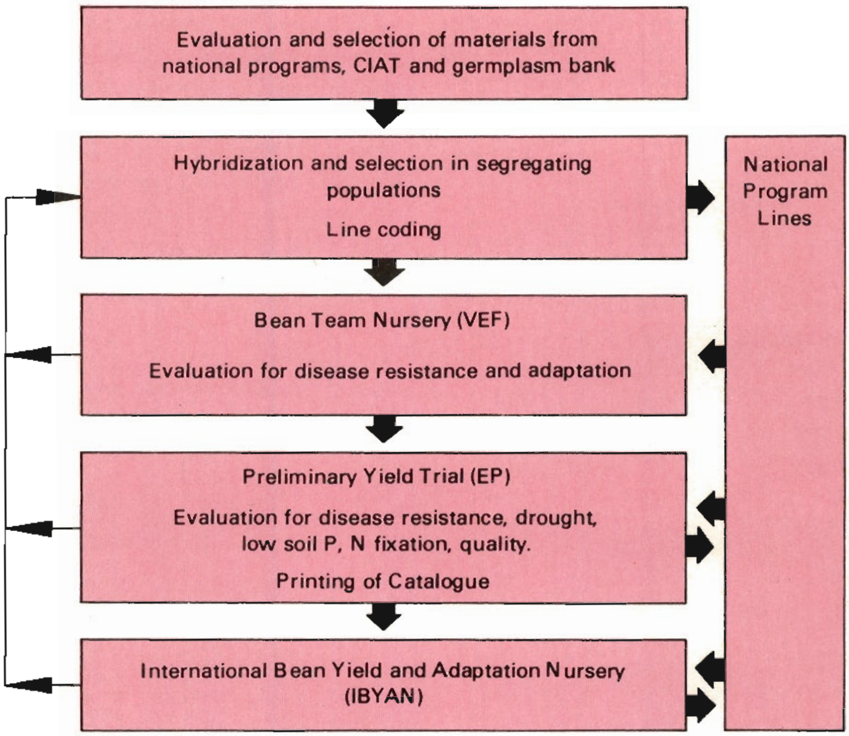


Figure 4. *Germplasm improvement and evaluation scheme of the Bean Program.*

Multiplication of ICA-Pijao seed in Cuba.

Table 4. **The outstanding colored materials from 1980 EP trials at CIAT-Palmira under non-protected conditions.**

	Identification	Growth Habit	Yield (kg/ha)
	Breeding materials		
1	A 51	II	1783
2	BAT 794	III	1755
3	BAT 874	II	1739
4	IAPAR-RAI-54	II	1734
5	BAT 947	III	1587
6	G 6520	III	1478
7	BAT 936	II	1464
8	BAT 331	II	1425
9	A 48	II	1424
10	BAT 805	II	1411
	Mean		1580
	Controls		
1	CARIOCA	III	1502
2	EX-RICO 23	II	1303
3	G 4421	II	1300
4	NEP BAYO 22-C-286	II	1224
5	AROANA	II	1206
6	BRAZIL 343	II	1141
7	BRAZIL 2*	I	1106
8	SWEDISH BROWN	I	693
9	NEP 2	II	415
	Mean		1099
	Elite Checks		
1	CARIOCA	III	1549
2	BAT 93	II	1339
3	BAT 332	II	1132
	Mean		1340
	Mean of 61 breeding materials tested		1161
	CV %		18.7
	LSD. 05		378

* International checks

bush beans, the climbing beans were planted without protection in CIAT-Palmira and with and without protection in Popayán; the results are presented in Table 5. The yield differences between breeding lines and controls are smaller under non-protected than under protected conditions, especially in the black seed color group. As in previous years, the results of all evaluations were published in the

Table 5. **Climbing bean breeding lines as compared to controls in CIAT - Palmira and CIAT-Popayán.**

Identification	Yield (kg/ha)		
	Non protected		Protected
	CIAT-Palmira	CIAT-Popayán	CIAT-Popayán
V 7936	1862	2366	2622
V 7939	1640	2035	2723
V 7923	1610	1308	2510
V 7944	1591	1963	2733
V 7945	1457	1979	2040
V 7955	1425	1441	2382
V 7917	1415	2617	3123
V 7920	1244	2999	3240
V 7921	1210	1668	2617
V 7913	1189	1339	1588
V 7918	1148	2750	3205
V 7959	1073	2157	2738
V 7949	983	2345	2919
V 799	769	1965	2370
Mean	1330	2138	2629
Controls			
G 2006	2245	1732	2518
G 2525	1664	1789	2144
G 2258	1581	2446	3135
Mean	1830	1989	2599
CV (%)	16	12	12
LSD. 05	388	400	545

Seed colors and sizes of a group of 1980 VEF lines. Each seed represents one line.

EP catalogue which was distributed to all interested parties for their selection of materials.

The International Bean Yield and Adaptation Nursery (IBYAN) consisted for the first time in 1979 of lines selected in the sequential evaluation system developed by the Program (VEF-EP-IBYAN). The IBYAN bush bean trial was tested in one trial for colored grains and in another for black ones; 157 nurseries were distributed in 33 countries, and the findings of 64 had been turned in as of October, 1980. Between 1976 and 1979, 515 nurseries have been distributed, 80% of them in Latin America.

In Colombia, performance of the BAT 271 black bean was impressive; BAT 304 performed well in Peru, Brazil, Venezuela, Ecuador, Costa Rica, Cuba and Dominican Republic; BAT 240 adapted to specific conditions in Venezuela.

The IBYAN of non-black materials was made up of 25 lines of various colors coming from the EP and included one ICA line, three international and three local checks. In 16 locations in 12 countries, Carioca and the BAT 85 and BAT 561 lines planted were outstanding in the advanced trial. Genotype x environment interaction was observed in both colored and black seeded materials in Popayán.

International tests with climbing beans began in 1978 with three nurseries of red, black and assorted colors. Climbing beans have undergone less genetic improvement than bush beans, are more sensitive to photoperiod and their adaptability is more limited. They underwent this year their first large-scale

Table 6. **Results of climbing bean international yield trials.**

Year	No. Results	Yield (kg/ha)		Days to flowering	
		Best entry	Best local check	Best variety	Best local check
1978/79	10	1351	1191	53	63
1979/80	12	1826	1323	52	71

adaptation trial in association with or in relay cropping with maize or in monoculture, depending on local preference. Some advanced breeding lines entered for the first time in 1979-80 and showed yield increases over checks despite their much shorter growing season. They were V7848 (black), V781 (red) and V717 (other colors).

Table 7. **The ten best out of 57 colored breeding lines from 1980 EP trials under protected and non protected conditions at CIAT-Popayan.**

Protected		Non protected	
Identification	Yield (kg/ha)	Identification	Yield (kg/ha)
BAT 1088	3304	G 6520	2569
BAT 799 *	3249	BAT 936	2447
BAT 838	3200	**BAT 839**	2257
BAT 331	3126	**BAT 799**	2233
BAT 477	3105	BAT 1105	2179
BAT 792	3097	BAT 337	2174
BAT 839	3081	**BAT 838**	2142
BAT 874	3002	**BAT 874**	2066
BAT 1061	3002	CENA 164-2	2063
BAT 947	2945	BAT 1127	2044
Mean	3111	Mean	2217
Mean control	2463	Mean control	1573

* The identifications in color show materials that belong to the ten best under both conditions.

Specific Studies

Genetic improvement, which is the main activity of the Bean Program, needs the support of specific studies in certain areas. Under non-stress conditions, yield potential of *P. vulgaris* was compared with eight other grain legumes. With the exception of *Arachis hypogea* (peanuts), the Leaf Area Duration (LAD) explained a large proportion of the variation in yield of the eight species compared.

Yield models were designed for each growth habit to help determine the relationship between the morphological and physiological factors on grain production. Their basic components were the Leaf Area Index (LAI), Crop Growth Rate (CGR), days to flower, and the number of nodes.

Likewise, a model was designed to predict crop phenology, which depends on temperature and photoperiod, and makes it possible to determine the suitability of the material for a particular region within the target area.

Evaluation of Agronomic Practices

Nitrogen fixation is one of the most important agronomic practices under study with the aim of identifying and supplying the cooperating programs with the best *R. phaseoli* strains. This year results were obtained from the first International Bean Inoculation Trial (IBIT) carried out with 10 superior strains of *R. phaseoli* in seven countries of the region.

In five of the IBIT trials yield increases occurred after inoculation; strains CIAT 632 and 640, in particular, were consistently among the best tested. In Piracicaba, Brazil, strain 640 outyielded the control to which the equivalent of 100 kg urea/ha had been applied. Studies were initiated to evaluate the competitive ability of CIAT strains of *R. phaseoli* in view of the high populations of soil *Rhizobium* in the IBIT sites in Mexico and Central America. In 1980, a second IBIT was distributed to 14 cooperating groups throughout the world.

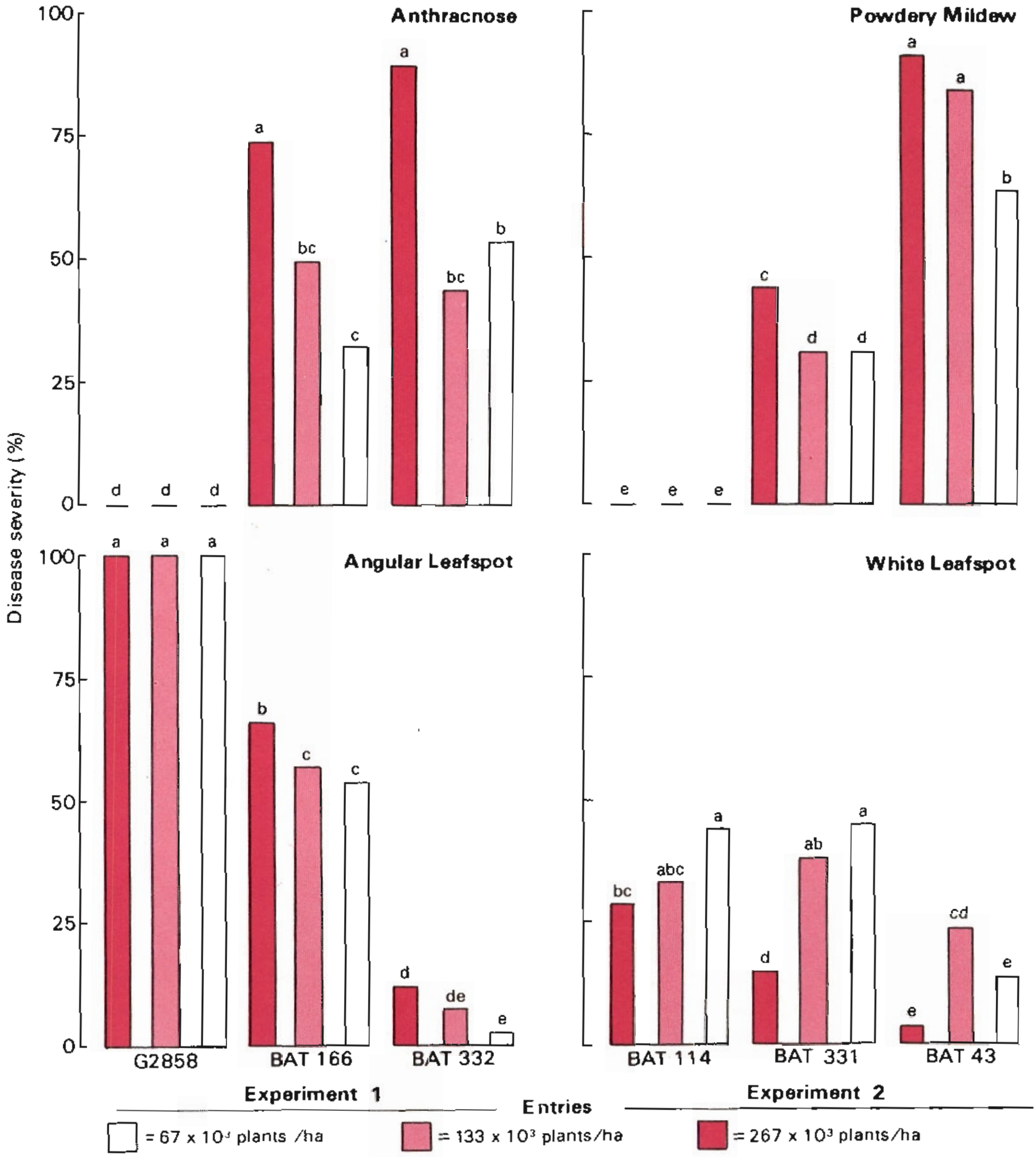
Another agronomic practice studied was the cultural control of *E. kraemeri* (leafhoppers) and other insect pests. In 1979 and 1980, it was reported that when beans were associated with surgarcane, insect pests occurred in lower populations than in bean monocrops. The experiments showed that the surgarcane-bean association is both agronomically and entomologically feasible.

Adequate on-farm storage of harvested beans could help the farmer overcome the problem of price collapse at harvest. Bruchids are responsible for most storage losses but they can be easily controlled by applying a small amount of cooking oil to the seed. Trials using this inexpensive non-toxic technology were established in seven farms in Huila. In a four-month storage period no damage to the seed occurred. Oil-treated beans are now sold in the Cali markets.

Experiments conducted in 1980 showed that high plant density foments disease development in susceptible materials. This may be one reason why farmers use low planting density in their bean crops. However, the Program has developed resistant varieties that when planted in high densities for better productivity do not show increased disease incidence (Figures 2 and 5).

Farm trials are the last stage in the series of evaluations of improved material and advanced agronomic practices. The principal aim of farm trials is to provide researchers with feedback information on the profitability of the new practices for the farmer and on the farm-to-farm variability in respect to new technology; these variations result from differences in micro-climates, disease and pest incidence, fertility, particular cropping systems and individual farmer's ability. Samples are taken of about 15 farms in each ecosystem which make it possible to stratify the various economic responses to the new technology. In Colombia in 1980 trials were again carried out on farms in Huila for bush beans and Antioquia for climbing beans; these two departments produce together almost one third of the beans grown in Colombia.

In Huila, bean-maize association was tried using Diacol-Calima and Suwan 1 maize, both

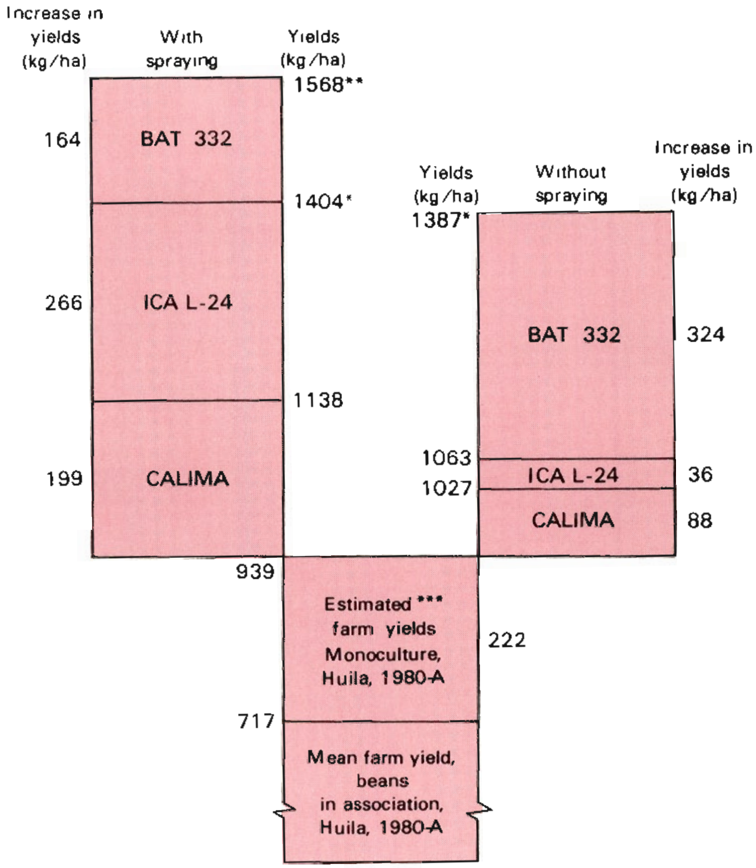


Values for each disease x entry x density interaction followed by a different letter are significantly different (p = 0.05) according to Duncan's multiple range test.

Figure 5. *Plant population density x disease interactions.*

under minimum inputs. The resulting profits were much greater than they were under monoculture practices primarily as a result of the Suwan 1 premium prices and increased yield which almost doubles the local ("criollo") maize yields. Bean yields in association were substantially below monoculture yields. Web blight seriously limits bean production in Huila. Preliminary observations indicated that mulching, a common practice in Costa Rica, is an effective cultural control of this disease.

The BAT 332 line is resistant to BCMV and is moderately resistant to angular leaf spot, rust and several strains of anthracnose. It was compared in on-farm trials with ICA line L-24



* Significantly different from farmers' yields at the 90% confidence level.

** Significantly different from farmers' yields at the 97.5% confidence level.

*** The Huila farm survey indicated a 26.6% reduction of bean yields from association; utilizing this same percentage gives an estimate of 939 kg/ha for farmers' monoculture yields; this yield estimate is also consistent with the yields of Calima without spraying of 1027 kg/ha.

Figure 6. *Farm yields of various varieties with and without spraying and high density compared with farmers' yields, monoculture systems, Southern Huila, 1980 (undamaged seed).*

which is resistant to BCMV. BAT 332 is not a variety with commercial seed color in Colombia, but its high yields without spraying — 324 kg/ha more than ICA L-24 — fully support the strategy of breeding for disease resistance and incorporating it into commercial varieties.

In Antioquia trials were conducted on such agronomic practices as the use of improved supports for the Cargamanto variety, increased crop density, better disease control and new varieties. The price of Cargamanto sharply fell in 1980, and the benefits derived from the improved practices also declined. During the 1980 trials, the yield from the new E1056 variety was high but did not outyield Cargamanto. However, its resistance to anthracnose reduced production costs and increased farmers' profits.

Training

Albert Okongo, trainee from Kenya, evaluates a bean-maize relay system.

Training is one of the Program's most important activities since it helps strengthen national bean improvement programs. In 1980, 69 professionals from all over Latin America received training at CIAT in short or specialized courses on bean production. Also, five M.S. and two Ph. D. candidates did their research work under the guidance of Program scientists.

Two workshops were offered in CIAT-Palmira for plant breeders from Brazil and Mexico who had the opportunity to exchange experiences and methodologies among themselves and with CIAT breeders and select lines of specific interest to them in the Team's nurseries.

Cassava Program

Highlights

In order to develop improved technology under unfavorable conditions, it is necessary to understand the cassava plant reaction to the various factors which constrain yields. This year progress was made in defining the manner in which water stress affects cassava growth and development. In addition, the importance of mycorrhizal associations in P absorption were clearly demonstrated. Mealy bugs are an important pest in Africa, and several potentially useful biological control agents were found in the past year. Superelongation disease is a major disease of cassava, and the causal agent shows considerable variation; its sexual stage was discovered last year.

The constraints on cassava production vary according to the growing conditions in different environments; these have been defined in broad terms and the yield limiting factors identified. There is a strong genotype by environmental interaction; as a result, efforts have been concentrated, through breeding and selection, on developing improved lines with stable high yields for each of the major production areas. The best lines have been tested in the regional trials with simple improved technology. In most cases, the local lines gave good yields with the improved technology, and yields were even greater with the best lines. Several of these showed a broad range of adaptability with excellent yields in several sites.

The effectiveness of the improved cultural practices has been demonstrated on farm trials and also on a commercial level in Cuba, where productivity, on a large number of state farms, has increased from about 7 t/ha to more than 20 t/ha. Several Latin American and Asian countries are now developing commercial varieties from material selected by CIAT. The interchange of such material has been greatly facilitated by the use of meristem culture, which has been widely accepted by cooperating agencies as the safest way of exchanging cassava clones.

Background and Objectives

Cassava is the fourth most important source of food energy in the developing countries of the tropics. Most of the cassava is used for direct human consumption either as fresh roots or as a variety of flours, but in the last few years the quantity utilized in animal feed has increased and small amounts are used for starch production and as the raw material to make ethanol. Increased demand in the future appears to depend mainly on reduction of the marketing margin in the case of fresh roots and reduced production and processing costs for the other markets. In the case of production costs, casssava has an innate advantage over many other crops in that it grows well under conditions normally considered as marginal for crop production. Nevertheless the crop is highly perishable once harvested, hence improved post harvest technology is of great importance if its role as a basic energy source is to increase.

Research results and some experience at the commercial level indicate that cassava production can be increased through simple improved technology based on relatively low levels of purchased inputs and improved varieties. While very high yields of 70 - 80 t/ha have been obtained on experimental sites with excellent conditions, it is of greater significance that under more marginal conditions yields much greater than the 11 - 12 t/ha average of Latin America have been obtained consistently. It, then, appears possible to develop technology that can increase yields in areas where cassava is presently grown and also to increase production by expanding the area planted on land that is presently not used for crop production. This latter fact would allow increased total production of cassava without displacing other food crops.

The potential benefits of this strategy are considerable. Not only can food production, through increased direct or indirect consumption of cassava be increased, but also new jobs and development can be expected in marginal areas, foreign exchange can be saved and a cheap source of calories be provided for the poorer segments of the population.

In light of this, the goal of the cassava program is to satisfy a need for food and feed carbohydrates by converting cassava from a traditional rural staple to a major, multi-use carbohydrate source in tropical food economies. This can be done by exploiting the plant's carbohydrate production efficiency under sub-optimal environmental conditions. The cassava program thus focuses on both production and utilization technologies, particularly for Latin America. The program also recognizes the potential of cassava as a major food and feed source in Asia and Africa and will place emphasis on adapting technologies developed at CIAT to Asian conditions.

This overall goal is to be reached through the following objectives:

- To develop germplasm and associated cultural practices that require low input levels and are responsive to improved management, to increase cassava production per hectare in areas where cassava is presently grown.
- To develop germplasm and associated management practices, which, under medium input conditions, will lead to increased cassava production in the acid, infertile, underutilized soils of the lowland tropics.
- To develop systems that can be used to improve the utilization of cassava and allow more efficient use of cassava for either direct or indirect human consumption.
- To strengthen national cassava research and development programs so that they can more effectively carry out their role.

Activities in 1980

Studies of Cassava Production Constraints

Cassava is generally grown in marginal areas with poor soils without the use of such inputs as fertilizers, pesticides, and irrigation. In these circumstances it is important to understand the plant's reaction to stress conditions and also to understand the ecosystem in which the plant grows. In order to do this the characteristics of the major production areas of cassava have been defined and the major constraints on yield and quality assessed (Tables 1 and 2).

Cassava is frequently grown under conditions of limited water supply; this year artificial drought, obtained by covering the soil with plastic sheets, was used to study growth and development under water stress. While total growth is reduced markedly by water stress, the growth of the tops is reduced more than that of the roots and hence yield reduction is minimized. A sparse root system, reduced leaf area and partial closure of the stomata all lead to a slow use of available water allowing continued but rather slow growth during drought periods. After a stress period, carbohydrate supplies in the roots are mobilized and the leaf area rapidly increases largely due to an increase in leaf size. The leaves on previously stressed plants are even larger than those on non-stressed plants in the recovery period. Nevertheless, top growth of previously stressed plants in the recovery period is less than that of non-stressed plants, leading to a more favorable balance between tops and roots. In the case of a vigorous variety, this resulted in greater yield of stressed plants than unstressed plants by final harvest; however, root dry matter content was slightly reduced.

Table 1. **Cassava production regions and their main characteristics.**

Growing region	General description and representative areas	Mean temperature	Dry season duration	Annual rainfall
1	Lowland tropics with long dry season; low to moderate annual rainfall; high year-round temperature. (Media Luna, Caribia, Nataima and Guajira, Colombia; Southern India, Northeastern Brazil; Northern Venezuela; and Thailand)	above 25°C	3-4 mo	700-1200 mm (unimodal distribution)
2	Lowland tropics with moderate to high rainfall, savanna vegetation on infertile, acid soils; moderate to long dry season; low relative humidity during dry season (Llanos of Colombia (Carimagua); Llanos of Venezuela, Cerrado of Brazil.)	above 25°C	3-6 mo	above 1200 mm (unimodal distribution)
3	Lowland tropics with no pronounced dry seasons; high rainfall, constant high relative humidity. (Florencia, Quibdo and Leticia, Colombia; Amazon Basins of Brazil, Ecuador and Peru; rainforests of Africa and Asia.)	above 25°C	absent or very short	above 2000 mm
4	Medium-altitude tropics; moderate dry season and temperature. (CIAT-Palmira and CIAT-Quilichao, Colombia; Costa Rica; Bolivia; Brazil; the Philippines, Africa; India; Indonesia; Viet Nam.)	21°-24°C	4 mo	1000-2000 mm (unimodal distribution)
5	Cool highland areas; moderate to high rainfall (Popayan, Colombia; Andean region; East Africa.)	17°-20° C		above 2000 mm
6	Sub-tropical areas; cool winters; fluctuating daylenghts. (Mexico (Culiacan);Southern Brazil; Cuba, Paraguay, Northern Argentina; Taiwan; Southern China.)	min:0° C		above 1000 mm

Table 2 **Production constraints in different cassava growing regions.**

Growing region	Major Constraints					
	Rainfall	Temperature	Diseases	Insects and mites	Soil fertility	Others
1 Lowland tropics (dry season) **Coast**	3 5 mo dry season, limited rainfall		Anthracnose, pathogens of planting material	Mites (*Mononychellus* spp) thrips hornworm whiteflies	Usually low	Low starch content, limited water retention in soils
2 Lowland tropics (dry season and infertile soils) **Carimagua**	3-5 mo dry season, relative humidity near saturation during rainfall season	Fluctuations enhance disease severity	CBB anthracnose superelongation *Cercospora*	Mites (*Mononychellus* spp) thrips lacebugs stemborers	Acid infertile soils; aluminium toxicity	Drought stress
3 Lowland tropics (humid) **Florencia**	Very high		*Cercospora* brown spots root rots	Mealybugs	Acid infertile soils with nutritional problems and Al toxicity	
4. Medium altitude tropics (≤1000 m) **CIAT**	3 4 mo. dry season		Root rots *Cercospora* brown spots	Thrips hornworm	Variable	
5 Highland tropics (≥1000 m) **Popayán**	Variable	Cool 17-20°C year round	Phoma leaf spots, anthracnose *Cercospora* white spots	Mites (*Olygonychus* spp)		
6 Sub-tropics (cool winter)	Variable	Cold winter 3 mo less than 10°C	Anthracnose	Hornworm		Limited harvest period, drought

In Latin America phosphorus is the major nutrient that is normally most limiting in the vast areas of acid, infertile soils. In both Carimagua and CIAT-Quilichao, lines are being screened for tolerance to low soil phosphorus and high acidity. In addition, mycorrhizal inoculation has been found to increase the absorption of phosphorus by plants grown under conditions where low phosphorous levels prevail. In green house trials a dramatic response to inoculation was observed (Fig. 1). When plants were inoculated, normal growth was observed even without applied P, while without innoculation plants were phosphorous deficient even with 800 kg P/ha applied, and reached maximum growth only when applications were as high as 1600 and 3200 kg P/ha. These results clearly indicate the dependence of cassava on mycorrhiza in P deficient soil. However, the practical implications of this technology are not yet clear. The relative efficiency of native and introduced strains on phosphorous absorption are still not known.

Many diseases cause yield losses in cassava; however, resistance to most of these has been identified. Fortunately,disease resistance tends to be stable throughout time. In 1980, however, the sexual stage of *Sphaceloma manihoticola*, the causal agent of superelongation disease, was discovered and tentatively identified as a species of Elsinoë not previously described in the literature (Fig. 3). This finding suggests that there may be considerable variability in the pathogen; the possible existence of physiological races is under study.

Considerable progress was also made in the study of cultivar susceptibility to post harvest deterioration. Varietal reaction is extremely variable both within and across different sites. Exogenous applications of a compound, shown by work at the Tropical Products Institute of London to be important in deterioration, resulted in effects similar to those found under natural conditions. Pruning plants before harvest and stress conditions were both found to reduce susceptibility to physiological deterioration; however, these treatments also reduced starch content of the roots.

In addition to diseases, insect pests are also important constraints on cassava production. Resistant varieties, biological control and, as a last resort, limited use of chemical products are utilized to develop integrated pest management. The biological control agents, *Trichogramma* and *Telonomus* (both egg parasites) were found to increase after an initial attack by the hornworm; damage caused by repeated attacks may be greatly reduced by the build up of natural enemies.

In the Americas natural enemies normally reduce levels of the mealybug to levels where the pest causes little damage. However, in Africa *P. Manihoti* causes severe yield losses. A species similar to *P. Manihoti* was identified for the first time in Colombia in 1978, and this year *Kalodiplosis coccidarum* was shown to be an effective biological control agent. This agent has now been sent to biological control programs in Africa for further testing.

Whiteflies, until recently, were considered of importance solely due to the fact that they are vectors of African Mosaic Disease. However, they can *per se* cause severe yield losses. The hybrid CM 489-1 was found to be tolerant to their attack with very little yield depression in spite of a heavy infestation.

The fruitfly *(Anastrepha pickeli)* does not normally cause severe yield losses, but it greatly reduces both the quality and quantity of planting material. Insecticides applied for the

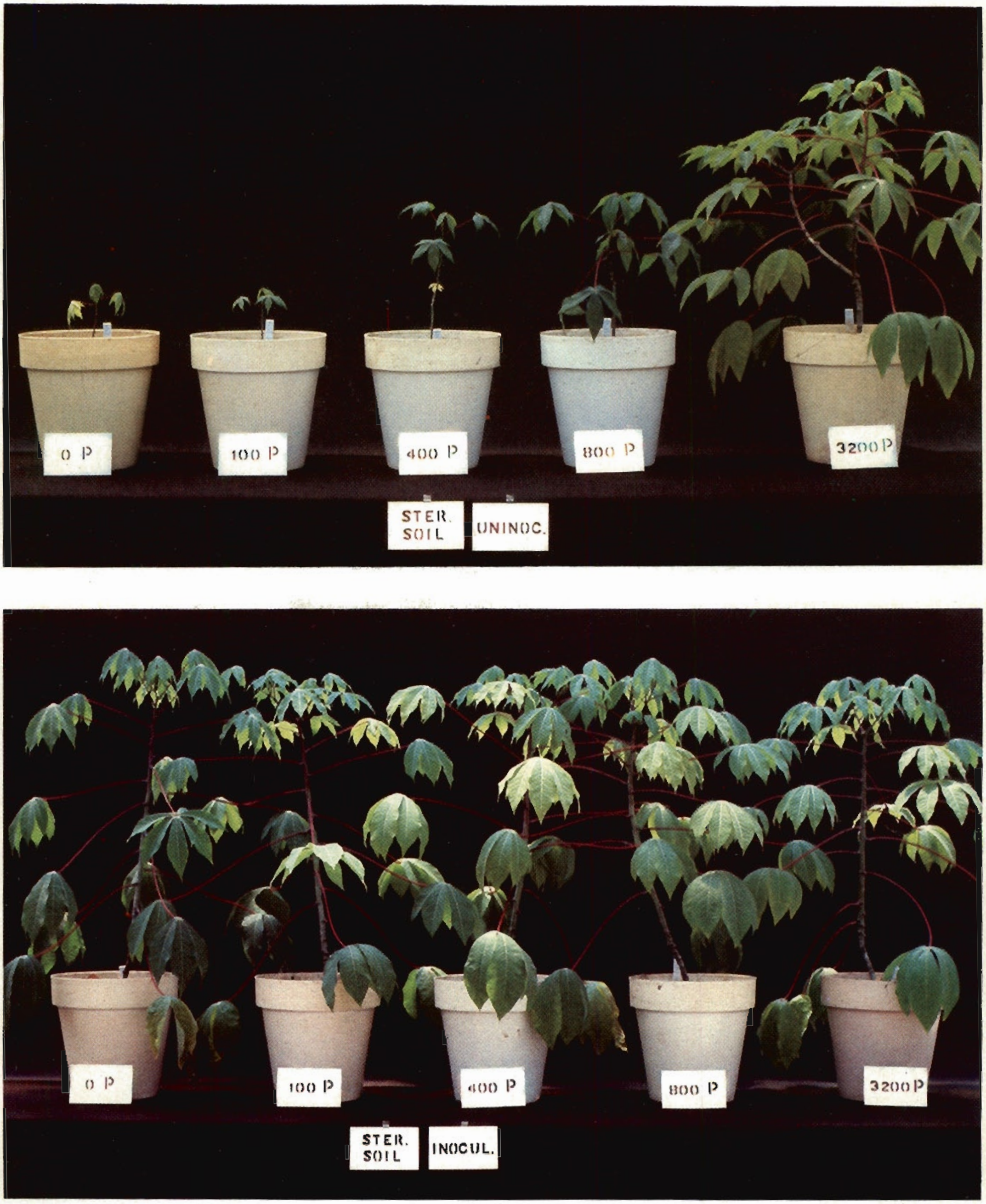


Figure 1. *Response of M Mex 59 to mycorrhizal inoculation and various P levels applied to a sterilized soil from CIAT-Quilichao.*

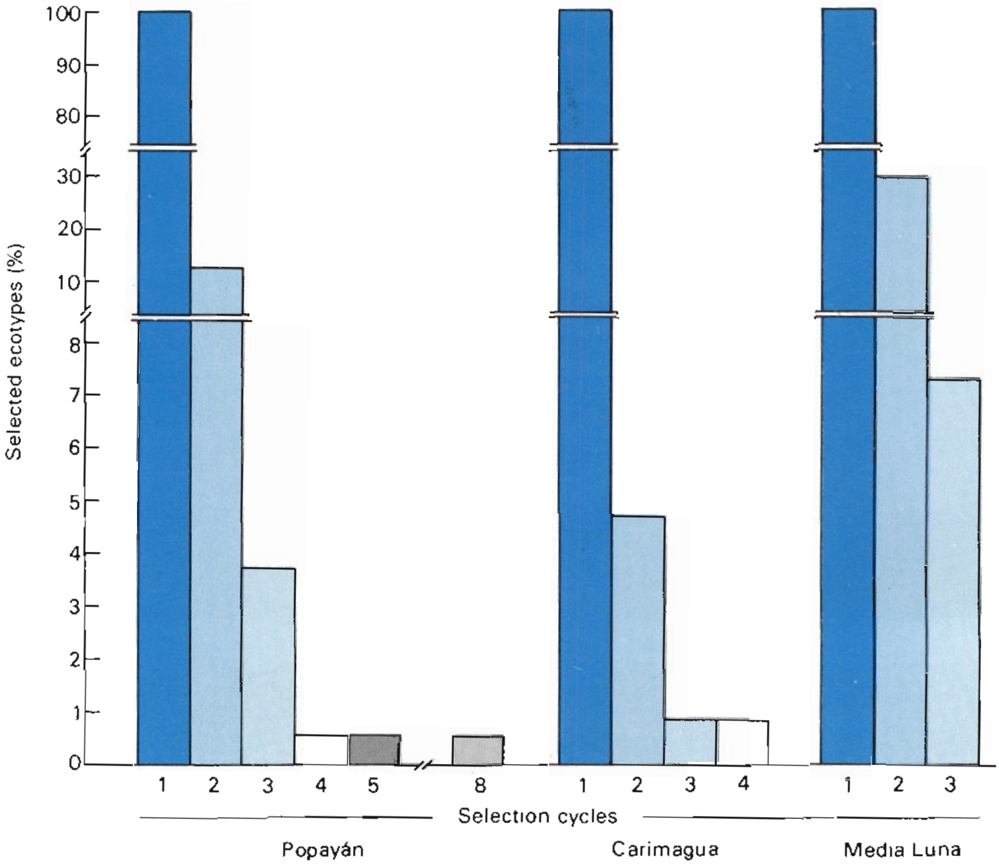


Figure 2. *Selection of genotypes with stable resistance to biotic problems in Popayan, Carimagua and Media Luna.*

first three months of the growth cycle effectively eliminate losses of planting material (Fig. 4). However, the use of insecticides for fruitfly control is only recommended during the early growth stages and on restricted areas for the production of planting materials. Disease and pest control, in general, is based on varietal resistance and biological control.

A major problem with screening for varietal resistance is the fact that only one cycle of screening will not necessarily determine the reaction of the plant to different diseases and pests over several years. Thus when the same materials were planted over several years, it was only after several cycles that lines truly tolerant to the disease and pest pressure, over time, could be identified (Fig. 2 above).

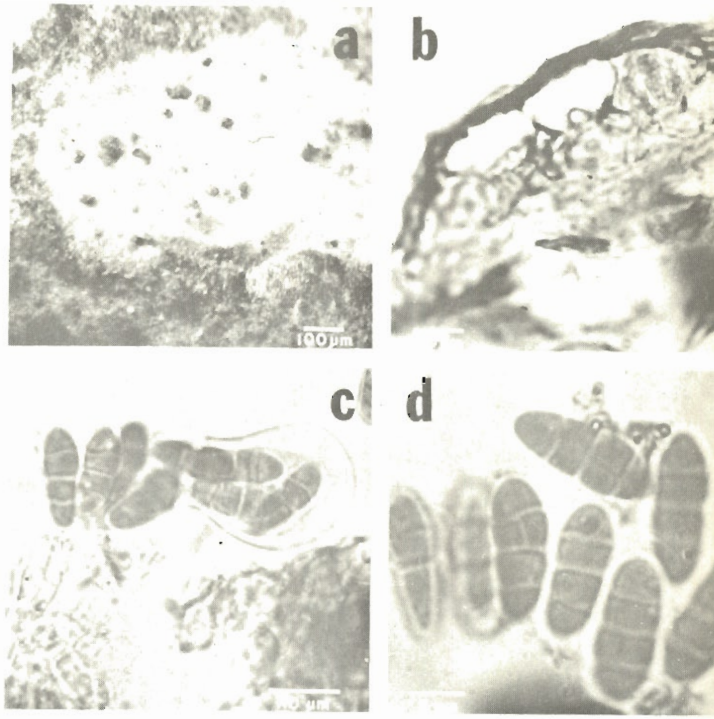


Figure 3. *Ascostroma, asci and spores of the sexual stage of* **Sphaceloma manihoticola** *tentatively identified as a species of* **Elsinoë:** *a) Ascostroma on surface of a stem lesion; b) section through an ascostroma showing well defined locules with only one globose ascus per locule; c) ruptured bitunicate ascus showing 8 ascospores; d) ascospores showing muriform character.*

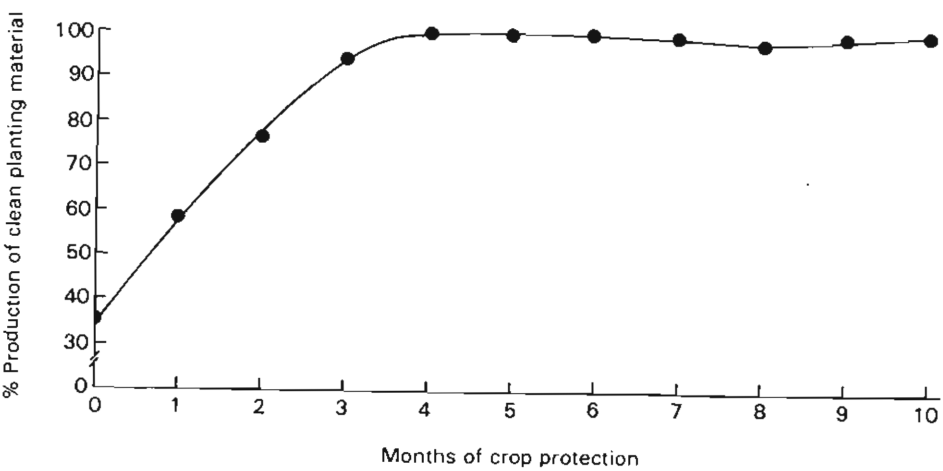


Figure 4. *Production of fruitfly* **(Anastrepha manihoti)** *damage-free planting material by periodic applications of insecticide.*

Genetic Improvement

Disease and pest resistance, tolerance to stress conditions specific to different producing areas, and stable yields of high quality cassava are the major objectives of genetic improvement. This is. however, a costly and slow research endeavour, particularly due to cassava's long growth cycle. Field evaluations must be done in environments similar to those where cassava has been traditionally grown, or those of new growing areas so that new selections maintain the same or greater levels of tolerance to diseases, pests or other stresses than the native varieties. For evaluation purposes, the program gives first priority to the following production areas: Caribia in the Northern coast of Colombia, representative of large cassava-growing areas in the Americas and Asia; Carimagua, in the Eastern Plains of Colombia, with acid infertile soils and very high disease incidence, representative of vast areas of underutilized land where cassava production could be expanded; Popayan, a high altitude, cool climate zone, and CIAT-Palmira, with low levels of stress.

The program has developed a multi-stage genetic improvement procedure involving: a) evaluation of germplasm accessions in various ecosystems for possible recommendation as new cultivars or for potential contribution as parents in hybridization programs; b) formation of broad-based gene pools with high levels of resistance/adaptation in specific ecosystems; c) "fine tuning" of the final product in the varietal improvement stage to assure acceptability in all aspects by producers, processors and consumers.

In Caribia, an outstanding germplasm selection, M Col 1684, and several hybrids continued to outyield local cultivars (Montero and Manteca), with several lines having high dry matter content of the roots as well as good yield potential. Three new hybrid selections were advanced to regional trials for further evaluation in the hot lowland tropics. In Carimagua the emphasis of selection continues to be a combination of stable yield with high dry matter content and disease and insect resistance. Six new selections were passed to regional trials in tropical savanna conditions. Tables 3 and 4 describe promising lines adapted to Caribia and Carimagua conditions, respectively.

CIAT-Palmira is a low stress environment where CIAT lines showed excellent yield and root dry matter content. A good example is CM 849-1 which gave a root yield of 71 t/ha/year with 39% root dry matter content. However, rather than develop varieties which occasionally produce very high yields, the emphasis is on selecting lines which give good yields and which are stable over years and seasons in each respective production region. Good examples are CM 342-170 in Caribia, and CM 516-7 in CIAT Palmira. At Carimagua, in spite of the extremely severe stresses, two lines, CM 517-1 and CM 523-7, gave moderate yields with little variation between seasons and years.

The production of good planting stakes is difficult under high stress conditions such as those in Carimagua. On the contrary, CIAT-Palmira is a low stress environment where it is relatively easy to produce good quality planting material. Nevertheless, several selected lines yielded well irrespective of whether the planting stakes were obtained from CIAT or from Carimagua (Table 5).

Table 3 **Promising lines adapted to Caribia conditions.**

Lines	Cross (year)	At Caribia							Pest Reaction[1]		
		Root yield (fresh, t/ha)	Harvest index	Root dry matter content	Eating quality	Ease of harvest	Root length	Root skin color	CBB	Superelon-gation	Thrips
1980 Selection											
CM 681-2	M Ven 185 x M Col 22 (1976)	38	55	39	good	easy	short	white	S	S	MR
CM 728-2	CM 180-5 x M Col 1684 (1976)	29 - 33	.47 - 53	34 - .37	acceptable	average	medium	white	S	S	S
CM 728-3	CM 180-5 x M Col 1684 (1976)	38 - 42	43 - 55	.30 - 37	bitter	average	medium	brown	S	S	MR
Selection before 1980											
CM 342-170	M Col 22 x M Col 1468 (1974)	24- -42	50 - .62	31 - 35	good	easy	short	white	S	S	R
CM 323-403	M Col 22 x M Mex 59 (1974)	27 - 66	40 - .64	.29 - 30	poor	easy	medium	white	S	S	MR
CM 91-3	M Col 688 x Llanera (1973)	8 - 42	.43 - 51	31 - .34	good	average	medium	brown	MR	MR	MR
M Col 22		17 - 39	45 - .57	31 - 35	good	easy	short	white	S	S	MR
M Col 1684		21 - 51	.41 - 58	.29 - .32	bitter	difficult	long	white	MR	MR	S
Local check											
Montero		5 - 29	15 - 40	.31 - 38	good	easy	medium	brown	S	S	R
Manteca		5 - 30	20 - 45	30 - 36	good	easy	medium	white	S	S	R
Secundina (Media Luna information)		6 - 16		33 - .38	good	average	medium	brown	S	S	M

[1] Ratings for pest reaction, S = Susceptible, MR = Moderately Resistant, R = Resistant

Table 4. **Promising lines adapted to Carimagua conditions.**

Lines	Cross (year)	At Carimagua							Pest Reaction[1]		
		Root yield (fresh, t/ha)	Harvest index	Root dry matter content	Eating quality	Ease of harvest	Root lenght	Root skin color	CBB	Superelon-gation	Thrips
1980 Selection											
CM 516-18	M Col 647 x M Col 1684 (1975)	6 - 16	42	30	acceptable	difficult	medium	brown	MR	MR	MR
CM 723-3	CM 180-4 x M Col 647 (1976)	16 - 24	.46 - 64	35 - 37	good	average	medium	brown	R	R	MR
CM 841-168	M Col 638 x M Pan 70 (1976)	22	.50	.28	acceptable	average	medium	brown	R	R	R
CM 946-2	CM 307-37 x CM 429-17 (1977)	33	.77	31	acceptable	easy	short	yellow	R	MR	MR
CM 961-6	CM 307-37 x M Col 638 (1977)	26	.64	28	acceptable	easy	short	yellow	R	R	MR
CM 996-6	CM 323-99 x M Col 638 (1977)	27	.60	.28	poor	easy	short	white	R	R	MR
Selection before 1980											
CM 523-7	M Col 655 A x M Col 1515 (1975)	12 - 26	33 - 62	.33 - .38	acceptable	easy	medium	brown	R	R	R
CM 517-1	M Col 647 x M Col 1515 (1975)	13 - 21	.37 - .56	.30 - 31	acceptable	difficult	long	white	R	R	S
CM 91-3	M Col 688 x Llanera (1973)	12 - 29	48 - 56	31 - .37	good	average	medium	brown	MR	MR	MR
CM 430-37	Llanera x M Col 647 (1974)	16 - 23	62 - 66	.32 - 34	good	average	medium	brown	MR	MR	MR
CM 507-34	Llanera x M Col 1684 (1975)	11 - 13	.36 - .53	30 - 31	good	average	medium	brown	MR	MR	S
CM 507-37	Llanera x M Col 1684 (1975)	9 - 17	.47 - 49	.29 - 31	acceptable	average	medium	brown	MR	MR	S
M Col 1684		4 - 36	.46 - .66	27 - .32	bitter	difficult	long	white	MR	MR	S
Local check											
Llanera		4 - 22	.25 - 56	.27 - 33	good	difficult	medium	brown	MR	MR	MR
M Col 638 (Chirosa Yema de Huevo)		6 - 25	24 - 48	24 - 31	acceptable	average	short	yellow	R	MR	MR

[1] Ratings for pest reaction. S = Susceptible, MR = Moderately Resistant, R = Resistant.

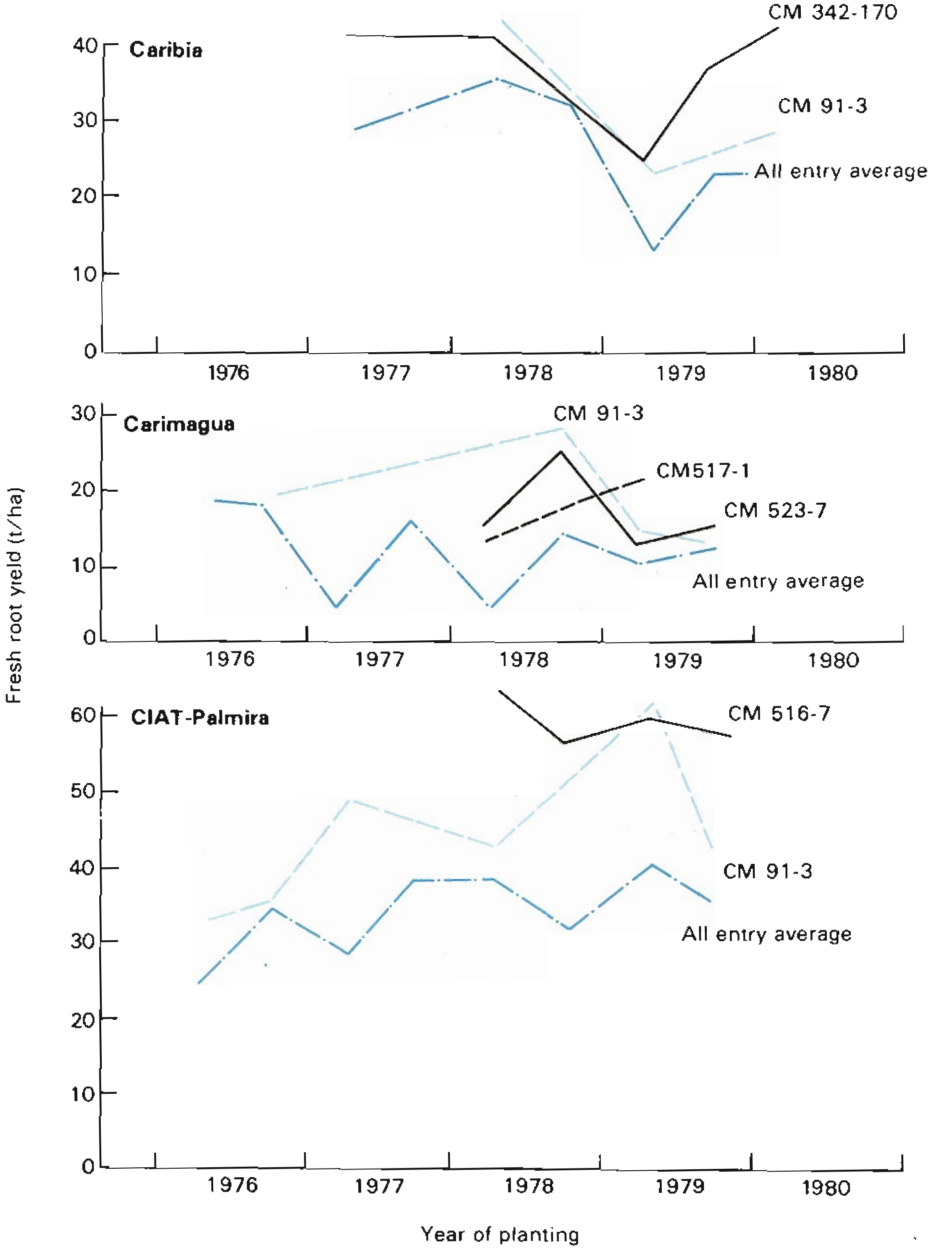


Figure 5. *Examples of stable yield lines at three locations.*

Table 5. **Yield comparison between Carimagua and CIAT planting stakes in selected cassava lines at Carimagua (planted October 1979).**

Lines	Root yield with Carimagua stakes (fresh, t/ha)	Root yield with CIAT stakes (fresh, t/ha)
New selections		
CM 946-2	31.3	34.7
CM 996-6	29.9	23.6
CM 983-5	22.9	not planted
CM 951-6	20.8	29.2
CM 976-2	19.4	9.7
CM 854-21	18.8	19.4
CM 1012-2	18.1	13.2
CM 840-323	18.1	16.7
CM 869-4	18.1	12.5
CM 840-324	17.4	20.1
Mean	21.3	19.9

Cultural Practices and Regional Trials

Improved varieties must be accompanied by low-cost cultural practices easily adaptable to small farm conditions. For this reason, at the same time as new lines are developed, improved practices such as weed control, management of mixed cropping systems, efficient fertilizer use, biological control, chemical protection and storage of stakes are developed and tested.

During the past year various herbicides and herbicide mixtures were shown to give effective weed control in monoculture and in mixed cropping systems. In the particular case of purple nut sedge *(Cyperus rotundus* L.), one of the most difficult weeds to control, integrated weed control methods were tested (photos following page) and found to be effective.

In many cassava growing areas the dates of harvest and planting do not coincide, and consequently farmers have to store planting material. During storage both the quality and the quantity of viable stakes decline. In the CIAT station stakes treated with fungicides and stored for six months remained viable and gave yields equal to freshly cut material (photo page 38).

Promising clones and cultural practices are jointly evaluated in regional trials. The sixth testing cycle was completed in 1980 with harvests at eight Colombian locations, each with different edapho-climatic conditions (Table 6).

The best selected lines yielded 37.5 t/ha as compared to 18.5 t/ha with the best local varieties, which in turn, yielded almost twice the world average yield of about 10 t/ha. This shows the tremendous potential to increase yields, even with local varieties, through improved management and also the further increases that can be obtained by adoption of superior lines. In addition, several lines showed a broad range of adaptability. M Col 1684, CM 324-55, and CM 489-1 outyielded the best local clones in seven out of eight sites CM 308-197 and CM 462-6 in six out of eight; CM 430-37, CM 321-188, CM 311-69, CM 451-1, CM 471-4 and ICA HMC-2, in five out of eight.

After six years of regional trials, the three most promising cultivars yielded an average of 34.6 t/ha of fresh roots as compared with 20 t/ha for local varieties. These are notable increases as compared to the national Colombian average estimated at 11 t/ha.

Cassava and mungbean intercrops in purple nutsedge control experiment. Mungbean provides a good ground cover as early as 30 days after planting, and shade is subsequently maintained through cassava. Caribia, 1979.

Table 6. **Main climatological and edaphic characteristics of the 1979-1980 Colombian regional trial sites.**

Site	Altitude (masl)	Mean temp. (° C)	Rainfall (mm)[1]	Days to harvest	Soil texture	Soil pH	Organic matter (%)	P Bray II (ppm)	K (meq/100g)
Media Luna	10	27.2	1190	328	Sandy loam	6.6	0.7	7.2	0.08
Chigorodó	28	28.0	1059	305	Silty clay loam	6.8	4.2	27.8	0.51
Carimagua	200	26.2	2867	398	Silty clay	4.7	3.2	1.9	0.14
Río Negro	250	27.0	2009	329	Sandy clay loam	4.4	2.1	4.0	0.11
San Martín	300	25.0	2373	332	Clay	4.2	3.2	7.4	0.16
CIAT-Palmira	1000	23.8	704	336	Clay	7.0	3.9	73.3	0.70
CIAT-Quilichao	1070	23.0	1233	310	Clay loam	3.6	6.7	40.5	0.35
Caicedonia	1200	22.2	1344	356	Sandy clay loam	5.5	3.2	40.5	0.35

[1] Total rainfall during the cassava growing cycle.

Cassava grown from stored stakes.

Farm Trials

The new technology is evaluated under farm conditions within the farmer's economic context in the on-farm trials. This year farm trials in Media Luna concentrated on further definition of varietal characteristics required for adoption, particularly in relation to cassava storage in the ground. The principal means of regulating market supplies is through staggered harvesting and, consequently, it is very important to preserve quality and yield during a prolonged period. The local variety Secundina maintains quality and resists root rot over a long harvest period, hence farmers can store their cassava in the ground and harvest according to market demands.

In the Mondomo region of Cauca, inherent soil fertility is extremely low, and this is further aggravated by erosion. Farmers rotate cassava with fallow periods to maintain fertility; however, as pressure on land becomes more intense, rotations are shortened. Yields were shown to be highly dependent on rotation (Table 7), and it was evident that as rotations shortened fertilizers were required to maintain yields. This is particularly important on the smaller farms where pressure on the land is more intense.

A major problem of cash flow exists with a long growth cycle crop such as cassava, when grown by farmers with limited financial resources. Farmers often intercrop cassava with shorter growth cycle crops such as beans or corn to improve their cash flow and also to utilize the land more intensively. Farmers tend to minimize competition between the two crops by low density planting, however, yields of maize in Media Luna were nearly tripled with only a minimal decrease in cassava yields when plant populations were increased.

In Caicedonia, a coffee growing area in the Cauca Valley, cassava must compete with high value crops. High yields and preferential price are obtained with the high quality cassava variety used in the zone. Cassava-bean intercropping was tested using higher plant densities and improved management including herbicides, fertilizer applications, and vertical planting. The main advantage of the improved system was higher bean yields which provided earlier returns for the farmer without reducing cassava production.

Table 7 **Algodona and Americana yields by farmer as related to plot history and farm size, Mondomo, Cauca.**

Root yield Americana (t/ha)	Root yield Algodona (t/ha)	Previous plot history	Rotation index*	Farm size (ha)
8.5	16.6	1 year cassava, 15 years fallow	13	44.8
**	13.7	2 years fallow; 1 year cassava; 10 years fallow	10	12.6
***	11.4	10 years fallow	10	19.2
6.6	8.7	8 years fallow	8	4.5
6.2	6.9	6 years fallow	6	5.8
3.5	6.5	2 years fallow	2	15.1
4.6	4.7	2 years cassava; 8 years fallow	4	5.0
2.7	**	2 years cassava; 2 years fallow	2	12.6

* Calculated as number of years in fallow minus two times the number of previous years in cassava.
** Same farmer but different plot histories for the two varieties
*** Plot lost

Cassava-bean intercrop.

Economic Studies

Even though cassava is an important food source, mainly in rural areas, new yield-increasing technology will only be widely adopted if the additional production can be easily marketed. There are five existing or potential markets for cassava: fresh for human consumption, processed for human consumption; animal feed, industrial starch, and fuel alcohol.

First priority is given to direct human consumption; however, indirect human consumption through the poultry and feed concentrate industry offers a promising potential market for cassava. A case study in Colombia estimated the price level at which cassava can enter into the feed industry and also the extent to which concentrate costs could be reduced. The impact of lower cost concentrates, as a result of using cassava in feed mixes, and the ensuing lower prices of poultry, was estimated. Tables 8 and 9 illustrate cost reductions in concentrates and benefits derived simulating three different levels of cassava production technology. The data indicate that cassava could at least partially replace sorghum imports.

Table 8. **Per cent reduction in cost of poultry concentrates, with three levels of new cassava technology and three levels of inclusion of cassava in the feed mix.**

Per cent cassava in feed mix	Levels of technology		
	12 t/ha	15 t/ha	24 t/ha
10	0.4	1.3	1.9
20	0.7	2.6	3.8
43*	1.06	5.5	8.2

*Economic optimum at all levels of technology

Table 9. **Gross benefits from cassava as a chicken feed, Colombia, $ U.S. (000).**

Per cent cassava in feed mix	Levels of technology		
	12 t/ha	15 t/ha	24 t/ha
10	208	658	973
20	353	1320	1941
43*	808	2795	4151

*Economic optimum at all levels of technology.

International Cooperation

The nature of cooperation with different countries depends upon the degree of development of their respective cassava programs. However, the overall objective is the same, that is, to help them increase cassava production.

Results of coordinated efforts between CIAT and the national programs are encouraging and support the philosophy of providing germplasm, training and technical assistance. A significant result of this cooperation is the testing of improved germplasm in several countries, and its multiplication for use by farmers (Table 10).

Particularly impressive advances have recently been made in Cuba and Ecuador. In the former, Cuban researchers, who received training at CIAT, returned to their country and selected three clones (two local clones and one introduced from CIAT) as outstanding. At the same time CIAT technology was validated and modified for Cuban conditions with the selected clones. This technology was then rapidly diffused to the state farms where it is now being used. As a direct result of this effort, commercial production on a large area has jumped from about 7 t/ha to more than 20 t/ha, and cassava

Table 10. **Varieties and hybrids selected and distributed by CIAT now being used commercially or multiplied for commercial use.**

Countries	MCol 1468	MCol 1684	MMex 59	MCol 22	MVen 218	MPan 51	SM1-150	CM 309 165	CM 323 375	CM 308 197	CM 192 1	CM 407 7	CM 305 13
Colombia	○	○		○									
Dominican Rep.	○	○											
Cuba	○												
Ecuador	○	○		○									
Brazil	○	△											
Mexico			○			○		○					
Honduras		○	○						○				
Venezuela	○	○			○		○			○	○		
Philippines		○											
Thailand												△	△
Australia			○		○		○						

○ planted commercially
△ in multiplication

which used to be rationed is now sold freely throughout the country.

Ecuador, in cooperation with CIAT, made an agro-economic survey of cassava. Results showed that yields were far below those obtained in regional trials with selected lines and improved agronomic practices. As a result, INIAP formally initiated a cassava program in 1980 with the understanding that it would receive support from CIAT, particularly with reference to germplasm.

A major problem with a vegetatively produced crop such as cassava is the safe exchange of germplasm. Tissue culture has now become the standard medium for exchange, and in 1980 sixty one lines were sent as meristem culture to eight countries, five of them in South East Asia. During the more prolonged periods of shipment to Asia, samples often arrived in poor condition. New methods were developed to prevent deterioration during shipment. On arrival in the various receiving countries, materials must be transferred to the field and rapidly propagated for further testing. A new leaf propagation technique, developed in cooperation with Philippine scientists, is now being used in several countries.

Training, an important component of international cooperation, was offered in 1980 to 38 professionals from 15 countries. Twenty one trainees came from Latin America and took courses offered in CIAT. In addition, two short courses were offered in Mexico and Dominican Republic with high attendance of extension agents.

Meristem cultures

Charn Tiraporn, trainee from Thailand, in his experiment to evaluate cassava germination under drought stress.

The first cassava course offered by CIAT in Asia took place in The Philippines with financial support from the International Development Research Center (IDRC) of Canada and participation of 24 trainees from five countries.

Asia produces 35% of the world's cassava, mostly in Thailand, India and Indonesia. Seventy Asian professionals have been trained in CIAT. Scientists from this center visited five Asian countries in 1980.

Rice Program

Highlights

The Rice Program is multiplying four promising lines carrying genes pyramided against the rice blast disease. One or two of these lines will be recommended as commercial varieties.

Preparations for upland rice research by the Program were completed, and financial support for this activity becomes available beginning in 1981.

National rice programs in Latin America selected 70 promising lines among those distributed to them by the International Rice Testing Program (IRTP).

Background and Objectives

View of upland rice field in Brazil.

Rice is one of the most important food crops in the world; both its consumption and the land area under cultivation are among the highest in food crops in Latin America and the Caribbean. Rice consumption increases in the region at an annual rate of 2.5%, and the area planted expands at a yearly rate of 2.4% — keeping pace with population and income growth which generate a 3.4% rise in demand each year. The region is almost self sufficient in rice and per capita consumption is relatively stable, although notable increases have occurred in Bolivia, Colombia, the Dominican Republic, Guatemala, Haiti, Paraguay and Uruguay. At the current rate of consumption, rice production must double by the year 2000 in order to meet demand.

The response of producer countries to the demand for rice varies; it is fundamentally determined by the different farming systems used in each country. There are five different systems in use, each one with its own potential productivity level. These five farming systems are:

Subsistence upland rice: This system is concentrated on forest soils that have been cleared. It is found in frontier agricultural areas, and the average farm size is about one hectare. Native varieties are planted and weeded by hand and no commercial inputs are used. Estimated average yield is 1 t/ha or less. Production is consumed on the farm. After one or more harvests, the crop is shifted to new land. The principal constraints on this system are its complete dependence on hand labor and the lack of technology and inputs.

Highly favored upland rice: this system is found on flatlands having slightly acid and well drained alluvial soils, receiving more than 2000 mm of rainfall over eight to nine months of the year. The system uses modern dwarf varieties, improved agronomic practices and mechanized farming methods. Yields vary from 2.5 to 5 t/ha on the best farms. It is found in parts of Central America, Colombia and elsewhere. The main constraints are weeds, which appear after two or three harvests, rice blast and lodging. CICA 8 is the highest yielding variety available at present for this system in Colombia.

Irrigated rice in CIAT-Palmira.

Moderately favored upland rice: this system differs from the preceding one in terms of climate: a shorter wet season with less total rain, and dry periods during the growing season. Dwarf varieties are used in Central America, producing an average yield of 2 t/ha; in the sub-Amazon regions of Brazil tall varieties are grown, producing average yields of 1.5 t/ha. Constraints result from moderate drought, mineral deficiencies, diseases, insects and weeds.

Mechanized unfavored upland rice: this system is very unstable and is characteristic of areas having irregular, low rainfall. It is highly mechanized, has a low planting density and employs tall varieties which produce an average yield of 1 t/ha; for the most part it is restricted to the traditional upland area of Brazil. Main constraints are insufficient soil moisture, periods of drought and high soil acidity.

Rainfed lowland rice: this is a transition between the upland and irrigated systems. It uses collected rainwater and is affected by occasional floods and droughts. Tall varieties are directly planted or transplanted on labor-intensive small farms where few commercial inputs are used. The average yield is 2 t/ha. The system is widely employed in Ecuador, Northern Colombia and Hispaniola. The principal constraint is absence of water control.

Irrigated rice: this system is used in every country in the region, especially in Cuba, Nicaragua, Colombia, Peru, Venezuela, Guyana, Surinam and the Southern Cone; it comprises 28% of the area planted and contributes 50% of the total rice production in Latin America. It has certain advantages over the other systems but the rapid rise in production costs are forcing many farmers to look to alternative systems. Its main yield constraints are blast and weeds. Tall varieties are used in the Southern Cone since dwarf ones are not cold tolerant; the Japonica variety cultivated in Chile is in itself the limiting factor.

Table 1 shows the approximate area under each production system, together with their yields and production.

The CIAT Rice Program has focused on the irrigated rice system since it has offered the greatest potential for rapid gains in terms of yield and production, and the technology is more easily generated and extended than in the other production systems. The Program has stressed varietal improvement. Until 1968 tall varieties predominated; then, IR8 was introduced into Colombia and produced an inmediate increase in productivity of 2 t/ha. Consequently, research was reoriented towards dwarf varieties, having strong culms, insensitivity to photoperiod, long grains with clear endosperm, resistance to the leafhopper *Sogatodes oryzicola* and to rice blast; more recently, the Program has concentrated on early maturity and adaptability to acid soils.

The ICA-CIAT cooperative rice research efforts have released five high yielding dwarf varieties that are grown internationally. Using CIAT improved lines, other national programs have developed many other dwarf varieties (Table 2). All together, improved varieties are grown on 1.5 million hectares in the irrigated and favored upland production systems. Yield increases ranging from 1 to 3 t/ha have resulted from the use of improved varieties and cultural practices (Table 3). Increased production has resulted in reduced rice prices, which in turn have stimuled greater consumption — especially among low -income groups.

Table 1. **Area, yield and rice production by farming system in Latin America, 1978.**

	Area (millons ha)	Yield (t/ha)	Production (millions ton)
Subsistence upland[1]		1.0	
Moderately favored upland	1.29[2]	1.5	1.94
Mechanized unfavored upland	3.50	1.0	3.50
Rainfed lowland[3]	0.14	2.2	0.31
Mechanized favored upland	0.37	2.4	0.89
Irrigated rice	2.10	3.5	7.35
Total	7.40		14.00

[1] Generally not marketed
[2] Comprises one million hectares in Brazil
[3] Mainly in Ecuador, the Dominican Republic and Haiti

Table 2. ICA-CIAT and IRRI lines released as varieties in Latin America up to 1980

Country	Lines												
	4	4422	4461	4444	P 723-6-3-1	4421	4440	IR1529-430-3	4440-10	IR930-31-10	P1042-2-3-18	IR841	P849-45-1M-40-4-3-1M
México	CICA 4				CICA 6	CICA 9	CICA 8						
Guatemala	CICA 4	Tikal 2			ICTA 6		ICTA Virginia		ICTA Cristina				
Honduras	CICA 4				CICA 6	CICA 9	40						
Nicaragua						Line 9	CICA 8						
Panamá			CICA 7	44.			CICA 8						
Cuba								IR1259					
Dominican Rep	Avance 72	ISA 22				ISA 21	ISA 40						
Venezuela	CICA 4				CICA 6	Ciarilacen 1							Araure 1
Colombia	CICA 4		CICA 7		CICA 8	CICA 9	CICA 8						
Ecuador	INIAP 6			INIAP 7							INIAP 415		
Bolivia					Saavedra V 5			Saavedra V-4					
Brasil	CICA 4									IRGA 408		IR841	
Paraguay							Adelaida 1						

Appropriate cultural practices such as planting densities and methods, fertilization and weed control, in addition to improved varieties, have been developed for use by farmers since 1971. More recently, emphasis has been placed on land preparation by puddling, weed control, reduced production costs, and use of good quality seed.

Favored and moderately favored mechanized upland systems have adopted advanced irrigated lines distributed through the international nurseries and regional trials. The vast savanna areas of Colombia and Venezuela with acid, infertile soils and plentiful rainfall, could be brought into rice production by adapting technology and using suitable varieties.

Table 3. **Rice yield increases in several Latin American countries.**

Country	Yield (t/ha) 1967	Yield (t/ha) 1978	Yield increase (%)	Area planted with improved varieties (%)	Origin of improved material
Nicaragua	2.4	3.8	58	78	CIAT
Colombia	2.2	4.2	91	76	ICA/CIAT
Cuba	2.1	3.0	43	100	IRRI/CIAT
Ecuador	1.7	2.9	71	69	CIAT
Costa Rica	1.4	2.6	85	100	CIAT
Venezuela	1.9	2.9	53	97	CIAT
México	2.5	3.5	40	55	Local + CIAT
Guatemala	1.5	2.3	53	50	CIAT
Twenty countries in Latin America (except Brazil)	2.0	3.3	65	56	

Activities in 1980

Breeding

This is a cooperative ICA-CIAT research activity conducted in ICA experiment stations and at CIAT-Palmira with the purpose of developing high yielding, good grain quality varieties that are resistant to major biological stresses such as rice blast *Pyricularia oryzae*, the hoja blanca virus and the leafhopper *Sogatodes oryzicola*. Other less important biological constraints include leaf scald *Rhynchosporium oryzae* and sheath blight *Thanatephorus cucumeris*.

The main focus of the breeding program is the achievement of stable resistance to rice blast. This is sought through the pyramiding of major genes, concentrating slow blasting components, combining slow blasting characteristics with vertical genes, backcrossing to resistant donors, and through multilines.

As part of the International Rice Testing Program (IRTP), regional trials in Colombia and international trials identified four promising lines having pyramided major genes (Table 4). These and other new lines were retested in regional trials in Colombia and Latin America. An additional 105 new pyramided lines originating from the same multiple crosses were evaluated at ICA stations in Monteria and Villavicencio and over 20 of them were

Table 4. **Performance of four pyramided lines tested in 14 locations in Colombia and identified as potential candidates for release.**

Line No.	Grain characteristics				Reaction to		Mean yield (kg/ha)
	White belly		Milling quality				
	Mean	Range	Total milled rice (%)[1]	Whole grain (%)[2]	Blast	Sogata	
5709	1.8	0.6-3.0	69	60	R[3]	R	5749
5685	1.52	0.4-3.4	70	64	R	R	5537
5715	1.28	0.6-3.0	71	65	R	R	5436
5738	0.82	0.2-1.4	71	66	R	R	5232
CICA 8	1.81	0.6-3.6	68	56	R	R	5586

[1] Whole grains, brokens and bits
[2] Milled rice: whole grains and ¾ size brokens
[3] R=resistant.

identified as promising. Lines 5006 and 5029, selected from F_4 generations in Villavicencio and carrying blast resistance from Tadukan and Colombia 1, were released by ICA for specific use in the Llanos because of their yields — which are similar to those of CICA 8 — better lodging resistance, and improved grain quality (Table 5).

Breakdown of varietal resistance continues to be a frequent phenomenon among varieties derived from crosses with parents having broad-spectrum blast resistance. A new project was initiated during the year to explore the possibilities of transferring an adequate load of the genetic complement of the tall broad-spectrum parents to dwarfs through a single backcross to the talls. Varieties from Africa, Asia, Costa Rica, Surinam and Brazil are being used for this purpose.

Other breeding projects emphasize early maturity and dual purpose crosses for upland and rainfed production systems; to this end, F_2 populations and advanced lines are made available to countries equipped with the facilities and personnel able to handle segregating populations and adapt them to their specific environmental conditions within irrigated, rainfed, and upland production systems.

Attempts to improve Bg90-2 continue due to its wide adaptability, high yield, excellent plant type and good early vigor which, if combined with blast resistance and better grain quality, should turn it into a very popular commercial variety. Several lines resulting from backcrossing with Bg90-2 have retained its qualities together with blast resistance and lower white belly ratings (Table 6).

Work continues on reducing the lodging tendency of CICA 8, particularly under upland conditions. Among the lines tested, nine were identified as having better straw strength.

Several dwarfs were identified in populations which had been irradiated to reduce the height of tall blast-resistant donors.

Table 5. **Performance of two new lines with blast resistance from Colombia 1 and Tadukan, in the Colombian Llanos.**

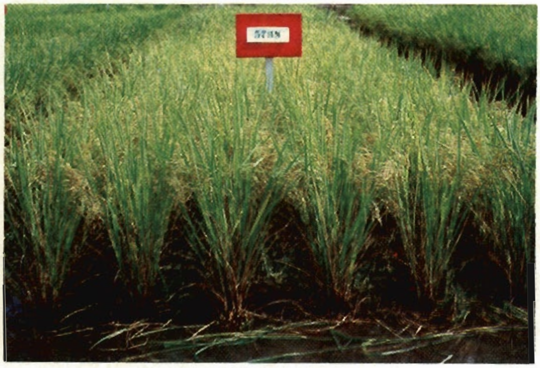
Line No.	Grain characteristics				Blast reaction	Mean yield	
	White belly		Milling quality				
	Mean	Range	Total milled rice (%)[1]	Whole grain (%)[2]		Irrigated (kg/ha)	Upland (kg/ha)
5006	0.5	0.4-0.6	71.5	63.9	R	5479	3731
5029	1.0	0.8-1.4	69.5	62.8	R	5040	3812
CICA 8	1.3	0.8-1.6	70.0	55.0	R	5990	4228

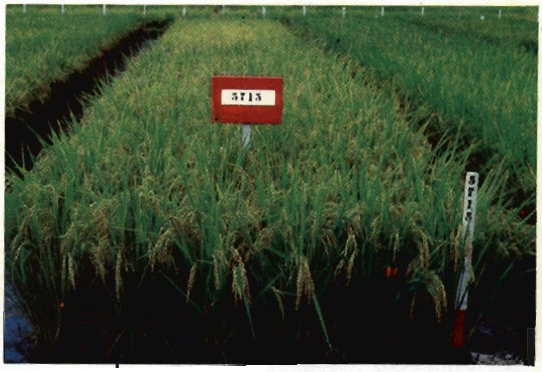
[1] Whole, grains, brokens, and bits
[2] Milled rice whole grain and ¾ size brokens.

Table 6. **Performance of five lines backcrossed to Bg90-2 (Bg90-2/3 x Tetep) at CIAT-Palmira.**

Line No.	White belly	Blast Reaction[1]	Yield (kg/ha)	Percent control
7222	0.8-1.2	R	8594	116
7181	0.6-1.2	R	8455	114
7153	0.2-0.6	R	7569	103
7152	0.2-0.4	R	7239	98
7140	0.2-0.6	R	6354	86
Bg 90-2	2.0-2.5	S	7396	100
CICA 8	0.6-0.8	R	7101	96

[1] R = resistant, S = susceptible.





Improved varieties 5738 and 5715 with pyramided blast resistance genes.

Pathology

Using improved methods for disease screening applied at the ICA-La Libertad station near Villavicencio, different levels of resistance to the major rice diseases were successfully differentiated in breeding materials. These diseases are: rice blast *(Pyricularia oryzae)*, leaf scald *(Rhynchosporium oryzae)*, sheath blight *(Thanatephorus cucumeris)*, bacterial leaf blight *(Xanthomonas oryzae)*, eyespot disease *(Dreschslera gigantea)*, and crown sheath rot *(Ophiobolus oryzimus)*.

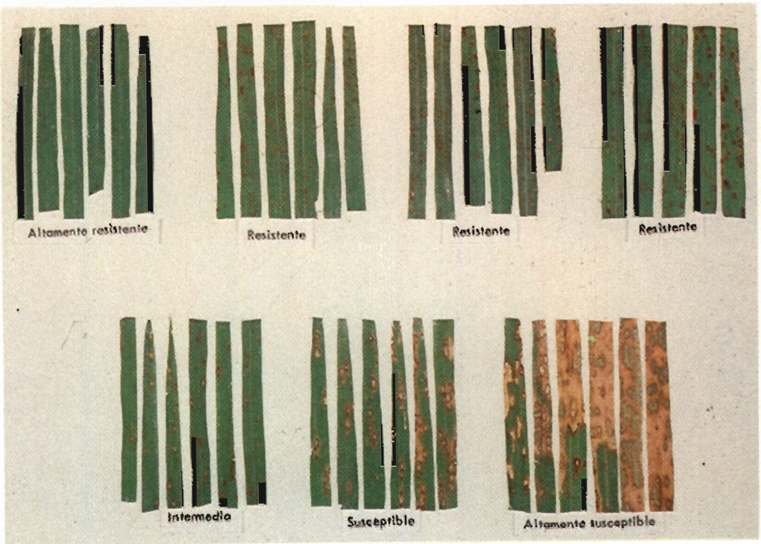
At CIAT-Palmira and ICA-La Libertad, many lines have been evaluated indicating the differences in pathogenicity of the fungus *P. oryzae* in these two locations (Table 7). Field evaluation of blast resistance included promising breeding lines, commercial varieties and

Table 7 **Summary of resistance evaluation in the blast nursery.**

Group of entries	No. of entries			Group total
	Resistant	Intermediate	Susceptible	
CIAT-Palmira				
Breeding lines	4195	4102	181	8478
IRTP entries	1015	719	9	1743
CIAT Phatology accessions	158	130	2	290
ICA-La Libertad				
Breeding lines	72	150	8	230
IRAT varieties	18	8	0	26
USA lines	86	108	6	200
Japanese varieties (field resistant)	20	29	1	50
Korean lines	16	76	8	100
CIAT Pathology accessions	138	361	50	549
Total				11,666

resistant donors which were planted under heavily fertilized upland conditions. Lines 5685, 5738 and 5698 performed better than CICA 8.

The evaluation of varietal resistance to sheath blight is complicated by the irregular occurrence of this disease in testing sites. To make evaluation easier, a simplified scale was developed to measure the disease index for artificial inoculation or field observation. The scale used to evaluate yield losses caused by panicle blast also was revised and corrected by adding the percentage of unfilled grain to the evaluation scale and by giving a weight to each grade in the scale so that it reflects the severity of neck infection.



Scale to measure sheath blight attack under artificial inoculation.

General and detailed views of experiment on fungicide application against rice blast. A micromonitor (top view) measures potential severity of the disease on the basis of meteorological conditions, thus providing information to farmers as to the best time to apply fungicides. Experimental method in upland conditions in ICA-La Libertad, using equipment provided by the University of Pennsylvania.

Panicle blast in experimental microplot in CIAT-Palmira. Adequate environment is created through manipulation to induce the disease, since natural infection is very low in the area.

International Rice Testing Program for Latin America

The CIAT-IRRI (International Rice Research Institute) cooperative project, established in 1976, is designed to transfer new technology to national programs and to serve as a bridge between researchers and international research centers.

The results with nurseries distributed in 1979 to 23 countries are still incomplete since several of them were affected by adverse climatic conditions. The nurseries distributed were:

VIRAL-P, International Rice Yield Nursery - early maturing

VIRAL—T, International Rice Yield Nursery - medium maturing

VIRAL-Tar, International Rice Yield Nursery - late maturing

VIRAL-S, International Rice Yield Nursery - upland

VERAL, international Special Rice Yield Nursery

VIOAL, International Rice Observational Nursery

VIOAL-S, International Rice Observational Nursery - upland

VIPAL, International Rice Blast Nursery

VIOAL-R, International Rice Observational Nursery - leaf scald

VIAVAL, International Rice Sheath Blight Nursery

VIOSAL, International Rice Salinity and Alkalinity Observational Nursery

VITBAL, International Rice Low Temperature Nursery

VIRAL-F, International Rice Yield Nursery-deep water

The results of international nurseries distributed in 1978 were analyzed, and findings were published for distribution to all those participating in the program.

The second International Blast Nursery for Latin America (VIPAL-79) was planted in 16 locations (Table 8). The resistant and moderately resistant entries, some of which are resistant to *Sogatodes* and have good grain quality, are included in 1981 nurseries.

National programs selected several lines for further regional trials, for example: 24 entries were selected in Brazil, 24 in Costa Rica, 19 in Haiti and 3 in Panama.

In 1980, the germplasm received from IRRI in 1979 for evaluation, seed multiplication and selection was harvested; 83% was discarded and 17% was selected. Fifty-five percent of the materials selected originated from IRRI and the rest mainly from India and Colombia. They were included in the nurseries for Latin America distributed in 1980. These nurseries also included 286 promising lines selected in 1979 and 55 lines from national programs. This year a new observation nursery for acid soils, VIOSAL, was formed with germplasm tolerant to leaf "yellowing" — a problem that occurs in acid soils and was observed in nurseries planted in Belize, ICA- La Libertad, and El Salvador. Resistant checks Colombia 1, Carreon and Tetep from the blast nursery were

Table 8. **Incidence of blast in the 1979 VIPAL germplasm, in 16 locations in Latin America.**

No. entries	Leaf reaction to blast[1]	Neck reaction to blast[2]		
		R	MR	S
36	R	11	3	22
37	MR	8	3	26
53	S	9	3	41

[1] Reported in 16 locations, R = resistant (1-3 scale ratings), MR = moderately resistant (4 scale rating) S = susceptible (5-9 scale ratings).
[2] Reported at 6 of the 16 locations

"Yellowing" in acid soils. Susceptible and tolerant materials in VIOAL-S, ICA-La Libertad.

also highly resistant to "yellowing" in La Libertad Experimental Station.

The international yield and observation nurseries distributed in 1980 are listed in Table 9.

Eight hybrids of rice x sorghum crosses from the People's Republic of China were introduced through IRRI. These hybrids showed early maturity, low grain yield, susceptibility to *Sogatodes* and resistance to hoja blanca virus under laboratory conditions and seedling resistance in the blast beds.

Monitoring tour of 10 rice scientists from Central America with IRTP coordination. The group observes rice diseases in Guatemala and evaluates VIRAL-S germplasm in Costa Rica.

Table 9. **IRTP nurseries for Latin America distributed in 1980.**

Nursery	No. entries	No. sets	Yield range[1] (t/ha)
Yield nurseries			
VIRAL-P	15	39	4.2 - 6.7
VIRAL-T	24	29	3.7 - 7.8
VIRAL-Tar	15	14	5.1 - 8.4
VIRAL-S	24	36	4.9 - 7.0
VERAL	11	26	5.4 - 7.2
VIRAL-F	13	7	3.5 - 7.5
VITBAL	25	7	2.7 - 6.1
VIAVAL	10	13	3.6 - 6.5
Observational nurseries			
VIOAL	83	18	3.6 - 8.9
VIOAL-S	63	24	2.5 - 9.0
VIOAL-Es	64	16	3.4 - 7.9
VIPAL	152	47	2.7 - 9.0
VIOAL-Sa	105	14	2.7 - 9.1
VIOSAL	19	10	1.8 - 7.5
Total	623	298	

[1] Average yield range for two plantings at CIAT under irrigated transplant conditions

Agronomy

Weeds, one of the most serious rice problems, have been studied at CIAT-Palmira in terms of mechanical and chemical control methods, and in conjunction with national programs by means of uniform trials. The factors studied were: varieties, irrigation (especially flooding), cropping systems, and nitrogen fertilizers. The purposes were to increase efficiency in the use of selective herbicides, and in mechanical weeding, to determine the best timing for herbicide application taking into account their particular performance, to evaluate phytotoxicity in seeds and germinating weeds, and to observe residual effects of two herbicides and the type of weeds resistant to them to justify subsequent use of hormonal herbicides.

An important aspect of the work done by the Agronomy section involves the study and evaluation of promising improved lines that could be selected and used as varieties in national programs. Lines are analyzed, and a description of their agronomic characteristics and performance in different production systems and cultural practices is provided to the national programs. As part of this work, the performance of six promising lines: 5684, 5685, 5698, 5709, 5738 and 5852 was observed and compared to varieties CICA 8, CICA 4 and IR22. Lodging was not observed in these lines fertilized with 150 kg N/ha, while the check varieties did lodge.

The efficiency of different nitrogen formulations is under study taking into account soil characteristics and their application in the root zone.

Saline soils are difficult to handle and present problems for plant growth. However, deep drainage facilitates rice growth under flooding, and in some cases soils may even recover and become productive. The resistance and plant development of six varieties were observed under those conditions, and the best performance was that of CICA 8 and IR 2153-26-3-5-2.

Diatrea *sp. damage. Insects attacking rice are collected periodically to study their population dynamics in relation to the different development stages of the plant and to environmental factors throughout the year.*

Two species of the biofertilizer **Azolla** *were found in Colombia and were primarily identified as* **Azolla filiculoides** *and* **Azolla caroliniana**. *Their commercial multiplication and value as nitrogen sources are under study.*

Continous planting method under observation for possible use on small farms.

Economics

A research method is being developed applicable to the different farming systems previously described, with the idea of establishing criteria for the allocation of research resources to the different farming systems in the region. Two criteria have been generally used in the past: efficiency and equity. A third one has been added, that of the relative advantage of a given country or region in terms of international rice trade in Latin America. To test these criteria, three research projects were planned: one is the evaluation of rice production systems in Latin America; another one is the evaluation of the distribution of potential benefits of each rice production system,and the third one the impact evaluation of increased production in each system on international rice trade flows. For the first project, six rice production systems have been defined and located. Three of them, which have undergone preliminary study, are the upland system in the Colombian Llanos Orientales, the irrigated system in the central region of Colombia and the upland system in the Pacifico Seco and Pacifico Sur in Costa Rica. This country in particular has been one of the main beneficiaries of the new rice varieties. The main effects of their adoption have been yield increases (from 1.4 to 3 t/ha between 1967-1980), increased consumption and export surpluses of rice.

Tables 10 and 11 present comparisons across regions and estimated cost-benefit ratios for the systems reviewed during the year.

Table 10. **Cost of three rice production systems in Latin America, first semester, 1980.**

Cost	Region and System		
	Colombia Llanos Orientales irrigated and upland	Colombia Central region irrigated	Costa Rica Pacifico Seco and Sur, upland
US $/ha	900	1215	810
US $/ton	180	202	279

Sources: FEDEARROZ, Colombia, Central Bank, Costa Rica; official exchange rates taken from *International Finance Statistics*, August, 1980, IMF

Table 11. **Cost/benefit ratios for three rice production systems in Latin America, first semester, 1980.**

Country and System	Cost/benefit ratio
Colombia	
Llanos Orientales, upland	0.84
Llanos Orientales, irrigated	0.93
Central region, irrigated	1.11
Costa Rica	
Pacífico Seco, upland	1.05
Average upland	0.96

Sources FEDEARROZ, Colombia, Central Bank, Costa Rica, discount rates taken from *International Finance Statistics*, IMF, August 1980. Colombia, 30% annually, Costa Rica, 8% annually.

Training

In 1980, training was offered on research in irrigated rice production in two stages: an intensive six-week course and an 18-week specialized training program. Twenty-seven professionals participated in the first course and 11 attended the second phase, all from Latin American countries. Those selected to specialize in agronomy and plant phatology were assigned experiments to plan, plant, evaluate and harvest. These trials focused on solving several of the problems affecting rice occurring in each participant's country; they also illustrated research methods to be used in those countries.

Two professionals from Cuba and Mexico received specialized training in breeding. During the year courses were offered in Peru and Panama with a total attendance of 28 people.

Tropical Pastures Program

Highlights

The release of **Andropogon gayanus**, *CIAT No. 621, named "Carimagua 1" by the Instituto Colombiano Agropecuario (ICA) and "Planaltina" by the Centro de Pesquisa Agropecuária dos Cerrados (CPAC) in Brazil, is an important event summarizing the purposes and activities of the Tropical Pastures Program. Having completed its evaluation in successive stages,* **A. gayanus** *is now available to cattlemen in the Colombian Eastern Llanos and the Brazilian Cerrados. At the same time,* **A. gayanus** *continues to play an important role in subsequent evaluative activities carried out by the Program. Results obtained from the Regional Trials Network indicate that this grass is also promising in the tropical forest ecosystems.*

Dr Bela Grof introduced **Andropogon gayanus** *to Colombia in 1973 when he received a handful of seeds from IITA, Nigeria, where this grass originated. It was planted for the first time in CIAT-Palmira, and in 1974 in Carimagua, where the Tropical Pastures personnel have worked ever since in its evaluation and improvement*

Background and Objectives

Beef and milk are staple foods in tropical America. In urban areas, particularly, they represent from 10 to 24% and from 7 to 15%, respectively, of the family food budget, with the greater percentage corresponding to the lower income segments of the population. The growing demand for these products causes continual price increases which further aggravate the nutritional problems of the population.

The low productivity of cattle in tropical America is due mainly to severe malnutrition of grazing animals and to resulting diseases. These problems, in turn, are caused by lack of permanent, good quality pasture lands. On the other hand, tropical America has extensive areas of acid infertile soils (Oxisols and Ultisols) — the continent's agricultural frontier — which make up 40 to 50% of its total land resources. In such areas the animal herd and its productivity are inferior even to the low national averages. With forages of adequate quantity and quality, per-hectare productivity could increase from ten to fifteen times and per capita productivity could at least double.

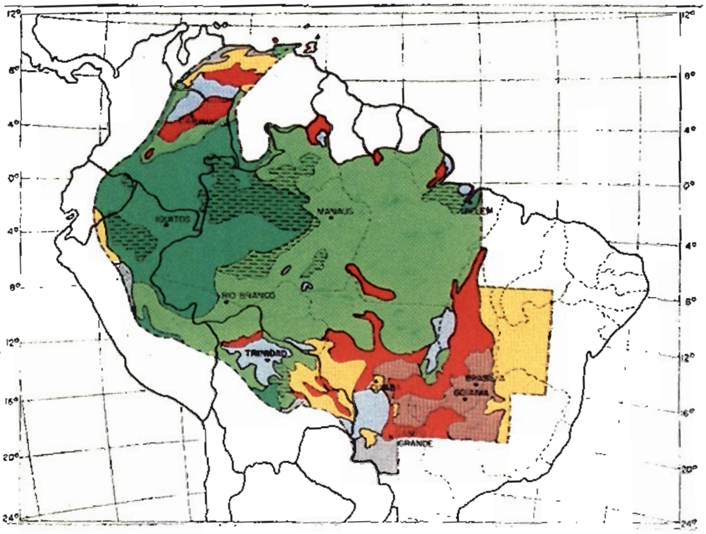
The goal of the Tropical Pastures Program is to increase production of beef and milk by means of low-cost pasture technologies that will facilitate expansion of the agricultural frontier in tropical America. In addition to increased productivity in these areas, it is hoped that massive transfer of cattle raising to acid infertile soils will release fertile land for crop production.

These objectives are pursued by means of the following strategies:

- Development of germplasm adapted to climate, soils, diseases, and pests of each ecosystem within the Program's target area;
- development of persistent and productive pastures;
- study of their role in cattle production systems, and development of complementary animal health and management practices.

In 1978 the study of acid infertile soils in tropical America was begun within the framework of various existing ecosystems. These are characterized by soil type, climate and landscape. The study, concluded in 1979, shows the area divided into five main ecosystems, as illustrated in Figure 1.

Within the well-drained savanna ecosystem, the Llanos and Cerrados are the focal point of the Program's research, although the Regional Trials Network extends to other ecosystems.



- Well drained isohyperthermic savannas
  TWPE* 901 - 1060 mm, 6-8 months wet season, WSMT** 23 5°C
- Well drained isothermic savannas
  TWPE 901 - 1060 mm, 6-8 months wet season, WSMT 23.5°C
- Poorly drained savannas (found in lowlands of Tropical South America, in varying climatic circumstances)
- Semi-evergreen seasonal forest
  TWPE 1061 - 1300 mm, 8-9 months wet season, WSMT 23 5°C
- Tropical rain forest
  TWPE 1300 mm, 9 months wet season, WSMT 23 5°C
- Poorly drained forest regions
- Deciduous forests, Caatinga***, etc
- Others***

*Total wet season potential evapotranspiration
**Wet season mean temperatures
***Not included within target area of Tropical Pastures Program.

Figure 1 *Agro - Ecological Zones of the Tropical Pastures Program.*

Germplasm Evaluation

The starting point of this activity is plant introduction. During 1980, more than 1200 accessions were obtained directly on collection trips and about 500 more through exchange. The present germplasm bank total is 7135 accessions, the majority of which originate from acid infertile soils in the tropics (Table 1). The materials undergo preliminary evaluation at CIAT-Quilichao and are subsequently evaluated in Carimagua (ICA-CIAT) and Brasilia (CPAC) for more advanced characterization. Table 2 lists key species selected for the well-drained savanna ecosystem.

Early evaluation of **Zornia Brasiliensis** *in CIAT-Quilichao.*

Table 1 **Germplasm accessions of tropical pasture species acquired through direct collection and exchanges with other institutions during 1980.**

Genus	Accessions from:			Occasional accessions	Exchanges	Total 1980	Total accessions in the germplasm bak
	Colombia Casanare, Arauca	Brasil No. East	Goiás				
Stylosanthes	22	168	176	31	38	435	1 723
Desmodium	13	50	32	32	4	131	865
Zornia	15	79	48	9	16	167	561
Aeschynomene	18	47	21	14	3	103	377
Centrosema	63	64	18	17	31	193	605
Macroptilium/ Vigna	18	21	7	10	4	60	486
Calopogonium	22	6	13	3	-	44	143
Galactia	14	7	8	10	-	39	226
Other legumes *	40	49	35	33	11	168	1421
Grasses	1	2	2	5	368	378	728
Total	226	493	360	164	475	1718	7135

* *Arachis, Cassia, Clitoria, Crotalaria, Dioclea, Eriosema, Indigofera, Leucaena, Pueraria, Rhynchosia, Tephrosia, Teramus,* and others.

Table 2. **Identification of key species for well drained savanna ecosystems.**

Species	Promising for: Llanos (hyperthermic)	Cerrado (thermic)
Stylosanthes capitata	yes	yes
Stylosanthes guianensis "tardio	yes	yes
Stylosanthes macrocephala	yes	yes
Stylosanthes leiocarpa	yes	yes
Centrosema brasilianum	yes	yes
Centrosema macrocarpum	yes	yes
Zornia brasiliensis	yes	yes
Desmodium ovalifolium	yes	no
Pueraria phaseoloides	yes	no
Andropogon gayanus	yes	yes
Brachiaria humidicola	yes	yes

Preliminary evaluation of **Centrosema** *ecotypes*

In Carimagua, an agricultural research center run by ICA and CIAT in the Colombian Eastern Llanos, CIAT has been conducting germplasm evaluation since 1970. Adapted grasses and legumes have been identified, and selection of improved ecotypes within the key species continues. Materials currently under evaluation are *Stylosanthes capitata, S. macrocephala* (previously *bracteata), S. guianensis, S. leiocarpa, Desmodium ovalifolium, Brachiaria decumbes* and *B. humidicola*. New materials entering evaluation in 1980 are listed in Table 3. Although the majority of 214 *Zornia* spp. ecotypes were susceptible to *Sphaceloma* Scab fungal disease, some ecotypes of *Z. myriadena* and *Z. brasiliensis* appeared promising. *Desmodium ovalifolium* 350, under grazing simulating rotation, proved to be compatible with the stoloniferous grasses *B. decumbens* and *B. humidicola* (Figure 2).

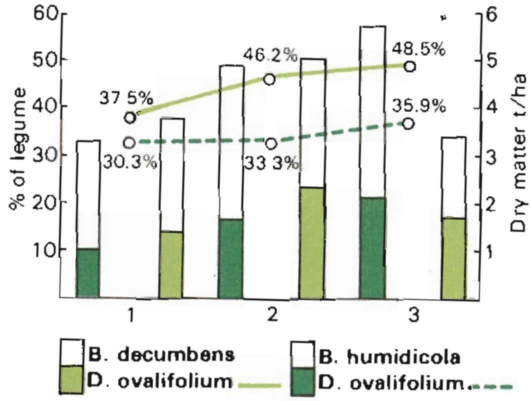


Figure 2. *Available dry matter and* **Desmodium ovalifolium** *content in mixtures with* **Brachiaria decumbens** *and* **Brachiaria humidicola** *on three sampling dates in the second year, Carimagua, Llanos Orientales, Colombia.*

After four years of experimentation, information regarding persistent and adapted forage species, particularly legumes, has been gained which will have a major impact on beef production in tropical savanna regions.

Table 3. **Forage germplasm introductions under evaluation, Carimagua, Llanos Orientales, Colombia, 1980.**

Genus	No. Species	No. Accessions: Introduction studies	No. Accessions: Grazing trials
Aeschynomene	17	187	-
Arachis	1	-	-
Cassia	1	8	-
Centrosema	8	30	26
Desmodium	5	124	11
Stylosanthes	8	101	17
Zornia	5	214	-
Mimosa	1	1	-
Andropogon	1	1	-
Brachiaria	8	-	3
Guinea grass	1	2	-
Total	56	668	57

At CPAC in Brazil, germplasm evaluation of grasses, legumes and their mixtures is done. The genus *Stylosanthes* has the greatest potential in this area, especially *S. guianensis* "tardio", *S. capitata, S. macrocephala, S. viscosa* and *S. scabra*. Each demonstrates different degrees of resistance to anthracnose, the most serious constraint in the Cerrado. *Centrosema macrocarpum* 5062 was the best among *Centrosema* species tested. In contrast to Carimagua, *Zornia latifolia* 728 is still the most productive within this genus in the Cerrado. During two years, several legumes associated with *B. decumbens* and *A. gayanus*

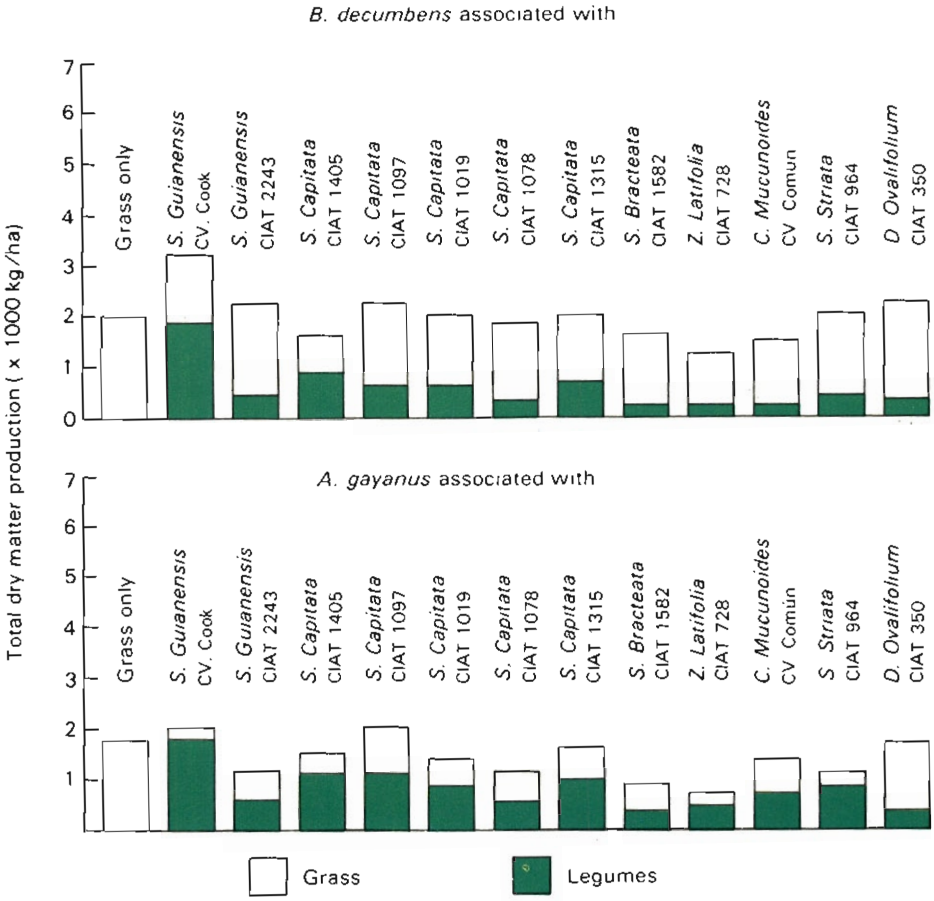


Figure 3. *Performance of grass-legume associations under grazing, CPAC, Brazil.*

621, under grazing simulating rotation, reached the levels of productivity illustrated in Figure 3.

In October 1979, the Regional Workshop on Adaptation of Tropical Forage Species adopted a set of methodological, organizational, and philosophical guidelines which are being implemented with the integration of a regional trials network. This network performs sequential evaluations of germplasm (in "A", "B", "C" and "D" trials) in the five ecosystems of interest to the Program. Twelve Regional "A" Trials were planted in representative sites with the collaboration of researches in national institutions (Figure 4). Selections from these trials will be tested in "B" Trials designed to assess seasonal productivity in sub-ecosystems. Selections from Carimagua and Quilichao for "B" Regional Trials are being established in the Llanos and tropical forest ecosystems.

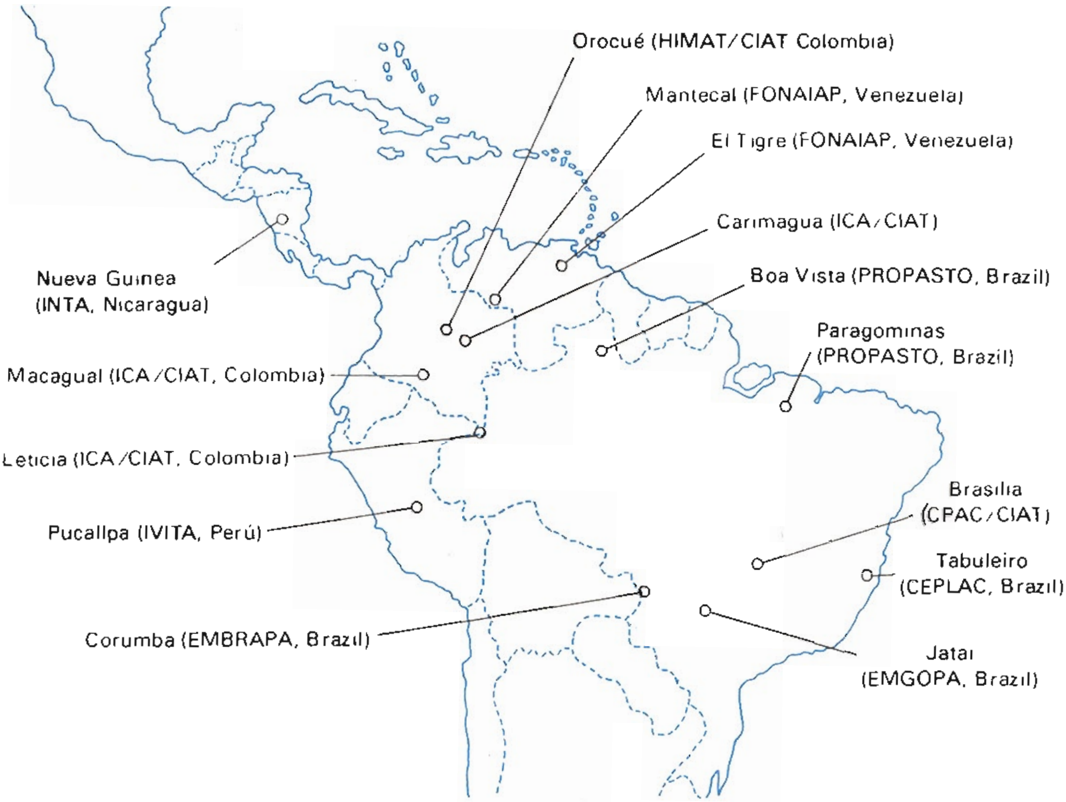


Figure 4 *Location of Regional Trials "A" and major screening sites by ecosystems.*

The disease x ecotype x ecosystems interactions are still being evaluated in the areas of major selection by the Program and in the Regional Trials Network. More than 35 locations were visited for this purpose and the incidence of pathogens assessed. Table 4 summarizes the distribution of diseases. Anthracnose is the most important and most widely distributed disease. It attacks different ecotypes of each *Stylosanthes* species in a different way. According to evaluations made in Carimagua, Quilichao and Brazil, ecotypes show different reactions at different locations which suggests the presence of different strains of the pathogen *(Colletotrichum)* in the natural habitats of these legumes.

The common and "tardio" types of *Stylosanthes guianensis* were evaluated in Carimagua for their reaction to anthracnose (Figure 5). Results to date display a higher degree of resistance among the "tardio" ecotypes than among the common ones. During the next few years the Regional Trials Network will carry out the same type of evaluation for *Stylosanthes guianensis* (both "tardio" and common types), *Stylosanthes capitata* and *Stylosanthes macrocephala.*

Anthracnose damage in **Stylosanthes capitata,** *CPAC, Brazil.*

Spittlebug attack on **Brachiaria decumbens,** *CIAT-Quilichao.*

Table 4. **Distribution of grass and legume diseases in different ecosystems. Summary.**

	Diseases	Ecosystems: Tropical savanna (Isohyperthermic)	Carimagua, Colombia	Tropical savanna (Isothermic)	Brasilia, Brazil	Semi-evergreen seasonal forest	Sub-mountainous evergreen seasonal forest	Tropical rain forests
1	Anthracnose	+	+	+	+	+	+	+
2	*Cercospora* Leafspot (grasses)	+	+	+		+	+	+
3	*Cercospora* Leafspot (legumes)	+	+	+	+	+	+	+
4	Root knot nematode			+*				
5	Blight		+	+				+
6	*Sphaceloma* Scab		+	+	+	+	+	+*
7	Smut - *Ustilago*		+	+	+		+	+
8	Smut - *Urocystis*			+*				
9	*Camptomeris* Leafspot		+				+	+
10	Rust - *Uromyces*	+		+	+	+	+	+
11	Rust - *Puccinia*					-		
12	False rust			+	+	+*		+
13	*Rhizoctonia solani*	+	+	+*	+	-	+	+
14	*Rhynchosporium* Leafspot		+				+	+*
15	*Dreschslera* Leafspot	+*	+	+	+		+	+
16	Little leaf *Phyllody*		+	+	+		+	+
17	Ergot		+	+*			+	+*
18	*Giberella* Inflorescence blight			+*		+		+*
19	*Botrytis* Inflorescence blight							+
20	Black mold			+*	+			
21	Powdery mildew		+		+		-	+*
22	Slime mold						+	+*
23	Bacterial blight		+				+	+*
24	Bacterial pod blight						+	+
25	*Botryosphaeria* Canker		+					+
26	*Macrophomina phaseolina*		+					
27	Crazy top							+*
28	*Cerebella* Inflorescence blight		+					+*
29	Viruses	+*	+	+	+	+	+	+
30	*Rhizopus* Inflorescence blight		+					

* At one site only.

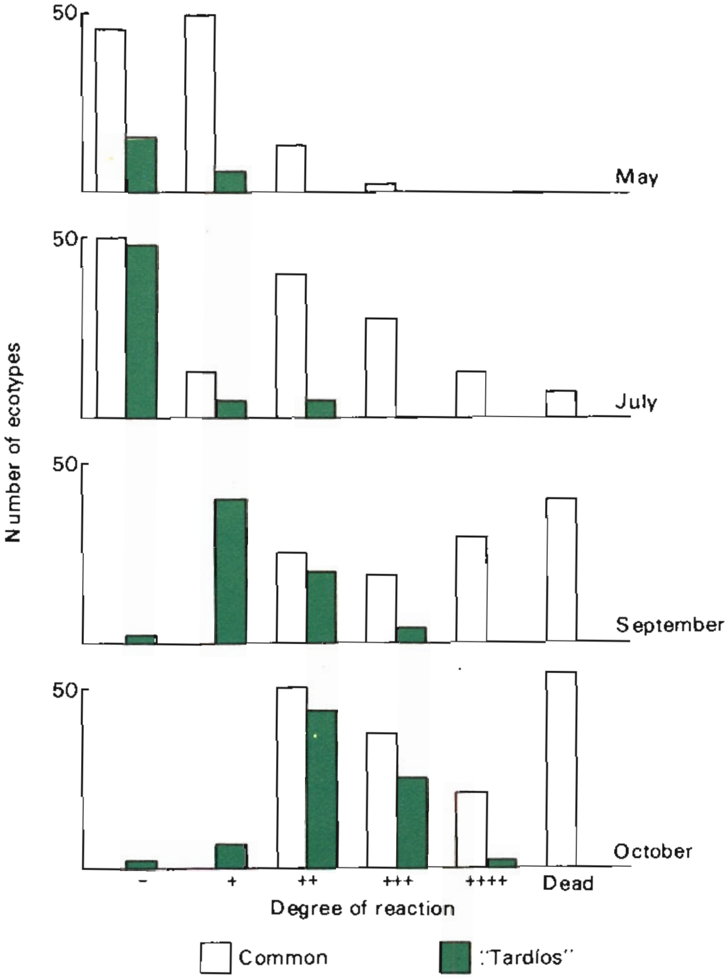


Figure 5. *Reaction of* **Stylosanthes guianensis** *ecotypes to anthracnose in Carimagua, 1980.*

The stemborer, *Caloptilia* sp. is the most important pest affecting the genus *Stylosanthes*. Several biochemical and physical characteristics of susceptible and resistant plants are being studied.

The spittlebug (Homoptera: *Cercopidae)* is an equally important pest affecting grasses in tropical America. It attacks the genus *Brachiaria* principally. *Andropogon gayanus* and *Brachiaria humidicola* are resistant or tolerant to it.

A. gayanus is, however, attacked by the yellow aphid *(Sipha flava* Forbes) which causes a reddish coloring of leaves without causing great damage. However, a certain loss of quality is observed due to mechanical damage, and for this reason the pest could become important in areas under severe attack. The dynamics of the yellow aphid populations are being studied with a view to their control.

The legumes *Stylosanthes guianesis, Stylosanthes capitata, Centrosema* spp. and *Leucaena leucocephala* are the subject of genetic improvement. In the first case, plants with even greater production capability in the dry season, a good capacity for natural regeneration, adaptability to acid infertile soils, and resistance to diseases and pests such as anthracnose and the stemborer, are being sought. *Centrosema pubescens* is being crossed to *Centrosema macrocarpum* in order to increase its tolerance to soils of low fertility and high aluminum content. The Cunningham variety of *Leucaena leucocephala* is being crossed to *Leucaena pulverulenta* to obtain, after several backcrosses to Cunningham, plants better adapted to soil acidity and with lower mimosine levels.

Stylosanthes guianensis is a well known species of high quality and productivity. Efforts are under way to combine its desirable characters with anthracnose resistance. For this purpose, the agronomic characters and genetic compatibility of both common and "tardio" ecotypes of *S. guianensis* are being studied. As for genetic improvement of grasses, *Andropogon gayanus* is undergoing preliminary evaluation to obtain, through breeding, a greater proportion of leaves and more uniform flowering of the plants.

With the purpose determining nutrient requirements for pasture maintenance, studies were begun in 1980 on soil-plant-animal

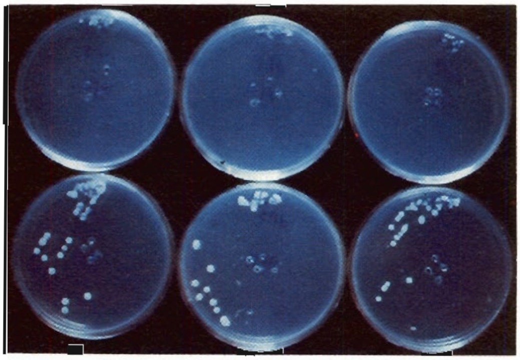
The tree **Leucaena leucocephala** *has the potential to produce valuable high protein forage throughout the year. Doctor Mark Hutton, the Program's legume breeder is attempting to reduce its mimosine content and increase its tolerance to acid soils. (Middle photograph)* **Leucaena** *plants showing adaptability and intolerance to acid Carimagua soil under low mineral fertilization.*

Results of improved tolerance to acid soil conditions in F_2 populations of **Centrosema***; plants were grown in sand with no phosphorous and high aluminum. Resistant plants behind, intolerant plants in front.*

relationships. A network of laboratories parallel to the Regional Trials Network and national institutions are doing comparative characterization of soil-plant relationships.

The Soil Microbiology Section is searching for better and more effective *Rhizobium* inoculants for forage legumes. A screening method has been adopted for *Rhizobia* collected from Regional Trials "A", which are sown without inoculant, and from exchanges with other institutions. Strains undergo different stages of evaluation. The first involves cultivation of the nodules in an acid medium for their reproduction. Isolated nodules are then tested on "Siratro" or the specific legume in test tubes. At this stage, inoculants which do not cause nodulation are discarded. During the second stage, effects of different strains on the same legume are compared in soil cylinders, and a selection is made of those which prove more effective in comparison with nitrogen applications. The third stage studies the range of specificity of strains in test tubes or Leonard jars. At the fourth stage, field tests are done of the best strains resulting from stage two to assess competitiveness, nitrogen-fixation ability and persistance. Finally, recommendations are made for inoculation of germplasm at advanced stages of evaluation.

Results of inoculating **Centrosema** *sp. with the addition of nitrogen.*



Selected **Rhizobium** *strains in neutral (above) and acid medium (below).*

Field evaluation of critical micronutrient levels in different genetic materials, Carimagua.

Pasture Evaluation

Kudzú and **Brachiaria decumbens** *in rows (above), and sparse plantings of* **Andropogon gayanus** *in Carimagua (below).*

More than five tons of *Andropogon gayanus* 621 seed were produced to provide basic seed to ICA in Colombia and to EMBRAPA in Brazil and to meet demand from research projects and the Regional Trials Network (see photo at left). The potential productivity of seed of different ecotypes of grasses and forage legumes is being assessed at five locations at different latitudes in Colombia, Brazil and Bolivia.

Simple, low -cost methods of pasture establishment with the most promising species and ecotypes are being developed in Carimagua. Their advantages and disadvantages are summarized in Table 5.

Research on pasture establishment in Brasilia involves investigating performance of germplasm in the two soil types prevalent in the Cerrados, i.e., the Red Yellow Latosol (LVA) found in higher parts of the landscape and the Dark Red Latosol (LVE) which predominates in the lowlands. Research on constraints in both soil types indicates that phosphorus is the main limiting factor, followed by sulphur, potash, zinc and molybdenum. Calcium is important in the case of the LVA.

Several different methods for establishing pastures and incorporating legumes into degraded and native savanna are also being evaluated in Brasilia. Figure 6 shows dry matter production by different components after two years of evaluation on native savanna. It can be seen that, although slow, *Stylosanthes capitata* has the potential of becoming an important

Table 5 **Principal advantages and disadvantages of planting methods and spatial distribution in pasture development, Carimagua.**

Systems	Advantages	Disadvantages
Conventional seeding (broadcast)	-Can be done manually or with scattering devices -a traditional method.	-Greater seed requirements -more weed problems -low fertilizer efficiency.
Row seeding	-Requires less seed -greater fertilizer efficiency -better initial establishment of each component -reduces initial competition -reduces shade.	-Requires more complicated machinery -slower than broadcast seeding.
Spatial distribution (species planted in separate bands)	-Results in more stable and persistant associations of some species than in intimate mixtures -permits association between otherwise incompatible species -keeps the advantage of association; avoids some of the problems of protein banks.	-More complicated than traditional planting -wide bands do not favor efficient use of nitrogen by associated grasses.
Low density methods	-Initially low labor, seed and fertilizer are required -well accepted on small farms -results in very strong and persistent mother plants -reduces risk of inherent failure in establishing pastures.	-May need more time to become established -not suitable for all species -may not work where weed potential is high.

component in native pastures if planted after disk plowing.

A further step in pasture evaluation is pasture utilization which concentrates on qualitative assessment of germplasm, characterization of plant-animal relationships and production potential of pastures in terms of the animal product. During 1980 there were indications that poor palatability of *Desmodium*

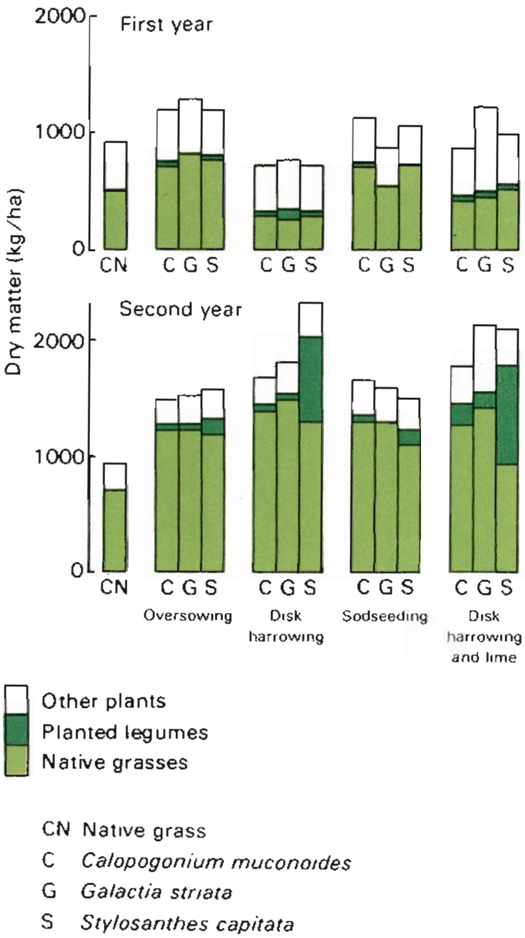


Figure 6. *Total production of dry matter and contribution of each component to total yield on a native prairie, Brasilia.*

Table 6 summarizes productivity evaluations of different types of pastures in Carimagua, expressed as weight gains. Clearly, in native savanna, animal productivity per year increases only slightly when grasses are introduced alone. However, when improved grasses are accompanied by legumes, the yearly per-animal productivity is doubled. In the same way, by using protein banks in improved pastures, animal productivity is twice that on native savanna, and, with only a small kudzu bank, it improves as much as 50%. With respect to yearly weight gain per hectare, grasses alone, such as *Brachiaria decumbens* or *Andropogon gayanus*, increased area productivity as much as 20 times. When *Andropogon gayanus* is associated with a legume, the area productivity is augmented approximately 15 times and animal productivity is equally raised.

ovalifolium 350 could be associated with soil fertility. The composition of tannins and other elements in *D. ovalifolium* and *D. gyroides* was also determined and their content found to be apparently related to protein content and their solubility in a medium simulating the rumen (Figure 7).

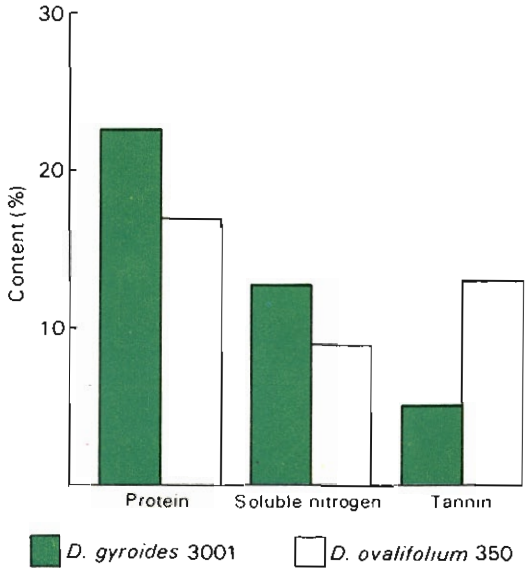


Figure 7. *Percent content, soluble nitrogen and tannins of two* **Desmodium** *species cut at 3-6 weeks of age, Quilichao.*

Table 6. **Pasture productivity expressed in weight gains. Summary of evaluations, Carimagua.**

Type of pasture	Average pasture productivity (weight gains)			
	Rains	Drought	Total / year	
	g/animal/day		kg/animal	kg/ha
Grasses only*				
Savanna with better management	-167	449	90	22
Melinis minutiflora	-445	508	97	43
Brachiaria decumbens	- 50	506	118	147
Andropogon gayanus	- 97	567	128	457
Associations**				
A. gayanus + *S. capitata*	303	656	201	330
A. gayanus + *Z. latifolia*	163	765	214	357
A. gayanus + *P. phaseoloides*	290	696	210	380
Protein banks***				
B. decumbens + *P. phaseoloides* in blocks	317	625	191	303
B. decumbens + *P. phaseoloides* in rows	540	606	213	341
Savanna + 1/20 of *P. phaseoloides*	52	468	121	30
Savanna + 1/10 of *P. phaseoloides*	126	537	147	74

* More than three years of observation
** Two years of observation
*** One year of observation.

The same occurs with protein banks in improved pastures, as in the case of *Brachiaria decumbens*. When protein banks were used in savannas, weight losses did not occur during the dry season, animal productivity increased by 60%, and per hectare productivity tripled.

In Brasilia, strategic management of the cow herd on native and improved pastures is presently being evaluated. In this respect, early weaning plays an important role in early reproduction of Zebu cattle.

Selective grazing of **Desmodium ovalifolium** *as a function of soil fertility.*

Pasture Evaluation in Production Systems

Prevailing production systems use native savanna as the basic feed component. The strategy for improving animal productivity in these areas, where there are problems regarding both quantity and quality of pastures, is to supplement the savanna with small extensions of improved pastures requiring low inputs and concentration of resources.

A study is underway with the support of the Technical University of Berlin and the GTZ (German Society for Technical Cooperation) on cattle production systems and their technological problems, both from the point of view of pasture development and of animal health and nutrition. This study is known as the ETES Project (Economic and Technical Evaluation of Beef Cattle Production Systems), which receives the collaboration of the North Eastern Plains Center (CIARNO) in Venezuela and CPAC in Brazil. On completion of the first phase of the project in the Colombian Llanos, ETES concluded that the Llanos cattle production system may be described as a low input-low output system. The differences in productivity from one farm to another are due mainly to variable availability of resources, the most productive farms being those with a greater proportion of low lands where more and better forage can be obtained during the dry season.

In Brazil, according to the ETES project, the prevailing production system employs relatively high levels of fertilization, two or three crops of rice and soybeans and, lastly, pasture establishment. The price of land in the Colombian Llanos is more than four times that in Brazil and Venezuela, fertilizers are cheaper in Venezuela than in Brazil or Colombia, and as far as credit subsidies are concerned, they are

much higher in Brazil, followed by Venezuela and Colombia.

The second phase of ETES will study the dynamics of adoption of a technology package designed in accordance with the constraints identified in the first phase, serving at the same time for large scale testing of improved pasture technology generated by the Program's research.

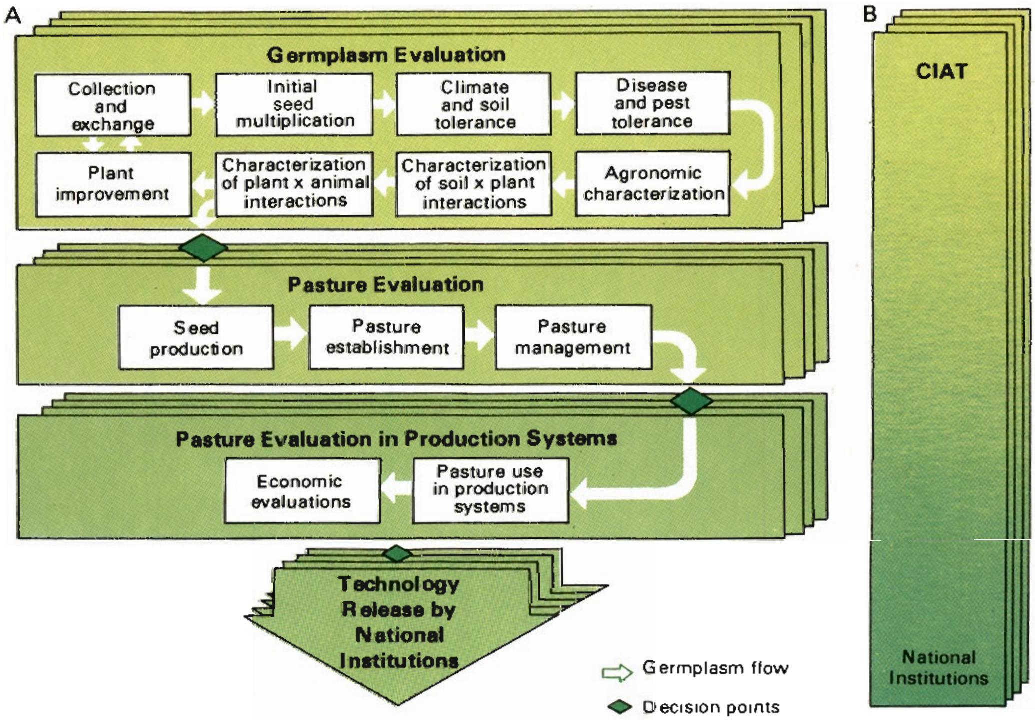
Training

During 1980 a total of 58 professionals from 12 Latin American countries was trained, 28 of them as participants in the Third Research Course on Production and Utilization of Tropical Pastures. The remaining 30 took part in research projects under the direct supervision of the Program. The third course on pastures differed from earlier ones in that it offered graduates greater participation in individual projects in different sections of the Program, especially Agronomy and Regional Trials, Soil Fertility and Animal Nutrition. In addition to this course, several visiting research associates worked on their theses, a form of collaboration offered by CIAT to different universities around the world.

The Program's Organization - a Graphic Summary

The various research steps followed by the Program are integrated into an organizational structure which allows for germplasm flow and information flow for each major ecosystem. The diagram also illustrates the degree of participation by national programs.

The decision points are key points in the operational flow of the Program, and answer sequentially questions regarding: a) the germplasm to be used in pasture development; b) the type of pastures needed by the production systems; and c) the types of technology to be transferred to cattlemen.



A Germplasm flow and research steps in the Tropical Pastures Program
B Degree of participation by national institutions and CIAT.

Training Program

Highlights

The year 1980 marked the culmination of a series of short intensive courses offered by CIAT since 1977 to form a "critical mass" of CIAT-trained professionals in Latin America and the Caribbean who work on beans, cassava, rice and tropical pastures. A total of 557 professionals participated in short intensive courses during the four years, and 441 more took part in medium- and long-term training.

Following this stage, a training program combining multidisciplinary short-term instruction (i.e., group phase) with long-term disciplinary specialization (i.e., individualized phase) was institutionalized — a combination deemed most appropriate and effective for the majority of professionals in collaborating national institutions.

Also, during the year, training in seed technology and assistance to in-country and regional training were intensified.

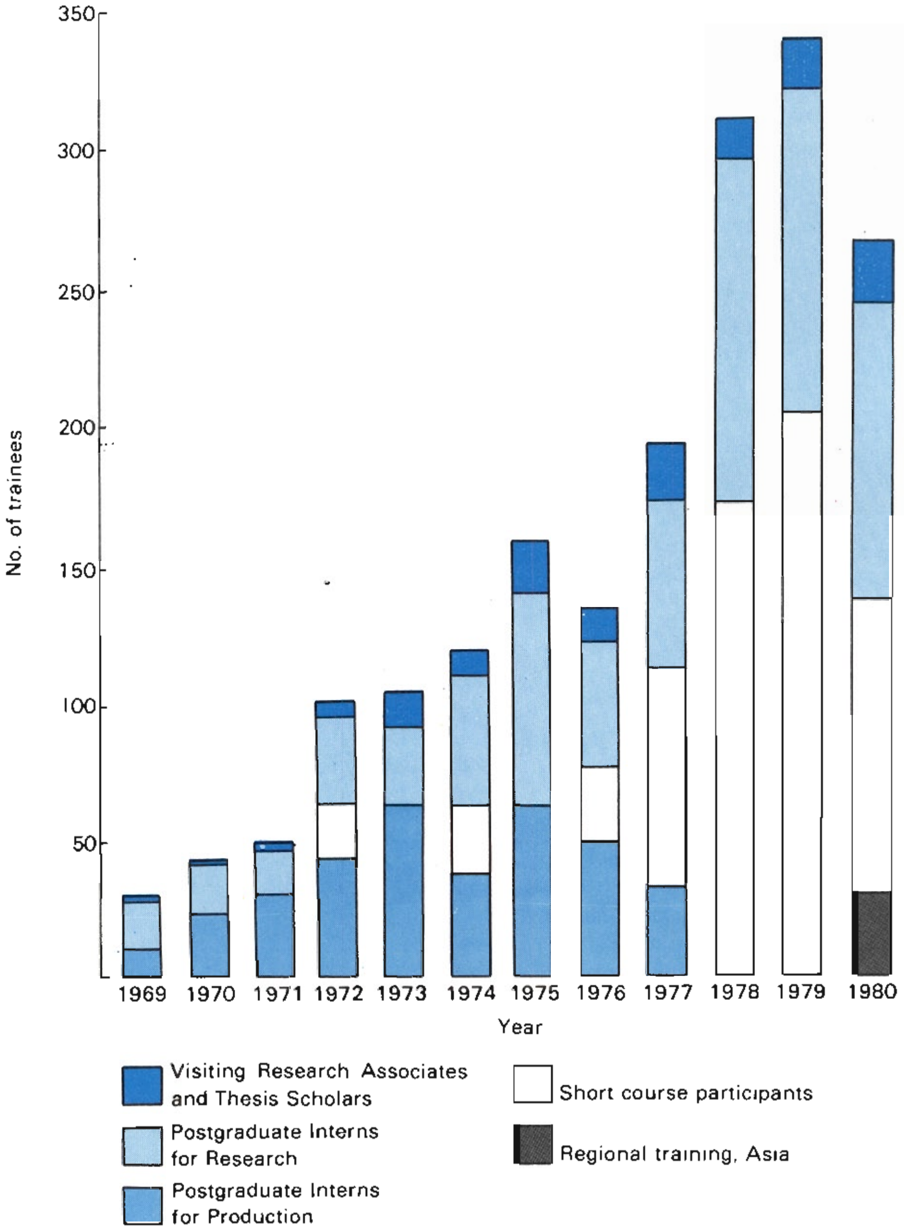


Figure 1. *Number of participants who completed training at CIAT from 1969 to 1980.*

Activities in 1980

Training is CIAT's single most effective tool to transfer research results to the countries. It is geared to help professionals from collaborating national institutions to adapt technologies to the specific needs of the countries and to engage in research using advanced methodologies.

Training opportunities are offered at the postgraduate level on commodities in CIAT's mandate. Candidates are selected with a view to form research teams for each commodity in the country or, alternatively, to train professionals that will bridge the gap between research and extension at the national level.

The main beneficiaries of CIAT's training have been the countries in tropical Latin America, eventhough a small percentage of participants has come from Asian and African countries. Financial support for the training internships is provided in a small proportion by CIAT, and for the most part from special project funding and from the participant countries themselves.

In 1980 five intensive short courses were offered followed by individualized internships in given disciplines (Fig. 2). Figure 1 shows the numbers of Postgraduate Interns for Research, Postgraduate Interns for Production, Visiting Research Associates and Thesis Scholars in 1980 and compares these to the numbers of the previous years.

In 1980, CIAT was again able to increase its efforts in assisting in-country courses organized by national institutions/agencies in favor of the commodities in CIAT's mandate. Normally, these courses are organized for research and

Table 1. **Professionals trained at CIAT by Research Program/Support Unit, 1980.**

Program or Unit	No. of trained professionals
Beans	69
Cassava	78
Rice	33
Tropical Pastures	60
Data Services	1
Seed Production	55
Station Operations Management	2
Communications	4
Training	1
Total	303

extension professionals and contribute much to the bridging of the gap between research and extension efforts on the national level. CIAT's involvement with in-country training efforts is catalytic in nature, and it may be instrumental in getting a series of in-country courses started, whereupon the national institution/agency is able to continue on its own. Table 2 summarizes the in-country training efforts which received CIAT assistance in 1980.

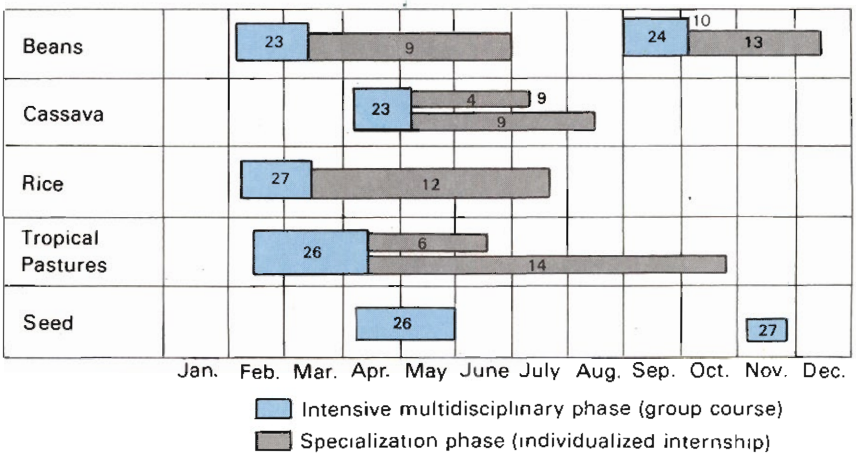


Figure 2. *Structured training programs on CIAT's commodities in 1980.*

Table 2. **Countries receiving in-country training assistance. Commodities and No. of participants, 1980.**

Country	Commodity	No. of participants
Peru	Rice Production	20
Panama	Rice Production	12
Mexico	Cassava Production	25
Dominican Republic	Cassava Production	25
Cuba	Bean Production	30
Colombia	Bean/Coffee Association	25
	Seed Technology	31
The Philippines	Cassava Research (Regional training)	25
Total		193

Seed Unit

This Unit initiated its activities in 1979 with financial support from the Swiss Development Cooperation. Its general objectives are to assist in the strengthening of seed programs in the region and to aid research programs of CIAT and the Center's collaborators in expediting the transfer of improved germplasm.

Traditionally, this process has been a bottleneck in developing countries and has prevented the timely transfer of appropriate varieties to farmers. The principal limiting factors are lack of trained personnel, often unclear and inconsistent government policies, limited supplies of breeder and basic seed for the seed industry, and production and marketing problems.

In view of the above the Seed Unit has adopted the following specific objetives: training of seed program leaders and technologists and encouragement of better communication among them; support to increased seed production, and adoption of improved varieties and hybrids; technical collaboration with national programs, as well as support to research on seed production and distribution problems.

Up to the end of 1980 the Seed Unit had offered basic and specialized courses to 123 seed technologists who received broad-based training in aspects of seed production, processing, marketing and quality control. The second phase of the training program included an advanced, specialized course in the production of breeder and basic seed.

The Unit has collaborated in accelerating the use of improved hybrids and varieties by national programs. This collaboration includes advice on the formation of seed associations and new local seed enterprises, as well as assistance to regional and national groups in conducting short courses and workshops.

CIAT commodity research programs receive support from the Unit in the multiplication of basic and breeder seed and delivery of promising germplasm materials to national programs and other interested organizations. Also, the Unit maintains links with CIMMYT and ICRISAT to assist them in the dissemination of promising materials in the region.

With respect to research on seed technology relevant to the region, there is a need to study production, harvesting, storing, and quality evaluation of most CIAT commodities. The Unit is working with the commodity programs and others in the region to help solve these problems.

Publications in 1980

Reports

Informe CIAT 1980
May, 1980
CIAT Series 02S1-79

CIAT Report 1980
May, 1980
CIAT Series 02E1-79

Informe Anual, Programa de Pastos Tropicales, 1979
November, 1980
CIAT Series 02STP-79

Informe Anual, Programa de Arroz, 1979
September, 1980
CIAT Series 02SR1-79

Informe Anual, Programa de Fríjol, 1979
September, 1980
CIAT Series 02SB1-79

Informe Anual, Programa de Yuca, 1979
October, 1980
CIAT Series 02SC1-79

Tropical Pastures Program, Annual Report, 1979
August, 1980
CIAT Series 02ETP1-79

Rice Program, Annual Report, 1979
September, 1980
CIAT Series 02ERI-79

Bean Program, Annual Report, 1979
September, 1980
CIAT Series 02EB1-79

Cassava Program, Annual Report, 1979
June, 1980
CIAT Series 02ECI-79

IBYAN 1977 Frijol Arbustivo
Oswaldo Voysest
Technical Report
December, 1980
CIAT Series 20SB2-77

Monographs

Problemas de Producción del Fríjol
H. F. Schwartz, G. Gálvez, ed.
January, 1980
CIAT Series 09SB-1

Bean Production Problems
H.F. Schwartz, G. Gálvez, ed.
January, 1980
CIAT Series 09EB-1

Desórdenes Nutricionales de la Yuca
R. Howeler
January, 1980
CIAT Series 09SC-3

Technical Manuals

El Mosaico Común del Fríjol
Francisco J. Morales
January, 1980
CIAT Series 05SB-1

Problemas en Cultivos de Arroz en América Latina
Peter R. Jennings and Robert L. Cheaney
(Reprint)
November, 1980
CIAT Series 07SR-1

Field Problems of Rice in Latin America
Peter R. Jennings and Robert L. Cheaney
(Reprint)
November, 1980
CIAT Series 07ER-1

Newsletters and Bulletins

Arroz del CIAT para América Latina
Newsletter
Nos. 1 and 2
CIAT Series 01SR-1

Hojas de Fríjol para América Latina
Newsletter
Nos 4 to 8
CIAT Series 01SB-4-8

Boletín Informativo sobre Pastos Tropicales
January-June 1980
CIAT Series 01SG-3

Boletín Informativo sobre Yuca No. 8
January-April, 1980
CIAT Series 01SC-8

Cassava Newsletter No. 8
January-April, 1980
CIAT Series 01EC-8

CIAT, sus Propósitos y Actividades
Informative booklet
November, 1980
CIAT Series 1S1C-3

CIAT, Its Purposes and Activities
Informative booklet
October, 1980
CIAT Series 12EIC-3

ARCOS, Periódico para información interna
Nos. 31 to 35

Catalogues, Analitical Abstracts, Directories

Ensayos Preliminares (Preliminary Trials) EP
Shree P. Singh
August, 1980
CIAT Series 20S/EB4-80

Catálogo de Publicaciones Periódicas
December, 1980
CIAT Series 01CI-1

Publicaciones - Publications, 1973-1980
Febrero - February, 1980

Resúmenes Analíticos en Economía Agrícola Latinoamericana, Vol. V
December, 1980
CIAT Series 08SE-4

Resúmenes Analíticos sobre Yuca, Vol. VI
December, 1980
CIAT Series 08SC-4

Abstracts on Cassava, Vol. VI
December, 1980
CIAT Series 08EC-6

Resúmenes Analíticos sobre Fríjol, Vol V
December, 1980
CIAT Series 0SB-5

Abstracts on Field Beans, Vol V
December, 1980
CIAT Series 08EB-5

Resúmenes Analíticos sobre Pastos Tropicales, Vol. II
December, 1980
CIAT Series 08SG-2

Directorio de Investigadores en Fríjol para América Latina y El Caribe
Second edition
March, 1980
CIAT Series 01NB-1

CIAT Rhizobium Collection
Peter H. Graham
May, 1980

Audiotutorial Units

Through special funding of the W. K. Kellogg Foundation, CIAT is in the process of developing a series of so-called audiotutorial training packages on research and production technologies related to the crops in the Center's mandate. These packages are for use by training participants at CIAT, and are also made available, at cost, to national institutions, universities, and private industry.

In 1980 more than 1000 copies of these packages were distributed. The audiotutorial training packages consist of an audiovisual presentation of the topic by means of 35 mm slides and a synchronized cassette recording, a supplemental study guide, the transcription of the recording, and formats for self-evaluation of learning achieved.

The audiotutorials produced and available for distribution, all of them in Spanish, are the following.

Rice

Selección y adecuación de lotes para la producción contínua de arroz
128 slides, 28 minutes, Series 04SR-01.01

Preparación de suelos mediante el sistema de inundación (fangueo) para el cultivo del arroz
78 slides, 18 minutes, Series 04SR-01.0

Siembra de arroz mediante transplante
97 slides, 22 minutes, Series 04SR-01.04

Producción y beneficio de semilla certificada de arroz
125 slides, 35.30 minutes, Series 04SR-01.08

Control y normas de calidad de las semillas certificadas de arroz
110 slides, 25.30 minutes, Series 04SR-01.09

Barrenadores del tallo del arroz en América Latina y su control
120 slides, 27 minutes, Series 04SR-04.01

Latencia y pregerminación de las semillas de arroz
78 slides, 29.30 minutes, Series 04SR-05.01

Morfología de la planta de arroz
75 slides, 17 minutes, Series 04SR-05.02

Crecimiento y etapas de desarrollo de la planta de arroz
128 slides, 31 minutes, Series 04SR-05.04

Evaluación de la calidad del arroz
107 slides, 28.30 minutes, Series 04SR-07.03

Evaluación de la resistencia varietal a la Sogata y al virus de la hoja blanca
80 slides, 27.30 minutes, Series 04SR-07.04

Weed Control

Principios básicos para el manejo y control de las malezas en los cultivos
85 slides, 26 minutes, Series 04SW-01.01

Información básica sobre la competencia entre las malezas y los cultivos
104 slides, 44 minutes, Series 04SW-01.02

Principios básicos sobre la selectividad de los herbicidas
110 slides, 39 minutes, Series 04SW-01.03

Los Herbicidas: modo *de actuar y síntomas de toxicidad*
First part: 78 slides, 34 minutes
Second part: 78 slides, 29 minutes, Series 04SW-01.04

Factores que condicionan la eficacia de los herbicidas
105 slides, 38 minutes, Series 04SW-01.05

Equipo para la aplicación terrestre de herbicidas
127 slides, 30 minutes, Series 04SW-01.06

Formulaciones de herbicidas
109 slides, 32 minutes, Series 04SW-01.07

Recomendaciones básicas sobre el manejo de agroquímicos
137 slides, 34 minutes, Series 04SW-01.08

Los surfactantes: clases, propiedades y uso con herbicidas
93 slides, 30 minutes, Series 04SW-01.09

Manejo y control de las malezas en el cultivo de la yuca
86 slides, 35.30 minutes, Series 04SW-02.01

Manejo y control de las malezas en el cultivo del fríjol
112 slides, 41.30 minutes, Series 04SW-02.02

Principios básicos para el manejo y control de las malezas en los potreros
129 slides, 42.30 minutes, Series 04SW-03.01

Guía práctica para el control químico de las malezas en los potreros
106 slides, 37 minutes, Series 04SW-03.02

Beans

Descripción y daños de las plagas que atacan el fríjol
140 slides, 54.30 minutes, Series 04SB-05.01

Principales insectos que atacan el grano del fríjol almacenado y su control
80 slides. 30 minutes, Series 04SB-05.03

El lorito verde **(Empoasca kraemeri)** *y su control*
83 slides, 30 minutes, Series 04SB-05.04

Enfermedades del fríjol causadas por hongos y su control
140 slides, 52 minutes, Series 04SB-06.01

Enfermedades del fríjol causadas por virus y su control
126 slides, 51.30 minutes, Series 04SB-06.02

Técnicas para el aislamiento, identificación y conservación de hongos patógenos al fríjol
97 slides, 27.30 minutes, Series 04SB-06.04

La roya del fríjol y su control
90 slides, 33 minutes, Series 04SB-06.06

Cruzamiento del fríjol
140 slides, 40 minutes, Series 04SB-08.02

Morfología de la planta de fríjol común
113 slides, 33 minutes, Series 04SB-09.01

Diversidad genética de las especies cultivadas del género **Phaseolus**
114 slides, 47 minutes, Series 04SB-09.02

Semilla de fríjol de buena calidad
122 slides, 52 minutes, Series 04SB-12.03

Cassava

Un tipo ideal de planta de yuca para rendimiento máximo
77 slides, 29 minutes, Series 04SC-02.01

El cultivo de meristemas de yuca y sus aplicaciones
53 slides, 35 minutes, Series 04SC-02.02

Descripción de las enfermedades de la yuca
94 slides, 28.30 minutes, Series 04SC-03.01

El control de **Erinnyis ello** *(gusano cachón de la yuca)*
71 slides, 25.30 minutes, Series 04SC-04.01

Descripción de las plagas que atacan el cultivo de la yuca y características de sus daños
93 slides, 39 minutes, Series 04SC-04.02

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62 slides, 19 minutes, Series 04SC-06.01

Selección y preparación de estacas de yuca para siembra
65 slides, 27 minutes, Series 04SC-06.02

Other topics

Preparación de suelos en zonas mecanizables
69 slides, 18 minutes, Series 04ST-01.01

Prácticas de manejo de las cerdas lactantes y sus lechones
101 slides, 39.30 minutes, Series 04SS-01.02

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BEAN PROGRAM

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Peter H. Graham, PhD, Microbiologist
Francisco J. Morales, PhD, Virologist

* Left during 1980

Silvio H. Orozco, MS, Plant Breeder (stationed in ICTA Guatemala)
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Federico Scheuch, MS, Agronomist (stationed in Lima, Peru)
* Howard F. Schwartz, PhD, Plant Pathologist
Shree P. Singh, PhD, Plant Breeder
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Oswaldo Voysest, PhD, Agronomist
* Kazuhiro Yoshii, PhD, Plant Pathologist (stationed in ICTA, Guatemala)

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* Paul Kretchmer, PhD, Physiology/Climatology
Marcial Pastor-Corrales, PhD, Plant Pathology

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* Gustavo Arcia, MS, Economics
Robin Buruchara, MS, Plant Pathology
* Aurora Susana García, Agronomist, Agronomy
Upali Jayasinghe, Ir., Virology
* Mary Katherman, MS, Plant Pathology
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** Marceliano López, MS, Training

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Carlos Bohórquez, Agronomist, Agronomy
Horacio Carmen, Agronomist, Plant Pathology
Mauricio Castaño, Agronomist, Virology
Jesús Castillo, Agronomist, Physiology
Aurora Duque, Agronomist, Microbiology
Myriam C. Duque, Math., Economics
Oscar Erazo, Agronomist, Agronomy
* Jaime García, Agr. Adm., Seeds
Jorge García, Agronomist, Entomology
* Ranulfo González, Biologist, Entomology
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RICE PROGRAM

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Manuel Rosero, PhD, Plant Breeder IRRI Liaison Scientist
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Jenny Gaona, Agronomist, International Trials
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CASSAVA PROGRAM

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Reinhardt Howeler, PhD, Soil Scientist
Kazuo Kawano, PhD, Plant Breeder
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Visiting specialist

Edwald Sieverding, PhD, Soil Scientist

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Jorge López, Head Bibliographic Services
Mariano Mejía, BA, Tropical Pastures Documentation
Lynn Menéndez, Translations
Piedad Montaño, Head Acquisitions
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CIMMYT/CIAT ANDEAN REGION MAIZE PROJECT

Senior staff
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James Barnett, PhD, Plant Breeder

Research assistant
Edgar Castro, Agronomist

* Left during 1980

Climatic data for research locations mentioned in this report.

Location	Altitude (masl)	Mean temp (C°)	Mean rainfall (mm/year)	Rainfall distribution	Duration of wet season (months)	Comments
CIAT-Palmira (Valle del Cauca, Colombia)	1000	23.7	1000	bimodal		
Popayán (Cauca Colombia)	1850	17 9	1600	bimodal		Site in lower montane area
Carimagua (Meta, Colombia)	160	26.0	2100	unimodal	8	Savanna vegetation on infertile, acid soils
Brasilia (Brasil)	950	21 3	1550	unimodal	6 7	Savanna vegetation on infertile, acid soils
Media Luna (Magdalena, Colombia)	10	27.0	1200	unimodal	7-8	Tropical lowland with long dry season; very sandy soils
CIAT Quilichao (Cauca, Colombia)	1052	24 8	1850	bimodal		Premontane area, acid, infertile soils
Huila (various sites Huila, Colombia)	900- 1062	17 0- 23.0	1100 1500			Traditional small farm bean production region characterized by high disease pressures
La Selva (Antioquia, Colombia)	2200	16 8	1900	bimodal		Lower montane site for selection of climbing beans in relay system
Caribia (Magdalena, Colombia)	10	27 0	1200	unimodal	7-8	Tropical lowland site; long dry season; sandy soils.
Obonuco (Nariño, Colombia)	2700	13.2	790	bimodal		Montane site for selection of climbing beans grown in direct association with maize
La Libertad (Meta Colombia)	220	26.5	3860	unimodal	10	Savanna vegetation on infertile, acid soils, important rice production area (upland and irrigated)
Montería (Córdoba, Colombia)	200	27 0	1120	unimodal	6 7	Fertile soils, high temperature, high humidity
Nataima (Tolima, Colombia)	350	28.0	1000	bimodal		Fertile soils high temperature
Mondomo (Cauca, Colombia)	1450	19.0	2400			Premontane site; acid, infertile soils