Research Highlights 1977

Published in March 1978

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Contents

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Introduction

The year 1977 was an important and historic period for CIAT. During the year new program directions were consolidated and dynamically advanced. Moreover, these changes and accomplishments were assessed and endorsed by comprehensive and authoritative review.

Early in the year CIAT was the object of an intensive review covering all of its activities. The review, conducted by a panel of top scientists for the Technical Advisory Committee of the Consultative Group for International Agricultural Research (CGIAR), is the mechanism for fully evaluating every five years the programs of each international center under the CGIAR.

The objectives of the review were not only to look at past accomplishments but to determine if these are contributing to a well-designed, overall strategy for the future. Thus, the exercise caused us to take a searching look at ourselves, at our mandate, and at our objectives for meeting that mandate. In addition, representatives of a few of our client institutions in countries of the region were interviewed to determine whether our technology transfer linkages were operating effectively. It was very encouraging that the overall report from the review was extremely favorable, indicating that we have accomplished a great deal and that these results will contribute to even more rapid future progress.

One of the early preparations for this intensive review was to closely look at our objectives as an international center. From these discussions, the following Statement of Objectives was developed.

Statement of Objectives

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

To look at these objectives in more detail, the product of our work is improved technology —improved methods of producing five commodities— beef cattle, beans, cassava, rice, and swine. (Development work in maize is a part of CIMMYT's global program, with CIAT serving as a relay center.) These improved methods are not designed to increase production at any cost, but rather, to lower unit costs of production so that the rural and urban poor will benefit most from any increases. Small farmers (low resource producers) are special targets; our improved technology must apply to the real conditions of this group.

Our intermediate product of trained manpower is implied in the objectives statement. Only with trained personnel can local institutions adapt improved technology to specific local conditions and deliver it to the ultimate users.

Clients of our improved technology are national institutions. We do not have the responsibility nor the right to trespass on national prerogatives of transferring technology within countries. While we do a great deal of testing in the region, evaluations are always with the approval or collaboration of institutions in those countries.

Research is directed to tropical areas that share the common advantages and related problems of a year-round growing season (if water is available) in Latin America and the Caribbean where our target commodities are basic foods. However, we have global responsibilities among the international centers for work with beans and cassava.

One of the very important tenets to which we adhere is our concern to improve human welfare by improving consumers' purchasing power and nutrition. Depending on the commodity, we work to increase available food both by bringing new land into production and increasing productivity in existing production areas. But we always attempt to develop technology that will achieve optimum production levels of foods that are high in quality and nutritious and at the same time, use as few inputs as possible.

Three administrative developments of 1977 were important for ensuring that we will continue to progress. First, CIAT's international cooperation functions were further consolidated within an overall policy under the leadership of an associate director general. This office is responsible for planning and coordinating the Center's outreach activities and is the primary linkage with client institutions of the region. Commodity programs also share responsibility for international cooperation. During 1977 several highlights discussed in the respective sections of this report emphasize the strong progress made in areas such as international testing and international cooperation networks.

The Beef Program, after much earlier review and discussion of its objectives, began 1977 in a state of dynamic change. During the year the Program's reorganization was largely completed and most of the new staff to be added were on the job. The Program will work toward developing beef production technology for the infertile, acid soil areas of Latin America. Field work in the Program was accelerated and three scientists were already in place (two at Brasilia, Brazil, and one at Carimagua, Colombia) to help direct field activities.

A new operating unit, the Genetic Resources Unit, began active development during the year. Its objective is to store, evaluate and distribute various germplasm species in support of other programs of the Center. This will consolidate these stages of germplasm maintenance and handling and free the commodity programs of these tasks. Most important among the Unit's activities was the completion of renovations and furnishing of a modern cold storage facility to permit long-term, safe storage of these valuable genetic resources.

CIAT's research programs received assurance of improved support during 1977 with the signing of a new, improved agreement for the operation of the Carimagua substation with the Instituto Colombiano Agropecuario (ICA) and the acquisition through lease of another substation near CIAT.

At Carimagua the new agreement between CIAT and ICA provides for cooperative management of this large station in the Eastern Plains of Colombia. Two CIAT principal staff, a farm superintendent and a beef team member, are living on the station.

The new substation, to be called CIAT-Quilichao, is a 184-hectare farm about 40 kilometers South of Cali and 60 kilometers from CIAT. The site provides a low stress location to evaluate technology for acid, infertile soils. Most of the physical development of the farm, including grading, road construction, drainage, and fencing, was completed in 1977 and a considerable number of experiments were established by commodity programs. The farm was acquired for CIAT's use by the Foundation for Superior Education of Colombia and is leased for a nominal rent.

In addition to these accomplishments, the overall staffing of the Center increased significantly with the number of principal staff rising from 68 to 84 with several more appointed and scheduled to arrive in early 1978.

Thus, it is clear that 1977 was a year of change for CIAT; and, while changes were numerous they were part of an overall strategy. All of them will support our everyday activities, insuring that we will make significant progress in future years as we have in 1977 and earlier years.

Bean Program

Introduction

The CIAT Bean Program concentrates its efforts on furnishing improved germplasm of *Phaseolus* beans for production in tropical areas of the world. This not only includes developing new materials that combine resistance to major diseases and insect pests with high yielding potential and tolerance to varying environmental conditions, but also involves a leadership role in the selection and distribution of existing finished materials that may be adapted over wide locations.

A significant part of the Program's work during 1977 involved international activities to make promising materials available to as wide a group of client programs as possible. In addition, testing networks were enlarged to reinforce the international evaluation and movement of selected materials.

Breeding

During 1977 the Bean Program defined additional breeding objectives and responsibilities. These included the goals of improved plant type, yield potential and adaptation. Moreover, specific characters will also be sought including lodging resistance and different maturity types.

Crosses were increased between parents with multiple disease resistances, especially employing non-black progenitors. Forty-eight percent of crosses made during the year were between non-black materials and another 31 percent were between black and non-black parents.

From the first group of crosses 22 red, 64 other non-black, and 122 black-seeded advanced progenies were yield tested in replicated trials at CIAT during the 1977 second semester. Yields of at least a few non-black selections were as good as those of the best black-seeded checks. This limited data suggested that great progress is possible in upgrading the yielding ability of non-black materials which are widely preferred but have lagged behind black cultivars.

Results from the project on breeding for early maturity were very satisfactory. The character appeared to be simply inherited and selection was found to be effective starting from the F_2 generation. Rapid progress could be made through a modified bulk-pedigree method. Few indeterminate segregates were as early as or earlier than the determinate parents (the source of early maturity). The former group seems to have higher yielding potential and stability.

Improved germplasm is the primary goal of CIAT's Bean Program. Here a bean breeder and his assistant make the visual evaluation of pod number and placement in a group of breeding lines just before their harvest when yields will be recorded.

Bulk seed of 646 F_2/F_3 early generation segregating populations were supplied to various national programs of the region upon their direct requests.

Plant Pathology

In order to understand the frequency of occurrence of bean common mosaic virus (BCMV) races and to provide better orientation for breeding work, 45 isolates of the virus collected in 10 Latin American countries and the United States were tested on a set of differential varieties. Sixty percent of the isolates were race BCMV-1, followed in frequency by BCMV-3, -4, -2, and -5.

A severe outbreak of black root at CIAT during mid-1977 was shown to be a hypersensitive reaction to BCMV, primarily the type strain (BCMV-1). The reaction was induced by high aphid populations and temperatures. A secondary value of incorporating the dominant I gene into breeding material was observed as plants exhibiting the hypersensitive reaction died quickly and did not transmit significant levels of inoculum to perpetuate the epidemic.

Field screening of the germplasm bank for resistance or tolerance to bean golden mosaic virus (BGMV), transmitted by the white fly, continued in El Salvador and Guatemala. Although no resistant sources have been identified, some tolerant accessions were observed; these include some non-black materials. Hybrid progenies were also screened at these locations and exhibited some positive transgressive segregation, indicating that additive effects were expressed in specific crosses between tolerant parents.

An International Bean Golden Mosaic Nursery with 190 entries was tested in Brazil, Mexico, the Dominican Republic, Guatemala, El Salvador and Nigeria. All materials behaved similarily in all locations and six entries were tolerant in all tests.

Bean rugose mosaic virus (BRMV) produces symptoms similar to those caused by BCMV, and the disease is probably more frequently present in Latin America and the Caribbean than currently realized. CIAT tests confirmed that BRMV is not seed-transmitted by Chrysomelid beetles, and that different races exist. Field screenings revealed that 25 of 190 promising materials and 26 of 355 advanced families were resistant to the race utilized for screening.

Results from the first two international rust nurseries revealed that no material was immune or resistant at every location in both years, however, some entries were at least resistant or intermediate at many locations in both years. CIAT and locations in the Dominican Republic, Costa Rica and Mexico had the highest proportion of susceptible entries and are optimum locations to test hybrid materials for resistance to diverse populations of rust races.

Only by examining each plant of each line in this rust nursery can breeders and pathologists be certain that promising materials are not overlooked. Close observation also provides the opportunity to check other growth characteristics of each segregating line.

Materials tolerant or resistant to common bacterial blight in temperate zones were susceptible at CIAT, primarily due to poor adaptation and photoperiod sensitivity. Experiments demonstrated that field screening techniques were more reliable when seedlings were inoculated and plants evaluated at first flowering of the earliest maturing line being tested. Much variation existed in virulence among isolates, however, there were no indications of the existence of different races.

Field and glasshouse inoculation procedures have been developed or improved to test hybrid materials for resistance to bean rust, angular leaf spot, root rot pathogens and anthracnose at CIAT and other locations in Colombia.

Entomology

Improved screening techniques for *Empoasca kraemeri* (leafhopper) resistance evaluations in segregating populations of bean materials were tested using a simulated F_2 population composed of a mixture of 40 varieties having various resistance levels. Scoring according to individual plant damage scores and yields gave a more reliable resistance estimate.

In studies to determine the optimum economic level for chemical control of leafhoppers, profits were calculated to be maximized by allowing about one nymph per leaf. In other words, it was not profitable to try to eliminate the pest. Moreover, studies also showed that farmers should concentrate protection efforts against the leafhopper during bean flowering and pod-setting stages of development. Plants that were protected only between 26 and 62 days after planting yielded as well as those protected for longer periods.

In other experiments for controlling leafhoppers, the use of rice straw mulch doubled yields over non-mulched or black plastic-mulched plots. The use of aluminum foil mulch tripled the yield over control plots. Light reflection and/or color contrast were the principal factors involved in reducing the insect populations.

Among the large number of Chrysomelid species usually found in bean fields, *Diabrotica balteata* was the most abundant one. Bean root damage from Chrysomelid larvae is common in the field but *D. balteata* could not develop on bean roots in the laboratory. However, larvae that had previously been fed on maize roots caused more damage to bean plants.

The use of vegetable oils was confirmed as an excellent material for protecting dry beans during storage against *Zabrotes subfasciatus*. Five milliliters of oil per kilogram of beans controlled the pests by increasing adult mortality and reducing oviposition and larval survival. Oil treatments did not reduce seed germination after six months of storage nor greatly affect water absorption.

Physiology

Results of 12 growth experiments over three years with the representative bean variety Porrillo Sintetico were used to determine the most important physiological factors limiting yields in beans. Factors that are identified become major goals for improvement during screening and selection of breeding materials.

Data supported earlier observations that crops with larger vegetative structure have higher yields. The most important parameters were pods per square meter (pod density), total dry matter at maturity and number of vegetative nodes. Leaf area duration, if combined with lodging resistance, also contributed to high yields. A maximum leaf area index of about 3.5 - 4 appeared to be optimal; a higher leaf area index may not produce an increased crop growth rate unless lodging resistance could be improved.

Growth analyses of five varieties representing the four bean growth habits defined at CIAT provided similar results to those with Porrillo Sintetico. Increased node structure and leaf area were strongly related to yield. The comparative earliness of two bush varieties apparently limited their maximum leaf area, and thus, the leaf area duration, resulting in slightly lower yields. Leaf area efficiency (yield/unit of leaf area duration) for the four non-climbing varieties was similar, indicating that canopy type does not greatly influence the yielding capacity of the photosynthetic system. In the climbing variety, leaf area efficiency was much lower, possibly because excessive leaf area development caused self-shading of lower leaves.

Carbon dioxide supplementation in field plots during the immediate post-flowering period increased yields 43 percent. Supplementation apparently increased available photosynthate supply, in turn causing increased pod set and more mature beans per pod. In practice, an increased photosynthate supply should be possible during this period by either increasing leaf area or by increasing photosynthetic efficiency of the available leaf area. Either of these factors would also be aided by stem erectness and lodging resistance.

Large genetic differences were found among 125 promising lines for resistance to excess water, which could be a serious limiting factor during periods of heavy rainfall on poorly drained soils.

Experiments also showed that *Phaseolus* germplasm exists which is comparatively widely adapted to temperatures occurring at altitudes from 880 to 1900 meters.

This material will be useful in breeding strategies aimed at wide adaptation.

Agronomy

During 1977 some results of the first International Bean Yield and Adaptation Nursery (IBYAN) became available. Data from more than half of the 90 testing locations showed that the mean yield for the five best entries was 35 percent higher than the mean of the five local entries used at each site, in both temperate and tropical zones. This shows that the germplasm material selected under tropical conditions has been widely adapted. Moreover, results point out the importance of assembling and distributing a wide array of materials that are already available as varieties for testing in a range of conditions. Mean yields were always lower in tropical locations, usually because of disease epidemics.

A second IBYAN consisting of 20 lines each of black and non-black materials was assembled and, through October 1977, had been sent to 104 locations, about 80 percent of which were in Latin America and the Caribbean. Of these, six varieties will possibly be released by national programs in countries where the varieties are not now grown.

The optimum time for planting beans with maize was investigated to help develop technology for associated cropping systems.

This intimate association of climbing beans and maize is typical of the cropping systems in much of Latin America. For this reason the climbing bean receives much attention in technology development for the small farmer.

Bean yields were sharply reduced by planting at the same time as the maize, compared to planting 10 days before. On the other hand, planting beans before the maize also reduced maize yields. Nevertheless, at CIAT, optimum production of both crops was achieved from simultaneous planting.

Three hundred accessions of climbing beans were selected from among about 2500 in the germplasm bank for further testing because of their yield potential and grain color. At CIAT they were planted with maize and at Popayan, Colombia, among old maize stalks. A number of the materials outyielded the eight standard controls representing the best varieties identified to that time. Among the high yielders were beans of several colors other than black.

Soils

Wide variations were found among bean germplasm being screened for tolerance to low soil phosphorus. A number of varieties yielded equally well at levels of 50 kg/ha of applied phosphorus (established as a level to provide maximum stress at Popayan) as they did at levels of 300 kg P_2O_5/ha.

At Popayan, experiments showed that the rate of phosphorus required for optimum (95 percent of maximum) yields was 500 kg/ha of P_2O_5 as incorporated triple superphosphate. This corresponded to 0.05 - 0.08 ppm phosphorus in soil solution or 0.38 percent in the upper leaves at flower initiation.

In soils with a high phosphorus fixing capacity, the method of application is often as important as the amount applied, and the optimum method can vary with different sources. For conditions at Popayan, band placement of 75 kg P_2O_5/ha as triple superphosphate was as effective as broadcasting 300 kg P_2O_5/ha, while sources with lower solubilities, like rock phosphates, were more effective when broadcast. Over time an initial advantage in yields from the application of triple superphosphate decreased compared with some of the more soluble rock phosphates which provided bean yields that were equally high. Due to this residual effect, the cheaper rock phosphates could be a good substitute for triple superphosphate on acid soils such as those of the Popayan location.

Economics

In cooperation with the Pilot Program in Maize and Beans (PROMYF), in Honduras, agricultural economists of the Bean Program made a simple economic analysis of bean production costs and returns for the project, which is attempting to increase incomes of small and medium farmers. The development of an improved early red variety suited to the second season plantings of the area was believed to be the most important component of a new technology package for this project. Variation in water availability and disease and insect incidence between production seasons made the use of high levels of inputs very risky.

In the Restrepo region of Colombia agronomic research continued in 1977 to identify improved varieties and profitable input use for small farmers growing beans. CIAT selections of red bush beans did not significantly increase yields over the local Colombian improved variety, Calima, however, several red climbing selections yielded significantly higher than the local red. The new technologies — including climbing selections, some phosphorus fertilizer, increased organic fertilizers and spraying for insect and disease control — increased net incomes by 42 to 55 percent, even though the new technology substantially increased the costs of purchased inputs.

Training

In early 1977 the Bean Program, in cooperation with the CIAT Training Section, held the first intensive course in bean production for Latin American researchers.

Thirty professionals from 12 countries participated in the one-month course. The professionals represented nine disciplines and this diversity of backgrounds assured a great amount of interchange among the group, both in discussion of specific problems as well as of general investigative methodologies.

Forty-one other professionals trained in the Bean Program during 1977.

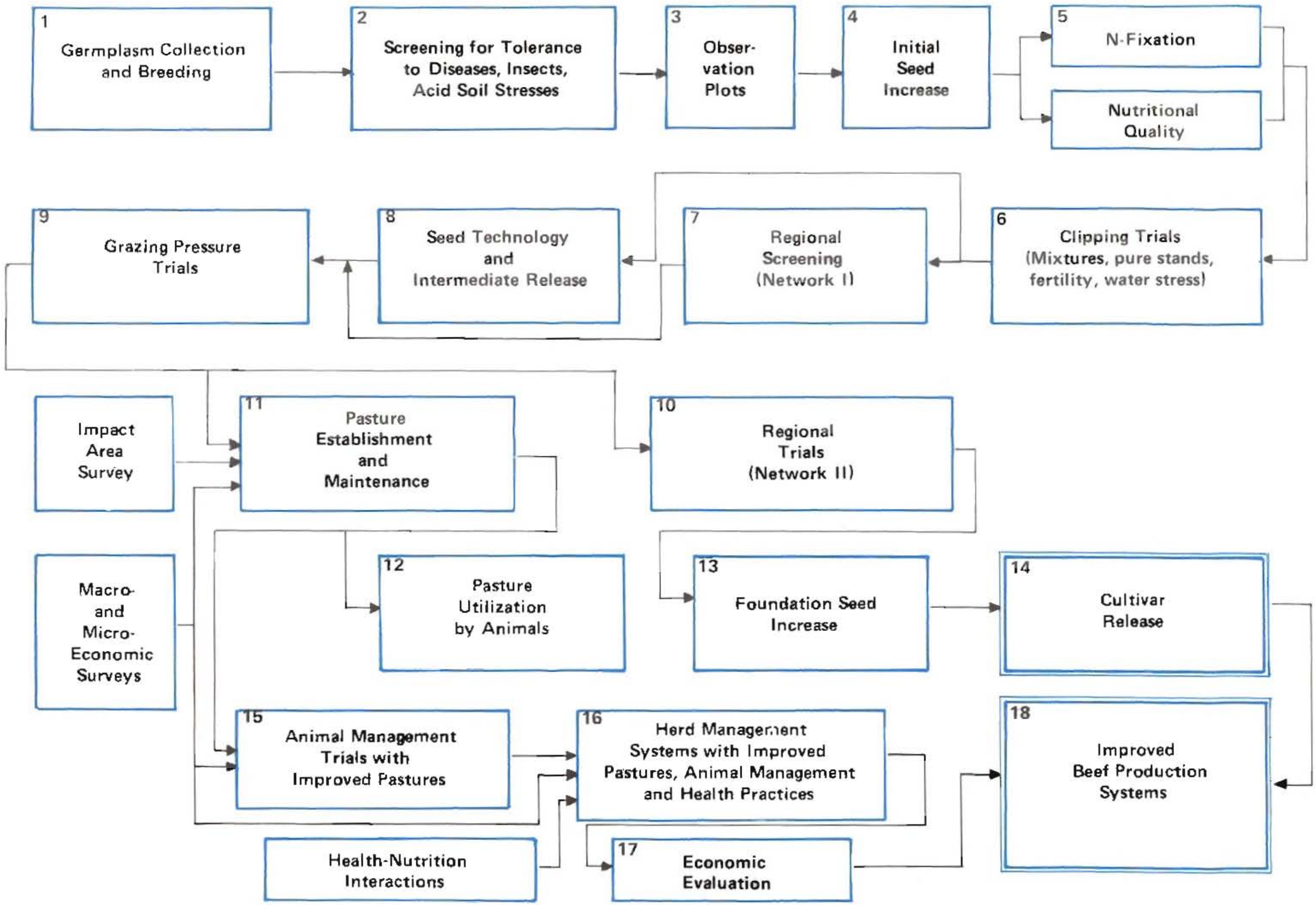
Beef Program

Introduction

The Beef Program's objective is to develop and transfer effective low-input technology for increasing beef production in acid, infertile soils of tropical America, primarily through improved year-round pasture production, supplemented by economically-sound animal management and health practices.

Research is conducted, and technology validated, at three principal research stations at Quilichao, Carimagua and Brasilia. The new Quilichao station provides an acid soil environment for initial and intermediate germplasm evaluation near CIAT's headquarters. Increased staffing and a revitalized collaborative agreement with ICA has enhanced the capacity for research at the Carimagua station, in the Llanos of Colombia. In view of the importance of the Brazilian Cerrados as a component of the target area, the location of three Program scientists at EMBRAPA's Centro de Pesquisa Agropecuária dos Cerrados near Brasilia is an essential first step to ensure development of adequately based technology.

During 1977 reorganization of the Program was accomplished and recruitment of new staff almost completed. Orderly integration of existing program components with planned activities has provided a strategy in which several technology development phases are well advanced to help fulfill the overall objective. The strategy is illustrated in the flow chart on the next page.



Flow chart of strategies and activities in the CIAT Beef Program

The impact area

The Program's target area has been defined as the acid, infertile soil areas of tropical America—areas that total about 850 million hectares. The soils of the target area are classified as Oxisols and Ultisols and are primarily covered by savanna or forest vegetation. These areas together encompass about half of tropical America's land surface and are characterized by high annual rainfall with a dry season of varying intensity, good soil physical properties, but extremely low native soil fertility and poor economic infrastructure. The paramount barrier preventing beef production is an inadequate year-round forage supply caused by the severe soil and water stresses.

To obtain a detailed, accurate picture of the impact area, work began this year under a special project to classify the land resources and provide a geographically-oriented, economic synthesis to serve as the basis of the Program's transfer of technology strategy. In the first phase, climatic factors are being analyzed, satellite imagery with aerial and land reconnaissance is being used to define landscape patterns, and soil fertility characteristics are being collected. Following the geographic delineation of land systems, priority areas for the introduction of improved beef cattle production techniques will be made according to economic considerations.

During the year, preliminary interpretation of the satellite imagery of approximately 200 million hectares was done over the major savanna regions of the area, representing about one-quarter of the project area as a whole and some 60 percent of the savanna regions to be studied.

Plant introduction

The primary facet of the overall program objective is to develop year-round, nutritious pastures. In 1977 the genetic base of CIAT's tropical forage germplasm collected from acid soil ecosystems was broadened considerably and the number of accessions doubled from a year ago. The table shows the present holdings of the forage bank. Major collections during the year were in the Eastern Llanos of Colombia, the Llanos of Venezuela, and the Cerrado of Brazil. Materials were also obtained through exchange with other groups.

Legume and grass agronomy

To provide for orderly and timely evalution of all forages being studied, selection criteria for legume and grass accessions were defined and a mechanism established to direct the flow of germplasm lines to appropriate evaluation levels taking into account the attributes of specific accessions and their

Tropical forage accessions in CIAT's germplasm bank as of 1 Nov. 1977.

Genera	No. of accessions
Stylosanthes	1021
Desmodium	525
Zornia	145
Aeschynomene	92
Macroptilium group (Macroptilium, Phaseolus, and Vigna)	278
Centrosema	232
Galactia	70
Arachis	77
Miscellaneous legumes	806
Grasses	154
Total	3400

promise for the impact area. Legumes are evaluated for 14 factors and grasses for 16 factors. Materials passing favorably through initial evaluations will enter advanced testing classified at four promising levels. Materials that perform favorably in these tests will be designated as "promising" and will enter a four-stage advanced testing program beginning at the small-scale agronomic level and passing to complete agronomic and animal grazing trials. A list of the most promising category 4 legumes and their attributes are shown in the accompanying table.

Forage legume accessions classified as promising Category 4 through November 1977.

Species	No.	Selection criteria*											
		YC	YQ	YM	YH	D	I	N	Sp	W	S	Q	P
Centrosema sp.	1733	–	+	+		+	+	+	+			+	
"	1787	–	+	+		+	+		+			+	
"	845	–	+	+		+	+		+			+	
Desmodium ovalifolium	350	+	+			+	+	+					
Stylosanthes capitata	1019	+	–	–	–	+	+	+	+				
"	1078	+	–	–	–	+	+	+	+				
"	1097	+	–	–	–	+	+	+	+				
"	1315	+	–	–	–	+	+		+				
"	1405	+	–	–	–	+	+		+				
Stylosanthes guianensis	136	–	+	–	–	–	–	+	+		+		
"	184	–	+	–	–	–	–	+	+		+		
Zornia sp.	728	+		–	–	+	+		+				

* Blanks represent unknowns. Codes: YC = adaptation to Carimagua conditions; YQ = adaptation to Quilichao conditions; YM = adaptation to medium fertility soils; YH = adaptation to high fertility soils; D = disease tolerance; I = insect tolerance; N = nitrogen fixation potential; SP = seed production potential; W = water stress potential; S = aluminum and low phosphorus tolerance; Q = nutritional quality; and, P = persistence under grazing.

At Carimagua several accessions of Stylosanthes capitata in mixed stands with grasses came through their establishment season virtually untouched by anthracnose and stem borer, the problematical disease and insect pests which consistently destroyed S. guianensis accessions grown in the same site in previous years. Accessions of Zornia sp., Desmodium ovalifolium and also one grass, Andropogon gayanus, have shown considerable promise for the region.

For the somewhat less stressful climatic, edaphic and pest conditions at CIAT-Quilichao, S. guianensis 136 and 184 plus the Centrosema hybrid 1733 appear most promising and are at advanced stages of testing. Swards of these legumes mixed with A. gayanus, Panicum maximum or Brachiaria decumbens produced sustained liveweight gains of 561 g/steer/day at a stocking rate of 2.3 animals/ha during an unusually extended dry period which caused severe weight losses in adjacent native pastures.

Seed production

In order to move promising forages through testing stages as rapidly as possible, it is essential that increasing amounts of basic seed be available to plant larger areas. And, to obtain good seed yields, pasture species must be grown in locations where conditions are optimum for seed production. The Quilichao area has proven to be an excellent location for basic seed production of several species.

During 1977 seed of 70 forage species were being increased. Sixty-five legume species were in seed production plots at Quilichao and five grasses were being increased both at Quilichao and at CIAT-Palmira.

Among some of the best results were the following. S. guianensis 184 was harvested three times and yielded 260 kg/ha/year. S. capitata accessions yielded an average of 215 kg/ha annually in low density stands during the establishment year. Yields of three Centrosema species averaged 750 kg/ha on an annual basis when the crop was grown on trellises and harvested by hand. Finally, Desmodium heterophyllum also produced abundant seed at an annual rate of 302 kg/ha. This is the first instance where economic seed production appears possible for this valuable species.

Soil microbiology

Development of the Rhizobium collection for inoculation of forage legumes continued in 1977 with the total number of accessions more than doubling to 1051. All accessions are characterized for 15 basic parameters and then are placed into a five-stage testing scheme which provides ratings of genetic compatibility, nitrogen fixation potential, performance under physical and chemical stress, biological and climatological stress, and range of applicability. Several of the strains in the collection entered stage 4 testing during 1977 in six trials seeded in Quilichao and four in Carimagua. Effective inoculation was recorded for all category 3 and 4 legumes tested in field conditions. At Carimagua, for example, forage production by a Macroptilium sp. (CIAT 535) was doubled by inoculating and lime pelleting, in this case contradicting the traditional concept that Macroptilium does not respond to Rhizobium inoculation. Forage legumes are frequently very slow in establishing themselves. The early growth advantage demonstrated by inoculated legumes should prove useful as a strategy for improving their rate of establishment.

The new CIAT-Quilichao substation provides an excellent site for evaluating forages under low stress, acid soil conditions. It has also proven to be an ideal location for forage seed production.

Soil fertility

A detailed soil survey was conducted at the new Quilichao station coupled with the thorough physical, chemical and mineralogical characterization of the soils which classified as Ultisols. Preliminary greenhouse experiments showed the soil to be extremely deficient in phosphorus, sulphur and boron and deficient in calcium, nitrogen and potassium. Aluminum and manganese toxicity affect certain forage species.

Several promising legume and grass accessions were found to have extremely low requirements of available soil phosphorus, coupled with an excellent tolerance to levels of aluminum considered toxic for most cultivated plants.

Oxisols and Ultisols are both extremely deficient in available phosphorus and fix or make unavailable large quantities of phosphorus fertilizers that are applied to them. The application of rock phosphates to these acid soils offers a promising, low-cost alternative for supplying this element.

Results of a 16-month field trial at Carimagua proved that after one year B. decumbens plots fertilized with rock phosphates from six sources approached or surpassed yields from plots fertilized with superphosphate. Total yield from triple superphosphate plots was 13.1 ton/ha. Over the entire test, high reactivity rocks from Sechura (Peru) were 99 percent as effective as superphosphate; a medium reactivity rock from Huila (Colombia) was 91 percent as effective and the low reactivity rock from Pesca (Colombia) was 88 percent as effective.

Low or medium reactivity rocks are abundant in Latin America. They normally provide little phosphorus during the first year. However, by keeping the soil pH low (4.6-4.8) the soil in effect becomes an efficient superphosphate factory. By using a species tolerant to high levels of aluminum saturation, the low pH did not affect growth and the total dry matter produced was 13.1 tons in 16 months, without irrigation and with the only fertilizer applied being 60 kg N, 100 kg K_2O, and 20 kg S/ha.

This indicates a very exciting potential for the medium and low activity rocks so common in Latin America, as an important component of the Program's low input strategy, coupled with the selection of germplasm efficient in utilizing low levels of available phosphorus.

Pasture establishment

Not only are capital, labor and fertilizer almost always limited in savanna areas, but in the case of improved pastures, seed are rarely available in sufficient quantity and are often very expensive in early stages of development.

An experiment was initiated this year at Carimagua with 10 grasses that can be expected to self-seed or spread via stolons to provide an acceptable stand in one year or less. Planting density was extremely low (1000 plants/ha) with phosphorus fertilizer applied only in the planting hill.

In less than three months Brachiaria radicans spread to almost completely cover the surface between the planting sites, which are 3.16 meters apart. B. humidicola also provided rapid cover although it was slower in establishing and initiating vigorous stolon growth. B. decumbens also developed rapidly but initial development was largely vertical before appreciable stolon development occurred.

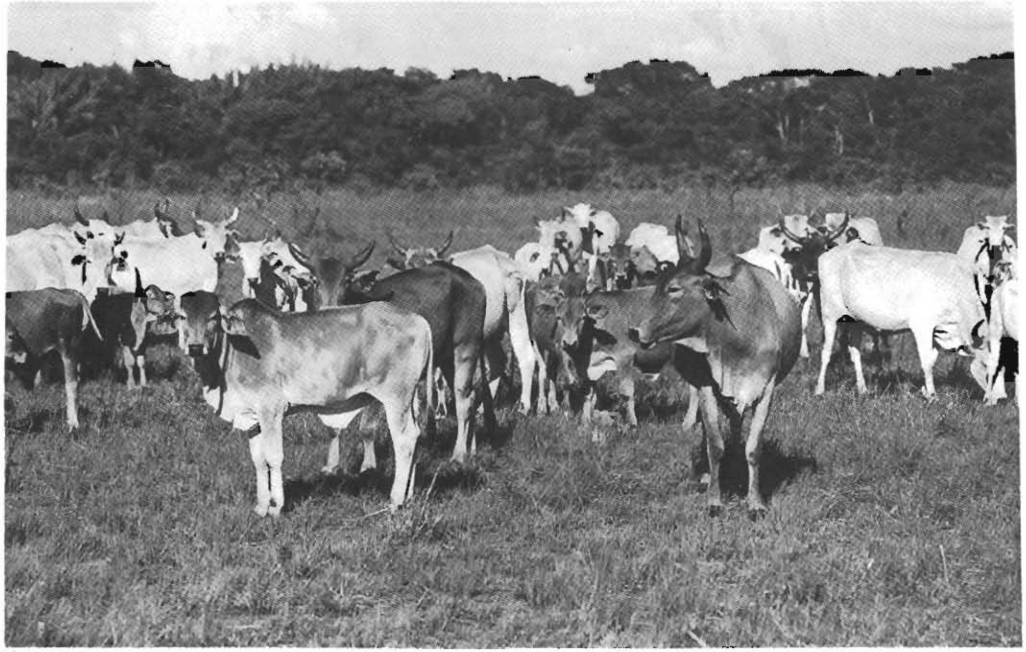
In another pasture establishment trial, the legume Pueraria phaseolides was seeded in 2.5-meter strips alternating with 2.5.-meter strips of each of the three grasses —B. decumbens, Melinis minutiflora, or Hyperrhenia rufa. After establishment, grazing began in 1977. The various systems have received rest periods of 28, 42, and 56 days and three maintenance fertilizer rates. Legume/grass balance has been good with B. decumbens with each species invading the other; the legume has dominated the other two grasses. B. decumbens has produced two to three times the volume of forage produced by either of the other two grasses. It appears that the Pueraria/Brachiaria combination should remain compatible for a reasonable period of time with this system.

In many savanna areas crops are normally planted as precursors of pasture. Research was initiated at Quilichao and Carimagua to test several crop/pasture successions including intercropping pasture legumes with crops such as rice, cassava, beans, peanuts, corn and soybeans.

Animal production

The long-term pasture utilization and herd systems studies and their economic analysis have provided an objectively derived baseline against which new technology can be evaluated. The need for improved nutrition is emphasized by the very limited beef production levels attained by grazing native savanna without improved, persistent pastures and the deficiencies in blood parameters of Zebu breeding cows grazing native savanna.

Evaluation of the herd systems trial which terminated in May 1977 provided excellent information on herd behavior on native savannas during four reproductive years. The most profitable improvement under such conditions is direct mineral supplementation. Salt supplementation, early weaning and the use of *M. minutiflora* pastures during the wet season are not profitable alternatives. New breeding herd management trials include improved pastures for strategic use in combination with grazing native savanna.



Cattle that are produced on the acid, infertile savannas of Latin America suffer from many problems, most of which are directly related to the quantity and quality of forages. For this reason, the CIAT Beef Program's primary objective is to create improved forage materials for these conditions.

Among other improved grasses, *H. rufa* has failed under grazing because of its relatively high phosphorus and potassium requirements and lower tolerance to high levels of aluminum. *B. decumbens* with modest fertilization requirements has produced annual liveweight gains in the order of 150 to 200 kg/ha, approximately 5 to 10 times more than the native savanna. Under the intense rainfall at Carimagua, these pastures are now showing severe symptoms of nitrogen deficiency, which raises questions as to how long they will remain productive.

Training

Transfer of technology activities are now integrated with research. Training is oriented towards program objectives and the development of a regional trials network throughout the impact area.

The Fifth Livestock Production Specialist Training Program was conducted for 18 participants with 13 coming from Guatemala, two from Bolivia and one each from Colombia, Honduras and Panama. The participants spent three months at CIAT during a theory phase of the course, then 15 of them went to Guatemala for a seven-month ranch phase supervised by two CIAT training assistants. The Program for Livestock Development (PRODEGA) supported the training phase in Guatemala. Primary emphasis during the ranch phase was on the establishment and proper management of improved pastures.

In addition to the participants in the formal course, another 23 professionals received training in the various disciplines of the Beef Program during the year.

Training and regional trials priorities were established through contacts with 20 national institutions in eight countries of the impact area. Arrangements were made for cooperative work in all countries.

Cassava Program

Introduction

Work in the Cassava Program in 1977 can be classified as activities directed to fulfilling the three primary objectives of the Program. These are (1) to produce a low input technology for increased cassava production in areas where cassava is presently grown; (2) to develop technology for cassava production on the acid, infertile soil areas of the tropics; and, (3) to diffuse these technologies to the national and local agencies and assist them whenever possible in adopting new practices.

Physiology

Computer simulation information has been used to predict which characteristics of cassava plants most affect yield. Field experiments during 1977 confirmed the importance of two characters – long leaf life and late branching. The variety M Col 72, which has a naturally long leaf life, yielded as much as one-third more than when its leaf life was reduced artificially. Experiments with the early branching variety M Col 113 showed that clipping early growth to simulate late branching increased yields by as much as 70 percent.

Simulation model predictions also suggested that quite small increases in crop growth rate should provide large increases in yield. Several varieties were screened to measure photosynthetic rate of individual leaves which could provide increased growth rates; large, consistent differences were found between varieties.

Work was done at three locations varying in altitude to assess the effects of different temperatures on cassava genotype adaptation. The same plant type yielded best in all three locations, which had mean temperatures of 20°, 24° and 28°C. However, at the coolest site – which represents the lower limit of cassava's range of adaptation – a more vigorous genotype was required to obtain satisfactory yields.

Soils

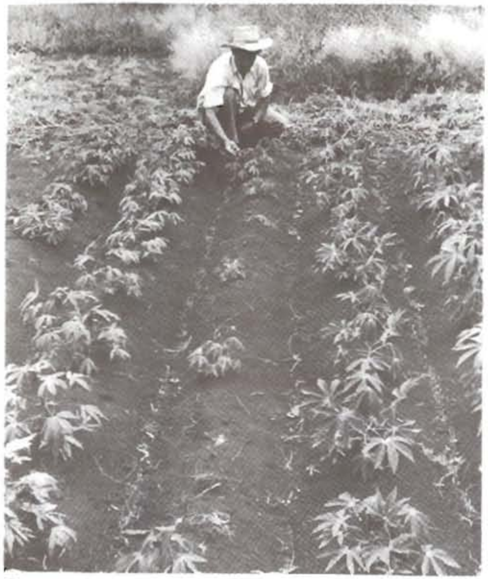
Cassava is frequently grown on acid, infertile soils and tremendous potential exists for increased production in these regions of the tropics. In experiments harvested at Carimagua, Colombia, in 1977, several varieties demonstrated tolerance to high soil acidity. For example, the variety M Col 1684, grown without applied lime, yielded 83 percent of its maximum obtained with 2 ton/ha of lime. Several other lines or varieties produced about 50 percent of their maximum yields without added lime.

In another trial, with 183 varieties, average production was 81 percent of maximum when grown with only 0.5 ton/ha of added lime. There appears to be ample opportunity for selecting lines that do well with little or no lime inputs.

In similar field screening experiments for tolerance to low phosphorus, lines were identified with the potential for good yields at very low levels of applied phosphorus. Although the technology being developed aims to employ the lowest possible fertilizer levels, the use of some fertilizer yields a high rate of return on investment. Rock phosphates showed particular promise as sources of cheap fertilizer. With moderate fertilizer levels yields of 25 to 28 ton/ha of fresh cassava can be obtained on the acid, infertile soils.

Pathology

Cassava is attacked in all areas where it is grown by diseases and pests. Attacks from a wide array of organisms begin in the planting material. Poor germination can result, especially if stakes are not planted immediately after cutting. A simple fungicidal and insecticidal dip was found effective in eliminating germination problems caused by attack from many organisms. The treatments cost only 3 US$ per hectare and treated planting material can be stored for up to one month before seeding.



Cassava is attacked by many diseases. Part of the Cassava Program's strategy is to develop varieties that incorporate resistance to the major diseases. Field screening of many materials permit the identification of clear differences in resistance.

The emphasis in diseases and pest control is not, however, on repeated chemical inputs. Rather, natural control methods are sought. For example, the devastating disease cassava bacterial blight can be controlled by planting resistant varieties. Many new hybrid lines developed at CIAT showed acceptable levels of resistance, even when infected with the most virulent strains of the disease.

The superelongation disease, caused by *Sphaceloma manihoticola*, was first reported in 1974 and its presence has been confirmed in several countries of Latin America. Although it can be disseminated by infected planting material, the fungicidal dip mentioned above eliminates the disease from stakes and prevents early infection from this source. During the year, laboratory and field experiments confirmed that at least three races of the organism exist. A small number of cultivars showed high tolerance to all races.

One of the most widespread disease problems in cassava is the *Cercospora* diseases. Experiments at CIAT showed that yield losses from these diseases are often as high as 20 to 30 percent. Resistant varieties and hybrid lines were identified and no losses were measured when these materials were grown in fields where the diseases were present.

Entomology

During the dry seasons severe attacks of thrips and mites can occur and these pests can cause yield losses of up to 50 percent.

CIAT's cassava germplasm bank was screened for resistance to thrips (*Frankliniella williamsi*) during a natural infestation in 1977. More than half the accessions demonstrated high tolerance.

In the case of mites (*Tetranychus urticae* and *Mononychellus tanajoa*), high levels of resistance have not been found. Nevertheless, in massive screening, including replicated experiments during 1977, 58 varieties were selected as most resistant to *M. tanajoa* and 31 as most resistant to *T. urticae*. Twenty varieties were common to the two groups, indicating a degree of cross-resistance that was not previously suspected.

Varietal resistance to the cassava hornworm (*Erinnyis ello*) has not been found, however, effective biological control appears possible against this important pest. Predation of hornworm eggs and larvae by *Trichogramma* and *Polistes* wasps, respectively, occurs naturally in many cassava fields. Experiments to increase predation and parasitism showed that the release of additional *Polistes* and *Trichogramma* effectively increased predation and egg parasitism.

A bacterial disease, *Bacillus thuringiensis*, is effective against the hornworm larva. First instar larvae numbers decreased as much as 88 percent in treated fields and second instar larvae decreased 46 percent four days after fields were treated.

Testing of these integrated techniques began on a commercial scale during the year and early results suggest the control method is effective.

The cassava fruitfly (*Anastrepha pickeli* and *A. manihoti*) affects planting material by tunneling into growing stems and providing an entrance for a bacterial pathogen which in turn causes severe rotting of stem tissue. Planting stakes from damaged plantations showed germination reduction as high as 16 percent and plants from damaged cuttings that did grow yielded as much as 17 percent less than those from undamaged cuttings. Merely by selecting sound planting materials, these yield losses were prevented.

Varietal Improvement

Although the desirable characters of an efficient plant type, lines tolerant to acid, infertile soils and resistant to major diseases and pests exist, they have yet to be combined into a single line. The breeding section tests more than 20,000 hybrids from controlled crosses each year to obtain new varieties with most of the desirable characters.

New hybrids demonstrated good yield potential at three very different locations in Colombia. Under the fertile conditions at CIAT, yield potential is 60 ton/ha; in Caribia, with less fertile soils and a very pronounced dry season, potential is 40 ton/ha; and, in the acid, infertile soils of the Eastern Plains, 30 ton/ha. Progress made in incorporating disease and pest resistance into potentially high yielding materials is summarized in the table.

Characteristics of promising lines of cassava compared with selected germplasm and local cultivars.

	Yield at CIAT	Yield at Caribia	Yield at Carimagua	Lodging Resistance	Ease of harvest	Shape and color of root	Eating quality	Starch content	HCN content	Post-harvest root durability	CBB resistance	Superelongation resistance	Mite resistance	Thrips resistance
Hybrid selections														
CM 181-13	2	2	4	4	2	4	4	2	2	1	3	2	1	1
CM 308-197	4	3	4	4	3	3	2	2	2	2	1	2	2	4
CM 309-41	3	2	3	3	1	2	4	3	2	1	3	1	1	3
CM 309-56	2	2	3	3	2	3	2	3	2	1	4	1	1	2
CM 309-163	3	4	2	3	3	3	2	2	2	1	1	1	1	3
CM 309-196	2	4	2	3	1	2	3	3	2	2	4	1	1	3
CM 321-15	3	2	4	4	4	3	2	2	2	2	1	1	1	1
CM 323-52	2	2	4	3	3	4	3	2	2	1	1	2	2	2
CM 323-142	4	2	3	1	1	2	2	2	2	2	1	1	1	3
SM 92-73	2	2	4	1	4	4	1	2	2	1	1	2	1	2
CM 305-38	4	—	—	2	3	2	4	3	2	1	1	1	2	4
CM 305-120	4	—	—	3	4	4	4	2	2	2	1	1	2	4
CM 305-122	4	—	—	3	3	4	4	4	2	1	2	1	2	3
CM 311-69	4	—	—	4	4	4	4	3	2	1	1	3	1	3
CM 321-188	4	—	—	3	4	4	3	4	2	1	1	1	1	3
Germplasm selections														
M Col 1684	3	3	4	4	1	2	1	2	1	1	1	2	1	1
M Ven 218	4	2	3	2	1	3	4	3	2	1	1	2	1	3
M Ven 270	3	2	2	2	3	3	2	4	2	1	1	1	1	2
M Pan 70	4	2	3	2	1	3	4	3	2	1	1	2	2	3
M Mex 59	2	3	2	1	1	2	2	2	2	1	1	1	1	2
Control or local cultivar														
Llanera	2	1	2	3	1	3	3	2	2	1	2	3	1	2
M Col 22	2	3	2	4	4	3	4	4	2	1	1	2	1	3
M Col 113	2	1	1	1	1	2	2	2	2	2	1	1	2	4
M Col 638	2	1	3	2	3	2	1	2	2	1	4	3	1	3
M Col 1468	3	3	1	2	4	4	3	1	2	2	1	1	1	1

Ratings: 4 = Very good; 3 = Good; 2 = Acceptable; 1 = Poor

Agronomy

The rapid propagation system for multiplying limited quantities of planting materials was improved during 1977 so that shoots were rooted faster with an accompanying savings of time and equipment.

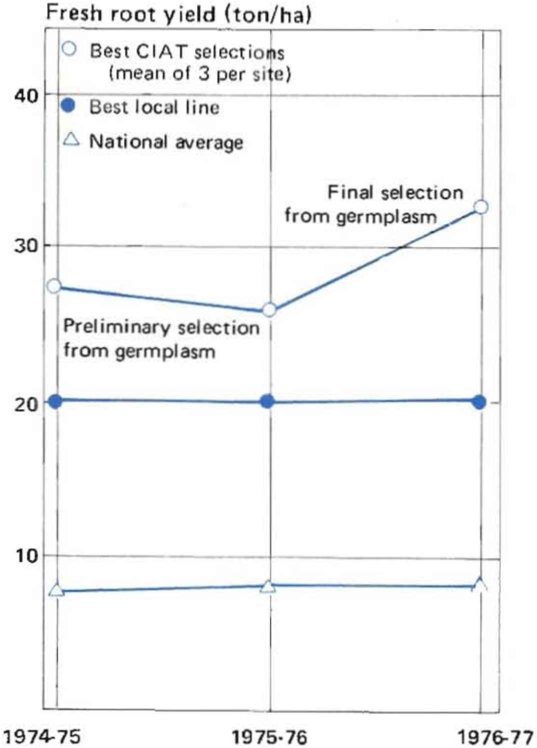
Promising materials were planted in regional trials throughout Colombia. Trials received no fertilizer, except for intermediate levels applied to trials on acid, infertile soils, and no post-emergence insecticides or fungicides were applied. Good weed control was practiced but no other special care was provided to fields.

Through 1977, results of these regional trials during three years at nine locations became available. Results are in the figure on the next page.

Merely by using simple and cheap, but effective, cultural practices to grow the best local lines, yields were doubled. In the first two years when only preliminary selections were used advantages of selected lines over the best local lines were quite small. However, with the final selections from the germplasm resources, a tremendous advantage was achieved in the 1976-77 season from combining good cultural practices and selected materials.

The CIAT Cassava Program has made excellent progress in raising yields simply by creating technology packages of cultural practices and selected lines from germplasm. Even better yields will come from the introduction of completely new materials such as this promising hybrid line.

Previously, all work at CIAT was with cassava as a monoculture crop. Much of the world's cassava, however, is grown in mixed culture. At CIAT, cassava was grown in association with beans to test the potential of cassava/grain legume associations. Very high land equivalent ratios (up to 1.7) were obtained. This meant that to produce the same quantities of beans and cassava in monoculture, 1.7 times as much land was required. In achieving that ratio, cassava and beans were planted at the same time, at their normal populations. Yields of both crops were high — 34 ton/ha for cassava and 2.9 ton/ha



Mean results of regional trials in nine sites in Colombia over three growth cycles.

for beans. These results confirmed that cassava can yield well in association and that the associated crop can also give good results.

Cassava Storage

A major problem faced by all cassava producers is the difficulty involved in handling the crop due to its extreme perishability after harvesting. Perishability is due to physiological deterioration which often occurs within 24 hours of harvest and microbial deterioration which occurs five to ten days after harvest.

Work in 1977 confirmed that physiological deterioration can be prevented by either pruning the plant tops three weeks before harvest or by putting roots into polyethylene-lined paper bags immediately after harvest. Microbial deterioration was prevented by treating the harvested roots with a broad spectrum fungicide.

International Cooperation

International cooperation activities of the Cassava Program increased markedly after January 1977 with the assignment of two staff positions for outreach purposes. One person, based at CIAT, coordinates Latin American activities, and the second, posted at SEARCA, in the Philippines, coordinates outreach activities in Asia. The positions are funded by the International Development Research Centre of Canada.

Because international cooperation activities in Asia represent a new program, major responsibilities for this region were defined for the present as the following: To multiply and exchange germplasm, including the establishment of regional trials; to select candidates for training and to coordinate their work after training; and, to evaluate the present status of cassava production in Asia.

In other activities in support of international cooperation, members of the cassava team made extended visits in both Latin America and Asia to assist in planning new programs being developed in national agencies and to provide technical advice.

Regional trials were established in six countries in collaboration with the respective national programs. In addition, seeds from promising crosses were distributed throughout Asia and Latin America to be tested under local conditions.

Twenty-three professionals received training in the Program during the year. Trainees came from more than a dozen countries, including nations of Africa, Asia and Latin America.

Rice Unit

Introduction

The CIAT Rice Unit cooperates with the International Rice Research Institute (IRRI) in evaluating promising materials for Latin American and Caribbean conditions and then distributing nursery collections to national programs of the region for more precise testing under local conditions. In addition, the Unit conducts research — especially in breeding and agronomy — to develop technology specific for conditions and preferences in Latin America. Finally, with CIAT's Training Section, an active training program is conducted to ensure successful transfer of technology and form a viable network of cooperators. In 1977, significant progress was accomplished in all to these areas.

International Rice Testing Program

Late in 1976 the International Rice Testing Program for Latin America was organized and the first yield nursery for the region was assembled and distributed. Results from the performance of the 24 lines and/or varieties in the nursery demonstrated the importance of testing materials in different countries under varying conditions. In several instances materials in the nursery out-yielded local varieties used as controls at each location.

During 1977, six more nurseries were selected from materials sent from IRRI, the necessary seed increased at CIAT, and the sets distributed to national programs in 19 countries of the region. The table shows the types of nurseries distributed to the programs.

To assist in strengthening this testing network, a conference on the International Rice Testing Program for Latin America was organized at CIAT in November 1977. Specific objectives were to maintain or improve the spirit of cooperation, correct weaknesses in operating procedures for the network and define the needs for future nurseries.

Forty-two delegates from 19 countries attended the conference. Most of the countries favored CIAT's continuing to make the preliminary evaluations and selections of the most promising materials coming from IRRI and national programs. Ten specific nurseries were planned for the next testing cycle and almost 200 sets were requested.

In mid-1977 IRRI assumed financial responsibility for the management and operation of these activities.

Selection of Line 4440

Rice line 4440 was developed in the cooperative Instituto Colombiano Agropecuario (ICA) – CIAT breeding program and was tested in regional trials in 1976 and the First International Yield Nursery, in all cases performing very well. In seed multiplication plots at CIAT it was observed to be segregating for grain type, plant height and maturation period. Sixteen hundred plants were selected for purification; from these ten were again selected, and, finally, two more selections were made to be multiplied for basic seed. One of the two selections will be named as a variety in 1978.

Breeding

Rice breeding strategy at CIAT seeks to combine high yielding potential with acceptable grain quality and resistance to major production constraints, of which rice blast disease (caused by *Pyricularia oryzae*) is the most important.

Various approaches are being used to produce effective and long-lasting protection to the blast disease. To impart resistance from several sources and possibly gain stable resistance (across all races of the disease organism) improved lines carrying resistance from five sources were crossed, observed and selected. Through 1977, 36,000 F_2 selections had been reduced to 1,000 progenies to be evaluated in the F_5 generation and another 330 lines to be evaluated in preliminary yield trials. All selections have survived neck blast infections in the field and also carry resistance to the plant hopper (*Sogatodes*), have acceptable grain quality and good plant type.

In a project to produce resistant multiline varieties, the third backcrossing among five sources of resistance to blast and two recurrent parents was completed. During the year this project was expanded to incorporate multiple resistance into the multiline varieties.

A large amount of material originally developed in Sri-Lanka was evaluated in various generations in 1977. At the most advanced levels, 44 lines selected from over 900 in F_5 and F_6 generations were tested against the variety CICA 9 in two yield trials. The best line (at 9371 kg/ha) outyielded CICA 9 by 29 percent. Also, 90 promising lines from F_5 progeny rows were selected for several characteristics including

Nurseries in the Program of International Rice Trials in Latin America distributed in 1977.

Country	Types and Numbers of Nurseries						
	International Yield Nursery for Latin America				International Nursery for Sheath Blight for Latin America (VIAVAL)	International Observation Nursery for Salinity for Latin America (VIOSAL)	Total
	Early Varieties (VIRAL-P)	Medium Varieties (VIRAL-T)	Upland Varieties (VIRAL-S)	Floating Varieties (VIRAL-F)			
Argentina	1	1	-	-	1	-	3
Bolivia	1	1	2	-	-	-	4
Brazil	5	5	3	1	2	-	16
Colombia	1	1	1	-	-	-	3
Costa Rica	1	1	1	-	-	-	3
Ecuador	2	2	1	1	1	1	8
El Salvador	1	1	1	-	-	-	3
Guatemala	1	1	2	-	-	-	4
Guyana	1	1	1	1	1	1	6
Honduras	2	2	2	-	-	-	6
Jamaica	-	-	-	1	-	-	1
Mexico	4	4	2	-	-	-	10
Nicaragua	2	2	-	-	-	-	4
Panama	2	2	2	-	-	-	6
Paraguay	-	-	1	-	-	-	1
Peru	-	-	2	-	2	1	5
Dominican Republic	1	1	1	1	1	1	6
Surinam	1	1	-	-	1	-	3
Venezuela	2	2	-	-	-	-	4
Total	28	28	22	5	9	4	96

resistance to the plant hopper and to bacterial leaf blight.

Immunity or high resistance to sheath blight (caused by *Corticium sasakii*) has not been detected, however, three tolerant materials were observed and selected. These were crossed with CICA 4, CICA 9, CICA 7 and line 4440 to attempt the incorporation of tolerance into these commercial materials.

Eleven varieties resistant to bacterial leaf blight in Asia were inoculated with an isolate of the causative pathogen, *Xanthomonas oryzae*, from Latin America. All maintained their resistance, indicating that the Latin American isolates react similarly to Asian strains with these genotypes. Accordingly, more than 800 advanced breeding lines selected at CIAT from bulk F_2 and F_4 populations were screened for resistance to the disease in the greenhouse. Fifty-nine percent were resistant, 20 percent tolerant and 21 percent susceptible.

Training

In each of the two semesters of 1977 the Rice Unit cooperated with the Training Section to offer one production course. A total of 15 professionals from 10 countries attended the courses. Course objectives were to train the participants to plan, develop, and supervise efficient rice production, pass on to producers new rice production technology, and, plan, develop, and supervise experiments in cultural practices and regional trials of materials under testing. Two other trainees also received training in research-oriented activities during the year.

Swine Unit

Introduction

Swine production statistics for Latin America and the Caribbean indicate that the majority of the problems limiting the development of this industry are closely related to the low efficiency and productivity of the existing swine population. In most localities, the limiting problems relate to the lack of knowledge of adequate techniques in swine management, nutrition and feeding, breeding and health practices.

In order to counter the gaps in knowledge that exist, the Swine Unit in recent years has increased its emphasis on training activities, especially through postgraduate courses at CIAT on swine production. The main objective is to form professional teams which will serve to initiate and develop swine production programs at the regional and national levels.

Research activities seek solutions to the main problems limiting the efficient production of pigs with special emphasis placed on evaluating agro-industrial by-products and non-conventional sources of energy and protein for swine feeding programs.

Training

The postgraduate training strategy in swine production improvement includes long (4-6 months) and short (6-8 weeks) courses in alternate years. In 1977 a six-week short course was offered for 25 professionals from institutions that are developing activities in swine production, training, extension and research. The participants came from the following countries: Colombia (9); Peru (4); Brazil, Bolivia, El Salvador, and Honduras (2 each); and Argentina, Costa Rica, Ecuador and Panama (1 each).

Course time was devoted about 40 percent to theory in the classroom and seminars and conferences, and 60 percent to practical activities. The latter portion included work both in CIAT's swine production unit and on nearby commercial swine farms. The figure on the next page shows a more detailed breakdown of major course activities.

Four trainees from the above course remained for additional work at CIAT for one month and to plan cooperative work between CIAT and their countries of Bolivia and Peru. Two professionals from Thailand also received training related to the use of cassava for swine feeding, and another trainee from Colombia studied the genetic parameters of the foundation herd at CIAT.

With the training offered thus far, CIAT's Swine Unit has built up a network of professionals located in most Latin American countries. The figure on page 38 shows the numbers and locations of these persons.

In October 1977, the Swine Unit sponsored a one-week workshop on swine production in Latin America. A major purpose of the conference was to bring together professionals who had been trained at CIAT up to 1975. Thirty-five persons from 12 countries participated.

The group reviewed the swine production situation in national and regional programs and especially in the cooperative projects that work closely with CIAT's Swine Unit, and tried to define the most important problems limiting increased production as well as some of their possible solutions. In addition, participants studied means of developing a cooperative network for international cooperation in different swine improvement activities.

Important recommendations from the conference included the following. Technical, economic and marketing feasibility studies are needed; swine programs for medium and small farms should receive emphasis and extension programs should be intensified, especially in the areas of nutrition and the utilization of non-conventional feeds; pork marketing needs to be improved and producers should play a larger role in this activity; and, closer cooperation needs to be developed between countries and regions to prevent duplication of efforts and to improve transfer of technology.

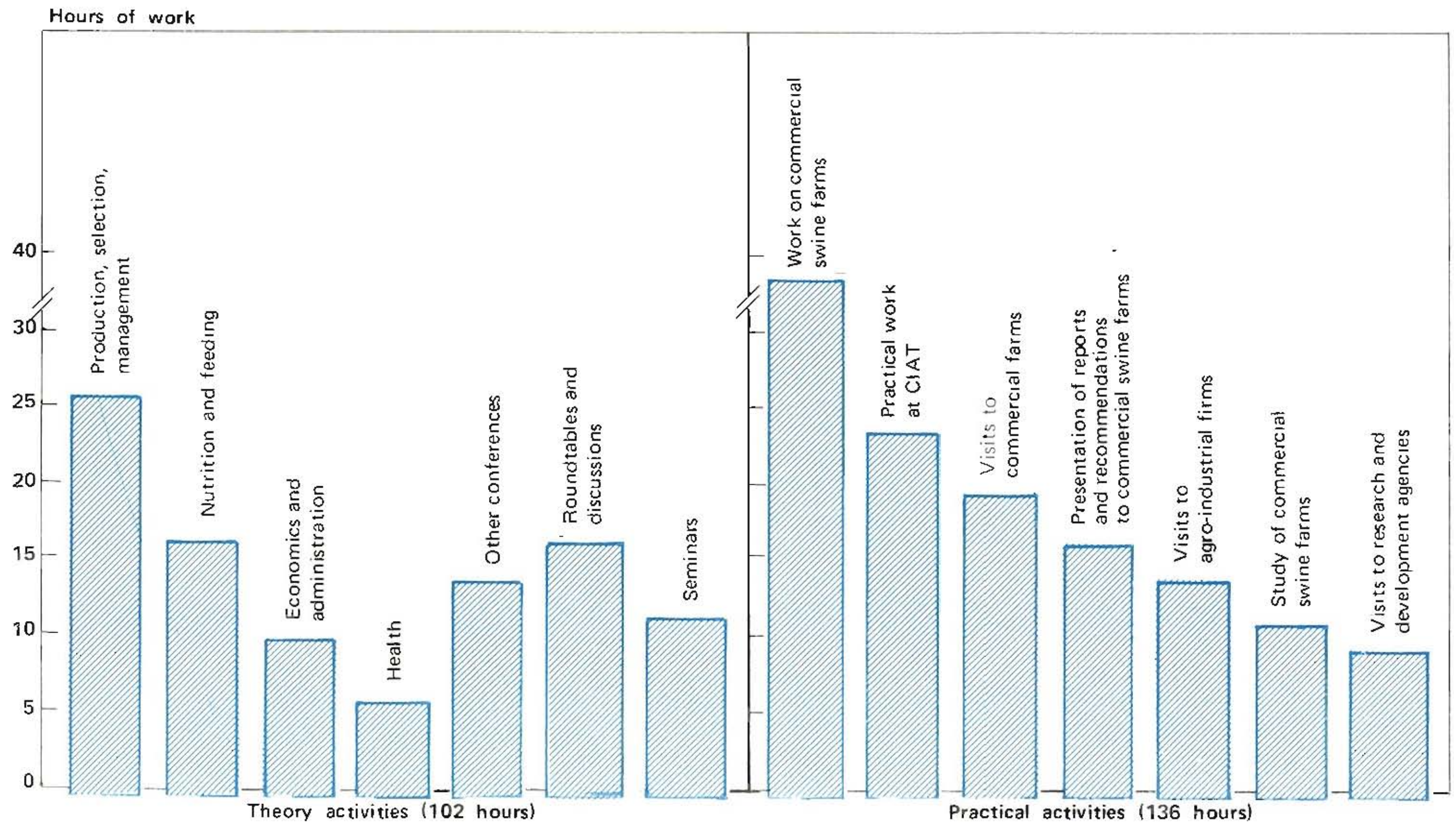
International Cooperation

In Bolivia CIAT swine specialists continued their work with the cooperative project of the University Gabriel Rene Moreno, the Heifer Project and the International Development Research Centre (Canada). In addition, training assistance was given to the Program of Swine Farming Development at Chuquisaca, a project of the Bolivian government and the Inter-American Development Bank.

In Colombia consulting and technical assistance was provided to the Swine Production Project for small farmers operating at La Victoria, in the Cauca Valley. The project is directed by the Colombian Agricultural Institute (ICA), the Agricultural Credit Agency, and the Rural Development Agency.

Activities in Costa Rica were in the form of technical assistance to the Swine Project at the University of Costa Rica, in San Jose, where active work began during 1977.

In Ecuador CIAT specialists provided help to the Swine Program at the National Institute of Agricultural Research (INIAP),



Distribution of activities during the 1977 Intensive Course in Swine Production at its experiment stations in Santa Catalina, Santo Domingo and Boliche.

In Peru work was in cooperation with the Veterinary Institute for Tropical and Highland Research (IVITA), at its principal tropical research station in Pucallpa.

Research

Research activities during 1977 were directed to feeding experiments utilizing local agricultural by-products such as rice polishings to substitute for more expensive grains in the swine rations. Earlier work had evaluated swine performance during the growing and finishing periods; work completed this year was for the gestation and lactation periods.

Litter performances were similar whether some were fed with the basic ration of soybean meal and maize, a ration of 85 percent polishings with soybean meal, or a ration of 60 percent polishings along with maize and soybean meal. These and earlier results show clearly that rice polishing can probably be used as the basic ingredient in swine rations for the entire life cycle without sacrificing reproductive and growth performances.

The CIAT Swine Unit has cooperated with the University of Guelph (Canada) in studying the production of microbial pro-

Cooperative projects and location of professionals who have participated in swine production training courses at CIAT.

CIAT's Swine Nutrition Unit provides direct technical assistance to some swine development programs in Latin America. (Left) From the facilities of the Gabriel Rene Moreno University/Heifer Project, selected improved stock is being distributed to small-scale farmers in the area of Santa Cruz, Bolivia. (Right) At the research station of the Veterinary Institute for Tropical and Highland Research (IVITA), in Pucallpa, Peru, CIAT is assisting in evaluating the adaptation of improved swine breeds to tropical conditions.

tein using fresh, chopped cassava or meal as the energy source for bacterial fermentation. During the year the pilot plant process with a 200-liter fermentor at CIAT was standardized so that a biomass that contains between 33 and 35 percent crude protein was produced. A major problem that caused lower than expected protein yields was solved by using sulfuric acid to maintain the pH of the process at the optimum level. In rat feeding trials, consumption and feed conversion of the protein product supplemented with 0.3 percent methionine were similar to performances on diets of either casein or soybean meal. Swine feeding trials with the protein product will be initiated in 1978.

Genetic Resources Unit

Introduction

The basic commodity of all international centers dealing with plant materials is improved germplasm with which to establish more productive farming systems. The Genetic Resources Unit has the responsibility for assembling, maintaining, making preliminary evaluations and distributing germplasm in support of the three major crop development programs of CIAT —Phaseolus beans, cassava, and forage legumes and grasses. Presently, CIAT has in its collections over 13,500 accessions of beans, 2400 of cassava and 3500 of forage legumes.

Facilities

In 1977 the Unit directed major efforts to completing its physical facilities. The core of these facilities is the cold storage complex of three rooms, details of which are shown in the table. In addition, the Unit also has work areas for threshing, seed sorting and seed lot weighing, plus laboratories for seed cleaning, classifying and viability testing, as well as for seed drying and packaging prior to storage and/or distribution. Additional laboratories are devoted to meristem tissue culturing of cassava. Other areas include a room for germplasm record-keeping, offices and a small herbarium to house botanical specimens of forages and beans.

Activities

Studies confirmed that seed dehumidification in preparation for long-term storage can be easily and rather quickly accomplished by drying at room temperature over silica gel. Bean seed initially at 23.5 percent moisture was brought to 8 percent in four days with this technique. Drying to this moisture content did not affect later germination.

A method of packaging seed for both storage and distribution was tested and adopted. Dried seeds are sealed in laminated packs (plastic/aluminum foil/plastic) to provide a non-breakable package impervious to moisture and oxygen. They can be opened easily to obtain samples and then resealed with a simple heat sealer.

The Unit will maintain 200-gram stocks of *Phaseolus* beans, 100-gram or less stocks of smaller seeded forage legumes and grasses, and probably much less for cassava seed. Under the excellent storage conditions available in the Unit, it should not be necessary to grow out more than 5 percent of the germplasm collection in any given year, that is, 1000 to 1500 lines.

In mid-1977 the Unit took responsibility for the maintenance of the *Phaseolus* bean germplasm as well as the increase, preliminary evaluation and distribution activities which were previously done in the Bean Program. Some 1500 new accessions of *Phaseolus* were received during the year. Evaluation of 4000 accessions on the basis of information on 32 morpho-agronomic characteristics was completed. Over 5500 samples were distributed from stocks, including some 2000 which were sent in response to requests from national (non-CIAT) plant breeding programs around the world.

Storage capability of CIAT Genetic Resources Unit

Room dimensions (vol.)	Type of storage (temp.)	Type of seeds	No. of bags (size)	Total seed capacity (ton)
5.6 x 9.2 m ($180\ m^3$)	Short-term (– 15°C)	General	64,000* (200-gram)	12.8 18**
2.0 x 5.6 m ($40\ m^3$)	Long-term (– 15°C)	Beans	16,000 (200-gram)	3.2 4.5
2.4 x 4.0 m ($33\ m^3$)	Long-term (0° – –15°C)	Forages, Cassava	25,000 (100-gram)	2.5 3.5

* Actually less since larger bags are stored during the short term.

** Underlined values are capacities if full 3.5-m high storage racks are used instead of the present 2.5-m racks.

Hemo- and Ectoparasite Research Unit

Introduction

Established as a special project in cooperation with Texas A&M University (U.S.A.) and funded by the United States Agency for International Development, the Hemo- and Ectoparasite Research Unit at CIAT assists in increasing cattle production in the lowland tropics of Latin America with its research on controlling hemoparasitic diseases and their vectors. More specifically, research has been directed toward development of diagnostic methodology, more efficient economic control of hemoparasitic diseases and their vectors, and transfer of these technologies to veterinarians of the region through training and outreach programs.

Hemoparasitology

In 1977, the indirect fluorescent antibody test, previously developed in the Unit as a rapid means to diagnose reactions to babesiosis (caused by *Babesia argentina* and *B. bigemina*) was adapted to diagnose another important disease anaplasmosis (caused by *Anaplasma marginale*). The new test proved to be significantly more sensitive than other common tests for detecting anaplasmosis.

A microtiter technique was developed for use in detecting anaplasmosis with the complement fixation test. The sensitive, reliable test reduces by one-third the time to process large numbers of sera and reduces by 20-fold the total volume of reagents required.

A study to determine the prevalence of hemoparasites on 12 farms in an endemic area of the Cauca Valley of Colombia showed that the occurrence of hemoparasites varied between farms according to the type of farm management practiced. Herds on dairy farms had significantly fewer hemoparasitic infections than mixed or beef herds, and mixed herds had fewer than did beef herds. Among the important management practices reducing infections were: early weaning of calves in small pastures, better control of the tick vectors through pasture rotation, and periodic control of ticks through acaricide treatments.

While dairy herds had fewer hemoparasitic infections they also had more clinical cases of anaplasmosis than did the other herds. It was concluded that excessive vector control made the cattle susceptible to the diseases in an endemic zone because they were not carrying the antibodies resulting from co-infectious immunity. In these cases, management programs could be modified or immunization programs against anaplasmosis and babesiosis initiated.

To understand the ecology of the primary vector of hemoparasitic diseases – the *Boophilus microplus* tick – efforts were directed to grasses which appeared to have anti-tick properties. It is possible that such grasses could be used as a component of an integrated tick control program to eradicate or perhaps maintain ticks at non-dangerous levels.

Gamba grass (*Andropogon gayanus*) and molasses grass (*Melinis minutiflora*) had the lowest mean numbers of ticks among six grasses artificially infested with tick larvae. Molasses grass repels ticks so effectively that cattle could become fully susceptible to tick-borne diseases if they were subjected to an accidental tick infestation. Hence, molasses grass would be most useful in tick control schemes within a marginal tick zone where the chance of future tick contamination would be slight.

Gamba grass exhibited the ability to maintain a defined, but constantly low initial host tick infestation and lengthy but low to moderate field tick population. It would appear to be most valuable in a control package for an endemic tick zone where cattle could be challenged but where ticks would never become so numerous as to cause direct tick effects or tick-borne disease mortalities.

Special Studies Unit

Introduction

The CIAT Special Studies Unit evaluates food production practices that are potentially useful for traditional farmers working in the region of CIAT's broad mandate. Activities are only directed to practices which do not receive attention from the commodity programs of the Center. Objectives of the agronomic studies are: to increase and stabilize production —especially on secondary lands, to reduce energy requirements and back-breaking toil, and to facilitate developing useful new plant species and crop cultivars.

Minimum tillage systems

Minimum tillage systems often reduce the energy required to prepare the land, avoid soil compaction, and reduce soil moisture and erosion losses. For the small farmer, a no-till approach represents a savings in hand labor normally required at planting time which will allow him to plant larger areas and do a more timely job of weeding his crops once they are growing.

Two preemergence herbicides (glyphosate and paraquat) were compared with the use of a machete to prepare land for planting maize and beans either in monocultures, in rotations or as associated crops. Weed control was generally better when a pre-emergence treatment was applied but the differences were not as great as those normally observed when traditional tillage methods are practiced. Over three seasons, weeds became more serious with time, suggesting that more intensive weed control measures may be required after the first season of a no-till system.

Crop evaluations

Several potentially useful crop introductions from other international centers were evaluated at CIAT in 1977. Among the materials tested were cowpeas from the International Institute for Tropical Agriculture (IITA), mung beans and soybeans from the Asian Vegetable Research Development Center (AVRDC), and sorghum and millet from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Perennial cover crops

The perennial peanut, Arachis glabrata, was established as a living mulch and maize was then planted with the peanut crop. Various methods of controlling the competition from the peanuts indicated that applications of 1.5 kg a.i./ha of glyphosate or 2 kg a.i./ha of atrazine over the whole plot and hoeing of the whole plot provided the best growth and yields of maize. The peanut was very competitive, however, it is able to recycle plant nutrients back into the system.

International Cooperation

The activities of International Cooperation at CIAT encompass all those aimed at establishing full-fledged collaborative links with national programs working with CIAT to achieve increased production in beans, beef, cassava, maize, pork and rice.

In early 1977, as part of the planned expansion of the overall International Cooperation program, a Strategy Paper on International Cooperation was drafted. The plan set forth CIAT's orientation and methodologies for technology transfer. To help accomplish the overall goal of international cooperation, several resource components were included under supervision of the Office of the Associate Director General for International Cooperation (ADG/IC). These are: Library and Information Services activities; Training and Conference activities; cooperative relay projects including the CIMMYT-CIAT Andean Maize Relay Unit; the ICTA-Guatemala Bilateral Contract Operations; and other outposted outreach staff.

Three other resource components, scheduled to begin operating in 1978, were planned: a Public Information and Relations Unit; a Country Documentation Office; and a Seed Training, Outreach and Research Unit. The latter unit received a coordinator position with the posting of a Rockefeller Foundation staff member to CIAT in October.

Effective links were also established with outposted research personnel and with commodity program outreach personnel to develop plans of action and supervision. To maintain country relations, visits were made to most national programs of Latin America, and to India and five Southeast Asian countries. Moreover, a large number of policy makers and research administrators also visited CIAT. These international contacts were in addition to those achieved by CIAT program staff and the Director General and Associate Director General for Research.

Relations were also developed and maintained with a number of international institutions outside of Latin America and the Caribbean. Agreements were negotiated with the Interamerican Institute of Agricultural Sciences (IICA) for provision of logistical support and services to CIAT outposted staff in Brazil and Costa Rica. A special project grant was secured from the United Nations Development Programme to support outreach staff in Brazil, and Central America and the Caribbean, and to expand training capabilities at CIAT. Research agreements were signed with the Deutsche Gesellschaft fur Technische Zusammenarbeit (Republic of Germany) and with the State University of Gemblux, Belgium.

During 1977 arrangements were completed, and in many instances staff were already on the job, for 13 scientific positions including outposted outreach and outposted research personnel as well as bilateral contract personnel. This was an increase of 10 positions over those available a year ago.

Training and Conferences

Introduction

Through its training endeavors CIAT fulfills the essential international cooperation function of training professionals to help strengthen national institutions –CIAT's primary clients. Training is offered according to five principles. First, because training is directed to individuals who will have to perform in leadership roles in technology validation, adaptation, and dissemination, it is restricted to the postgraduate level. Secondly, training is directed to providing a critical mass, that is, the step-wise training of selected individuals from priority institutions who will eventually work together in teams. Also, trainees at CIAT learn by doing with a major part of each trainee's internship taking place in the field, laboratory, or other appropriate working sites. Fourthly, each participant is trained to specific skills so that he or she can function to the optimum as a link in the technology development/transfer chain upon returning to the work environment. Lastly, because training is a principal means for transferring technology from the individual commodity programs, all training is commodity specific.

Classification and commodity programs of professionals entering training at CIAT in 1977.

Program	Training Category							
	Post-doctoral fellows	Visiting research associates	Research scholars	Post-graduate research interns	Post-graduate production interns	Special trainees*	Short Course participants	Total
Beans	1	5	3	22	-	3	22	56
Cassava	1	3	2	8	-	2	-	16
Rice	-	1	-	-	11	5	-	17
Beef	1	3	2	1	18	7	-	32
Swine	-	-	-	2	-	1	25	28
Others								
Library and Information Services	-	-	-	-	-	4	-	4
Station Operations Management	-	2	-	2	-	1	-	5
Seed Production	-	-	-	-	-	-	34	34
Others	-	1	-	1	-	1	-	3
Total	3	15	7	36	29	24	81	195

* Trainees who cannot readily be classified into other categories.

Training

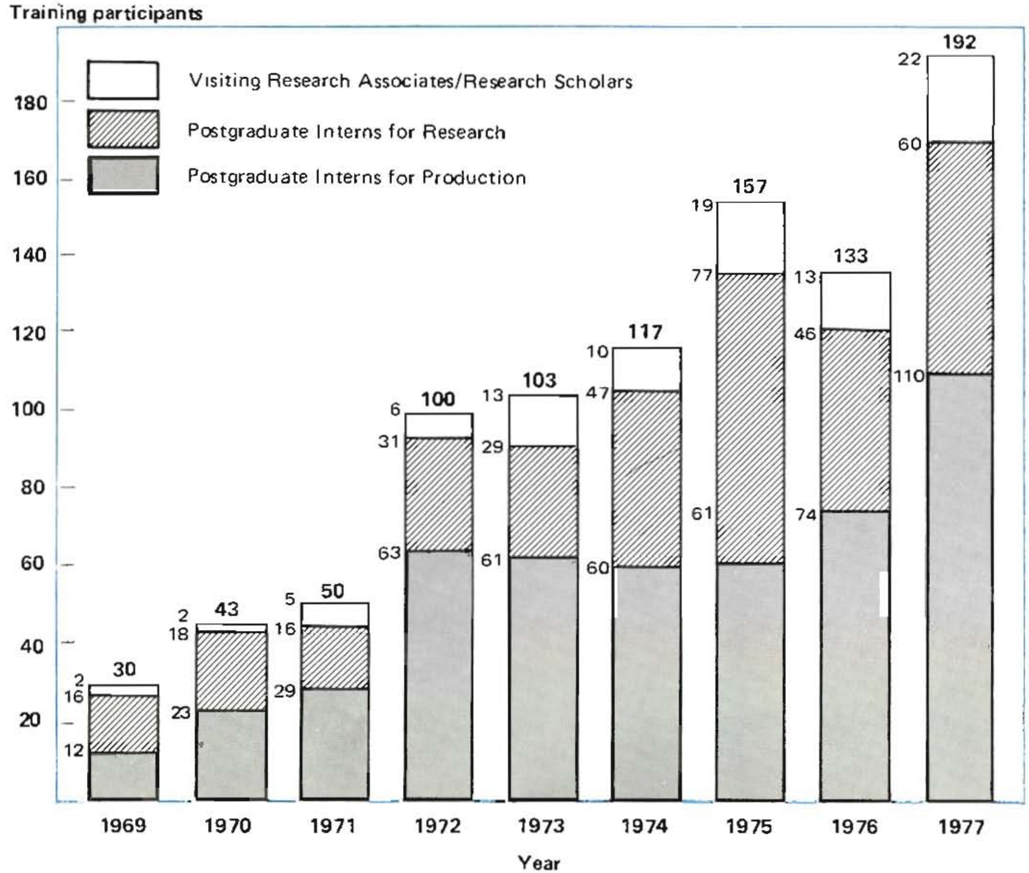
During 1977, CIAT provided training for 235 persons composed of 40 whose training carried over from 1976 and 195 who came to the Center during the year. The table shows the programs in which the 195 arrivals during 1977 were trained and their classification. The figure shows the numbers of trainees who began their internships at CIAT each year since 1969.

The general increase of training activity during 1977 illustrates both the expanded capacity of the Center's commodity research programs and support units to pass on new technology, as well as the increased international activities of CIAT.

Responsibilities for providing training are within the commodity programs. In addition to the individualized research-oriented training provided by program scientists, four production courses were taught in beans, beef, rice, and swine. These are briefly discussed in those respective sections of this report. In addition, a Seed Production Course lasting one month was offered to 33 participants. The Instituto Colombiano Agropecuario (ICA), Mississippi State University, through a contract with the U.S. Agency for International Development, and CIAT cooperated in offering the course. Objectives were to provide knowledge and skills in all aspects of seed production, processing and commercialization, development and operation of seed enterprises and seed services.

CIAT also provided direct training assistance to institutions in Guatemala and the Dominican Republic. In Guatemala, a CIAT training associate worked during the year with the Instituto de Ciencias y Tecnologías Agrícolas (ICTA) to help establish an on-going training program in that Institute. A crop production course which included practice in conducting validative regional trials, trials in farmers' fields and other technical information dissemination activities was held for 19 professionals.

In the Dominican Republic another training associate taught three consecutive ten-week courses on rice production to a total of 60 farm administrators and extension workers. These courses were sponsored by the Department of State for Agriculture in that country. The courses presented in



Number of CIAT training participants by training categories, 1969-77.

CIAT offers several levels of training to professionals from throughout the world and especially from Latin America and the Caribbean. Three examples are shown here. Above, at the left, trainees in an intensive one-month course in seed technology work in a field experiment with their instructor. Above, right, a training assistant and two trainees from a rice production technology course do field evaluations, and, at the left, a research thesis trainee working on an individual basis with this advisor.

Guatemala and the Dominican Republic were patterned after the model developed at CIAT for in-country training.

Conferences

Conferences has a principal role in the Center's efforts to receive, pass on, and interchange information related to its technology development and dissemination endeavors.

In 1977, 26 main events were held in the facilities. These activities were either directly supported by CIAT or were sponsored by other groups or institutions whose objectives are related to those of CIAT. More than 1,000 persons attended these events, several of which were international meetings.

Library and Information Services

Introduction

Library and Information Services activities in CIAT are unique in that a complete service of consolidated information is offered, providing a new concept in information supply. Interaction between scientific research activities and information services is close. The teams of the different commodity research programs are supported by comprehensive services; on the other hand, the Documentation Center is able to offer outstanding services because it is backed by the invaluable collaboration of specialists in a range of disciplines.

Documentation Center

During 1977 the Cassava Project of the Documentation Center began expanded activities under Phase II of the special project funded by the International Development Research Centre (IDRC, of Canada). Under this new philosophy a greater integration of documentation per se with the other information activities began.

In addition to documentation services which continued in the areas of cassava, beans and Latin American agricultural economics, initial interest profiles were conducted for the CIAT Beef Program. This survey is the basis for beginning a five-year retroactive bibliographic search and to initiate a current awareness service on tropical pastures and forages.

Some countries in Central America have adopted the CIAT model of technical information management and are setting up national information systems in the agro-industrial sector. These activities will eventually be linked into a Central American network. In cooperation with the Inter-American Program for Information and Communication (PIADIC) technical advice was provided through conferences in Panama and the Dominican Republic to increase understanding of this type of information system.

Training

Two-month training courses in documentation were given to two professionals from the Dominican Republic and one each from Peru and Honduras. One student from the Dominican Republic was trained in administration aspects of a library and documentation center and two other persons from that country were given a general overview of modern library operations. Seven other persons received short, informal training in library and documentation activities.

Public Information Office

During 1977 the Public Information Office welcomed 3736 visitors to CIAT. Articles and press releases appeared in newspapers and magazines of several Latin American countries, Canada, Europe and Southeast Asia, and television filming assistance was provided to networks from Canada and Colombia.

Information Services

In 1977 this section provided editorial and/or production support for producing 46 publications in the established CIAT series. In addition, numerous other materials were produced in support of the Center's overall activities.

CIMMYT-CIAT Regional Andean Maize Unit

Introduction

With the arrival of the second staff member in January 1977, the two-man CIMMYT-CIAT Andean Regional Maize Unit completed a full year of work devoted primarily to international cooperation. The team is expected to spend about 80 percent of its time in international cooperation activities and the remainder in research at CIAT. The major objective of the international cooperation activities is to form and maintain effective linkages between national maize programs in Bolivia, Colombia, Ecuador, Peru and Venezuela, and between those programs and CIMMYT and CIAT.

International Cooperation

A total of 132 on-farm trials were planted in cooperation with national programs during 1977 in two areas of Bolivia, two in Colombia, and one in Peru. Half of these trials were variety trials established to validate improved materials and different types of technology.

The Unit also assembled and distributed 46 regional trials to the national programs of the five Andean countries. These trials included the best varieties or open pedigree hybrids produced by national breeding programs of the region, providing an orderly method of germplasm exchange among the countries. Types of trials and their distribution are shown in the table.

During the year the Unit assisted in organizing two workshops on tropical maize production and three workshops on floury maize. To help develop staff capability in programs of the region, 15 persons, representing all of the Andean countries, were selected for training at CIMMYT. Five professionals representing four countries were sent to CIMMYT as visiting scientists.


A member of the CIMMYT-CIAT maize team discusses the performance of improved materials being grown in these on-farm trials in Ecuador.

Maize Trials Distributed in 1977 by the CIMMYT-CIAT Andean Regional Maize Unit.

Type of Trial	No. of Entries	Country and Number of Sets Sent					
		Bolivia	Colombia	Ecuador	Peru	Venezuela	Total
Highlands							
Variety Trial (ENZAS)	25	1	1	1	2	--	5
Introduction Nursery	42	1	1	3	2	–	7
Earworm Resistance	200	1	1	1	3	–	6
Peruvian Racial Composites	26	1	1	1	–	–	3
Lowlands							
Opaque Material	37	2	2	2	1	–	7
Variety Trial (ENZAT)	36	2	2	2	3	2	11
Introduction Nursery	68	–	1	1	1	1	4
Early Varieties	14	--	1	–	1	1	3
							46

Activities at CIAT

In late 1976 and during 1977 four International Progeny Testing Trials, three Experimental Variety Trials, and a progeny trial of opaque-2, hard endosperm materials were grown at CIAT. The first two types of trials formed part of CIMMYT's international testing program. The opaque-2 materials were selected at CIAT from two CIMMYT populations and final selected materials will enter regional trials in 1978.

Among other projects conducted at CIAT during 1977 were seed increases of materials crossed and selected for short plant type (brachytic-2 materials), early flowering, fall armyworm resistance and downy mildew resistance. Most of these materials will enter regional trials in 1978.

An experiment was planted near CIAT in cooperation with a sugar company (Ingenio Central Castilla) and the Instituto Colombiano Agropecuario (ICA) to test the feasibility of producing a maize crop during the early growth of sugar cane. Maize was planted in one row between each row of cane or two rows of maize between every other row of cane. The best plant density in both planting systems was 26,000 plants/ha. The only fertilization was 69 or 92 kg/ha of actual nitrogen. Although germination was lower than normal because of dry weather, maize yields were as high as 3.2 ton/ha and there was no response to the higher rate of nitrogen. Because the sugar cane was not harvested in 1977, no data are available on the interaction between the two crops.

A major portion of the CIMMYT-CIAT maize work involves the development of international contacts between the two centers and national maize programs in the Andean region. Here a member of the team discusses an experiment on the Pichilingue experiment station of the National Institute for Agricultural Research (INIAP) in Ecuador.

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