ANNUAL PROGRAM REVIEW

Kellogg Auditorium

Monday, 2 December

08 00-08 05	Introductory Remarks	*Gustavo Nores*
08 05 08 15	Comments on Role of Program Committee and External Reviewers	*Josef Nosberger*

Tropical Pastures Program

Chair Filemon Torres

08 15 08 30	Introduction	*Raul Vera*
08 30-09 00	Target Environment	*James M Spain*
09 00-09 15	**Coffee Break**	

Germplasm and Pasture Development

09 15 10 00	Regional Germplasm Evaluation	*John Miles*
10 00-10 30	Methodological Challenges in Pasture Research	*Carlos Lascano*
10 30-11 00	Discussion	*Opener Oswaldo Voysest*

Germplasm Case Studies

11 00-11 30	Brachiaria spp	John Miles ~~*Steve Lapointe*~~
11 30-12 00	Arachis pintoi (good slides!)	*Pedro Argel* ✓
12 00-12 30	Discussion	*Opener Julia Kornegay* ✓
12 30-14 00	**Lunch**	

Resource Integration

14 00-14 30	Integration of Savannas and Improved Pastures	*Myles Fisher* (part)
14 30-15 00	Discussion	*Opener Gerardo Habich*
15 00-15 30	**Coffee Break**	
15 30-16 15	Experiences at the R/D Interface	*John E. Ferguson* ✓
16 15 16 45	Discussion	*Opener Luis Sarint*

Tuesday, 3 December — *Chair Filemon Torres*

Pasture-Based Production Systems

08 00 08 45	Production Aspects	*Richard Thomas*
08 45 09 30	Discussion	*Opener Robert Zeigler*
09 30-10 00	**Coffee Break**	
10 00-10 45	Processes Affecting Productivity	*Idupulapati Rao*
10 45 11 15	Discussion	*Opener Jeffrey White*
11 15 11 45	Conclusions	*Raul Vera*
11 45 12 15	General Discussion	
12 15 14 00	**Lunch**	
14 00-15 30	Meeting of Program Committee (PC) and External Consultant (EC) with senior staff of TPP Interactive question and answer session	w EC's
15 30-15 35	**Coffee Break** (Dirs Terrace)	
15 35 16 00	Meeting of PC EC Program Leader (PL) of TPP and Deputy Director General (DDG) to discuss points needing clarification (Board Room)	w ECS
16 00-18 00	Preparation of the components of the first draft of the PC report on the TPP by PC and EC	

(Note Afternoon free for all senior staff not involved in discussions)

Wednesday, 4 December

Genetic Resources Unit

Chair Douglas Laing

08 00-08 20	General Introduction	*Masaru Iwanaga*
08 20-08 55	Tropical Pastures Germplasm	*Brigitte Maass*
08 55-09 20	Discussion	*Opener John Miles*
09 20-09 50	Phaseolus Bean Germplasm	*Rigoberto Hidalgo*
09 50-09 55	User Perspective	*Steve Beebe*
09 55 10 15	Discussion	*Opener Steve Beebe*
10 15 10 35	**Coffee Break**	
10 35 10 55	Manihot Germplasm	*Masaru Iwanaga*
10 55 11 00	User perspective	*Carlos Iglesias*
11 00-11 10	Discussion	*Opener Carlos Iglesias*
11 10-11 20	Seed Health Laboratory	*Masaru Iwanaga*
11 20-11 40	Summary Progress and Prospects	*Masaru Iwanaga*
11 40-12 30	General Discussion	
12 30-14 00	**Lunch**	

Cassava Program

Chair Douglas Laing

14 00-14 30	Introduction	*Rupert Best*

Session 1 Germplasm Development

14 30-15 10	Germplasm Overview	*Carlos Iglesias*
15 10-15 25	**Coffee Break**	
15 25 15 55	Crop Physiology Its Contribution To a Breeding Strategy	*Mabrouk El Sharkawy*
15 55 16 25	Discussion	*Opener Elcio Guimaraes*

Session 2. Crop Protection

16 25 17 05	Crop Protection Research Overview	*Carlos Lozano/Anthony Bellotti*

Thursday, 5 December *Chair Douglas Laing*

Session 2. Crop Protection (Continued)

08 00 08 30	Advances in Research and Implementation of Cassava Crop Protection	*Ann Braun*
08 30-09 00	Discussion	*Opener Cesar Cardona*

Session 3. Crop Management

09 00-09 40	Crop and Soil Management Research	*Reinhardt Howeler*
09 40-09 55	**Coffee Break**	
09 55 10 25	Integrating Crop Management Components for Sustainable Production	*Raul Moreno*
10 25 10 55	Discussion	*Opener Albert Fischer*

Session 4. Utilization and Marketing

10 55 11 35	Cassava Utilization and Marketing A Product Development Approach	*Christopher Wheatley*
11 35 12 05	Improving Small Scale Cassava Starch Extraction Processes (presented in Spanish)	*Gerard Chuzel*
12 05 12 35	Discussion	*Opener Jacqueline Ashby*
12 35 14 00	**Lunch**	

Session 5. Regional Collaboration

14 00-14 15	Introduction	
14 15 14 50	Latin America Linking Cassava Research with Development The Integrated Cassava Projects Concept	*Bernardo Ospina*
14 50-15 10	Africa CIAT's Collaboration with IITA	*Marcio Porto*
15 10-15 25	**Coffee Break**	
15 25 16 00	Asia What Have we Achieved and Where Are We Going?	*Kazuo Kawano*
16 00-16 30	Discussion	*Opener Roger Kirkby*
16 30-17 00	The Way Ahead	*Rupert Best*
17 00-17 30	General Discussion	
17 30-19 00	Meeting of EC and PC with members of the Cassava Program in the Board Room to discuss general aspects of the Cassava Program and first draft on the PC/EC report on the Program (Coffee available at 17 30)	

Friday, 6 December — *Chair: Gustavo Nores*

Presentation of other Programs and Units of CIAT
Highlights of Activities 1990 1991

08 00 09 45	Presentations by Bean Program and Discussion	*Douglas Pachico*
09 45 10 00	**Coffee Break**	
10 05 10 25	Perspectives on Rice Blast Research	*Cesar Martinez*
10 25 10 45	Molecular Markers for Manipulation of Rice Blast Resistance Genes	*Joe Tohme*
11 05 11 25	Population Structure and Dynamics of the Rice Blast Pathogen	*Morris Levy*
11 25 11 45	Synthesis of a Rice Blast Resistance Management Strategy	*Robert Zeigler*
11 45 12 55	Closing Ceremony	
	Employee Recognition	*Lucia de Vaccaro/ Gustavo Nores*
	1991 ORPA Presentation	*Richard Flavell*
	Closing Remarks on Behalf of the Board	*Lucia de Vaccaro*
	Closing of APR 1991	*Gustavo Nores*
12 55 14 00	**Lunch**	
14 00-15 00	Meeting of the EC and the PC with the Program Leader of the Cassava Program and the Director General to clarify points related to the PC report on the Cassava Program and finalization of the first draft of PC report by PC/EC on the Program (Board Room)	
15 00-15 05	**Coffee Break** (Dirs Terrace)	
15 05 16 00	Meeting of the EC and the PC with the Unit Head of the GRU and the Deputy Director General to clarify points related to the PC report on the GRU and first draft of PC/EC report on GRU (Board Room)	
16 00-17 30	Meeting of the DG and the Management Committee with the PC and the EC to discuss the overall outcome of the Internal Program Review process including the first draft of the PC report	

(Note Afternoon free for all senior staff not involved in above meetings)

Saturday, 7 December.

08 30-17 00 Finalization of the report by the PC
(Coffe Breaks 10 00 and 15 30 hours)

Sunday, 8 December

Departure of Board Members and External Consultants

TROPICAL PASTURES PROGRAM

EXECUTIVE SUMMARY

Objectives and strategies

The objective of CIAT's Tropical Pasture Program for the period 1986 1991 has been to contribute to the improvement of beef and milk production in the acid soils of the tropical lowlands by means of improved grass legume pastures with its main emphasis placed on Latin America and the Caribbean. In so doing the Program aimed also to contribute to economic growth and social welfare and to support the development of sustainable tropical farming systems based on productive and persistent pastures

During the period under review and as consequence of changes both in the external and also in the institutional environment, the Program gradually incorporated new specific objectives and new strategies to accomplish them The initial emphasis regarding increased livestock production on marginal soils so as to release fertile lands for crop production (CIAT in the 1980s revisited, 1985) has remained a dominant one throughout the period Nevertheless the dynamism experienced by the economies of the region and its effect on the livestock sector led the Program to include also other perspectives Thus at the beginning of the period (Annual Report, 1987) the main research strategies were based on the broadening of genetic variability through collection and highly selective breeding, and the screening of forage germplasm for adaptation to biophysical constraints in the mandate area. These two main strategies were supplemented with the development of low external input, and low risk techniques for the establishment of grass legume associations Half way through the period the need to develop a more mechanistic understanding of the processes underlying tropical pasture adaptation, persistence and production was recognized Consequently the need to develop an understanding of soil plant animal interactions in grazed pastures was incorporated as a significant Program strategy It should be

noted however that the adoption of this new strategy was only made possible by the existence of persistent and productive species identified previously by means of massive evaluation of hundreds of accessions in the Program s major screening sites and through RIEPT Progress made in pursuing this new strategy is reported in several of the following chapters

In a similar vein, the Program also identified the need to progress beyond the formal on station stages of pasture evaluation, to incorporate grazier s perspectives into its screening criteria. Intimately related to this challenge was the by then apparent concern regarding the lack of institutional means for effective delivery of emerging pasture related technologies at the level of most countries in the mandate region, This deficiency was most notable in, but not restricted to the seed sector Surmounting these deficiencies was essential to be able to document the technical and economic feasibility of using grass legume pastures This theme evolved towards the end of the period under review and was aimed at overcoming the doubts in this type of technology aroused by the consequence of well meant but technically weak pasture development programs implemented in several countries in the in the late 1960 and 1970's The Program reallocated funds to pursue these new initiatives and also redesigned the objectives of some of its Sections Even more significant though was the fact that the Program thus began to explore the limits of orthodox research and even overlap in some areas traditionally linked with technology transfer and agricultural development To accomplish these objectives without overstepping in the domain of National Institutions the Program developed studies in a small number of carefully selected contrasting cases It was hypothesized that these initiatives would also provide methodological insights while serving as a testbed for some of the new approaches being researched Several examples of these cases are included in the full report

In conclusion it is postulated that the Tropical Pastures Program responded dynamically to changes in perceived needs regarding research and development, while

maintaining its central focus on exploiting natural genetic variability in forage germplasm for adaptation to acid soils of low fertility

The setting

The objectives strategies and mode of action of the Tropical Pastures Program have been and are influenced by many factors These can be grouped into those belonging to the overall economic environment, those dealing with the National Institutions with which the Program collaborates and those intrinsic to CIAT itself

Since pastures are seldom if ever an end product by themselves pasture research has to take into account the trends of the main products of pasture utilization. In the tropical lowlands of Latin America and the Caribbean, these are beef and milk produced by ruminants directly grazing pastures Previous Annual Reports in both the corresponding Introductions and the chapters dealing with Economics have dealt extensively with the trends of beef and milk production and consumption in the mandate region and their implications Similarly all of the recent issues of Trends in CIAT Commodities contain detailed analyses What follows therefore is only a brief summary of the most recent trends

It is well known that on average 70% of the population in the region of interest is urban, and this trend continues unabated The implication is that most of the beef and milk produced on pastures will benefit primarily urban dwellers It is also well known that the Latin American populations have much larger levels of meat consumption than those of other developing nations In effect, meat consumption was 31 8 kg per capita in 1989 with beef representing 46% of the total, poultry 34% and the remaining being pork. The unsatisfied demand for beef and milk has been well documented, as has the large demand elasticities for even the poorest segments of the population. Unfortunately growth rates for meats in general, and beef in particular lag behind population growth (Table 1) with the only exception being poultry In the

case of beef it has been well documented in the recent past (CIAT Strategic Plan Supplement, p 66) that beef production is increasingly being displaced towards more marginal lands with a subsequent reduction in production per head

Table 1 Growth rates of animal products and of human population in tropical Latin America.

Product	1961/69	1970/79	1980/89
	% per year		
Beef	3 2	2 6	1 0
Milk	4 7	3 3	2 2
Poultry	10 1	10 1	4 4
Pork	3 1	2 8	0 6
Human population	2 8	2 4	2 2

Since the 1960s, poultry production and consumption have increased rapidly In effect, total production of meats in tropical LA in 1970 was 5 2 million metric tons of which poultry represented only 14 1% whereas in 1989 out of a total of 9 7 million, its contribution rose to 35 1% The respective percentages for beef were 63 5 and 46 2% Nevertheless the rapid growth experienced by poultry as consequence of technological innovations and grain subsidies has tapered off and there is some evidence that the price ratio between the two meats is now favoring beef (Table 2)

Table 2 Price ratio between poultry and beef

Country	1980	1989
Brazil	0 52	0 60
Colombia	0 57	0 73
Venezuela	0 49	0 57

This brief update together with numerous previous analyses (Trends in CIAT Commodities various issues) reinforces the notion that cattle production will remain important in tropical Latin America for the foreseeable future a perception clearly shared by TAC and the CGIAR in recent documents (TAC 1990 TAC, 1991) In this context, there has been a tendency in recent years to pay increasing importance to research on pastures and forages for dual purpose systems (beef and milk, based mostly on crossbred cattle) in the tropical lowlands (TAC, 1990) The Program anticipated this trend in 1987 when new initiatives dealing with on station and on farm pasture evaluation begun receiving serious consideration. More recently though doubts have begun to emerge regarding the future role of those systems in terms of milk production, particularly with the opening up of economies and the consequent drive for increased efficiency and specialization This is a dynamic situation which will require constant monitoring since it has important implications for forage ideotypes for different production systems

The effectiveness of research carried out by the Program depends heavily on the existence of National Institutions that assign priority to the development of improved pastures The extent to which this cooperation has been successful in tropical America is witnessed by the continued qualitative and quantitative growth of RIEPT and has been paralleled by a significant effort in training Nevertheless during the period under review and particularly over the last two or three years, economic reforms implemented in various countries and aimed at decreasing public expenditures have had negative impact on the operational resources available to many NARDs (see

survey in Sere Mesa y Franco 1991 Documento de Trabajo No 80) and, to a lesser extent, has contributed to a loss of human resources On the other hand, there is anecdotal evidence of an expanding suite of nongovernment and quasi government organizations active in agricultural development and technology transfer These two contrasting trends place different demands on the Program, but may also offer new opportunities This Annual Report includes brief accounts regarding the interaction of the Program with some of the new actors, including private industry nongovernment organizations graziers cooperatives and others This evolving situation will also require continued monitoring to assure that the Program finds effective research and development institutions with which to cooperate

It is appropriate to briefly review the historical evolution of investments made in the Program and to examine the derived benefits The total budget of the Program grew from 3 9 in 1980 to US$ 7 9 million in 1989 The flow of total expenses accumulated over those ten years amounted to $96 5 million (US$ of 1989) It has been estimated (Rivas y Toledo 1991) that the net present value of the benefits accrued, based on the additional beef and milk produced by the new cultivars is $ 5060 millions which is equivalent to a benefit of about $ 55 for every dollar invested in the TPP These estimates therefore tend to support the contention made by Jarvis and Sere (1991 Doc de Trabajo No 80) that there has been underinvestment in tropical pasture research in Latin America by the respective countries and confirms the value of such research

The third and last dimension of the setting in which the Program has operated over the last 5 years, is that of CIAT's overall objectives and strategies The changes in objectives and strategies experienced by the TPP over the last few years were briefly reviewed at the beginning of the present Introduction This evolution naturally reflected not only current thinking in the Program itself but also its relevance to CIAT's goals The increasing importance assigned to natural resource conservation and management led the Program to begin research to document the contribution of well

managed grass legume pastures to soil enhancement and to more efficient production systems Some of those initiatives are dealt with in various chapters of the present report Similarly the Program has been recognized as being able to contribute to the design of more productive and sustainable agricultural systems and as such its staff made valuable contributions to CIAT's current Strategic Plan. In fact and as has been indicated previously some of the research activities undertaken by the Program since 1986 predated initiatives that would quite naturally fall in a natural resource management program This was the expression of the inherent recognition by the Program, made explicit in different opportunities that legume based pastures not only provide increased beef and milk at reduced economic cost, but are also associated with decreased environmental degradation and risks

International cooperation

The process of decentralization initiated earlier advanced further during the period under review In 1986 RIEPT's Advisory Committee decided to divide a large network into four subnetworks namely those for Central America and the Caribbean, Llanos, Cerrados and Humid Tropics thus paralleling the decentralization of the Program itself Each of the subnetworks was to be coordinated by the respective regional Agronomist. The last of these regional agronomist was outposted in 1987 to Costa Rica, in a joint project with IICA and the Ministry of Agriculture of Costa Rica Very effective field and logistical support was obtained from two farmers cooperatives and a vocational agricultural school, which made available field facilities office space and other support In parallel with this initiative agroecological studies in Central America were initiated by the Agroecological Studies Unit The information subsequently collected in the region has been of use not only to the Program but also as bases for the elaboration of CIAT's Strategic Plan.

Also within the realm of RIEPT's activities a substantial number of technical meetings and workshops was held Two very large technical meetings of the Central

America and of the Humid Tropics subnetworks were held The first of these took place in Mexico in 1988 and was attended by pasture scientists of Panama, Mexico Central America and the Caribbean. The meeting of the Humid Tropics subnetwork was held in Lima, Peru in 1990 and brought together the largest number of participants and technical papers ever presented in a meeting of this nature The proceedings of both events contain a wealth of information on germplasm screening pasture establishment, grazing experiments and development related projects and provide an excellent insight into the qualitative and quantitative evolution of RIEPT In this respect, the last three years have witnessed a large increase in the demands for seed of advanced materials accompanied by the more pressing need to develop human resources in seed multiplication The need to implement seed multiplication mechanisms in the region led the Program to carry out workshops at the national and regional level A total of 8 workshops involving over 100 participants has been held to develop national plans for forage seed multiplication and to follow up on those plans This has been an extremely successful initiative that has begun to have a large impact in many countries especially those in Central America.

A similar approach was taken earlier regarding the need to develop both the expertise on, and the supply of Rhizobium inoculants An intensive training effort was carried out in the period 1986-1988 in techniques dealing with Rhizobium management and multiplication. Parallel to that activity simple methodologies to detect the need to inoculate were developed and amply demonstrated in field trials in several member countries of RIEPT

A very important aspect of international cooperation and institutional strengthening is that dealing with more formal training than the preceding initiatives At the beginning of the decade many countries of tropical Latin America totally lacked trained staff and in many countries tropical pasture research did not formally exist To meet this need the Program regularly offers a training course to pasture researchers from February to April followed by an optional period of specialization

in one of the Program s Sections This yearly course is generally attended by approximately 25 participants and in the period 1986 1991 a total of 299 trainees was received This has been a critically important mechanism to develop expertise in the area of pasture research

Germplasm development

The identification and development of selected forage germplasm adapted to the prevailing edaphic biotic and climatic constraints of the mandate area constitutes the main area of research

As is known, until the creation of the Program there was a marked void of pasture germplasm adapted to the acid oxisols and ultisols of tropical America During the period under review the Program continued implementing its main strategy to deal with this issue namely that of exploiting the natural genetic variability of a wide range of unknown or little known grass and legume species while restricting plant breeding efforts to highly desirable species in which discrete traits need to be incorporated or improved This strategy relied upon assembling a large collection of tropical pasture plant germplasm, mostly through direct collection in the centers of origin. During the period under review the number of direct collection expeditions decreased relative to the beginning of the decade and those that were undertaken, were generally more closely focused The most significant effort in this area was the collection of *Brachiaria* undertaken jointly with ILCA and African National Institutions in 1985 This collection was received in CIAT beginning in 1986-87 Although at the time of this writing a small proportion of the initial collection has not yet been received, it is clear from the evaluation of these materials carried out in all of the Program s major screening sites that this material holds enormous potential Significant progress has been made in the characterization and evaluation of this collection, including baseline studies of mode of reproduction, preparatory for breeding activities In this context, the cooperation with Dr Cacilda do Valle EMBRAPA CNPGC Brazil was instrumental in the

introduction to CIAT of an induced tetraploid sexual that can be used to develop interspecific hybrids in this predominantly apomictic genus

A number of relatively modest collecting expeditions was undertaken in countries of S E Asia These aimed at enlarging the collection of some key leguminous species mostly in *Desmodium* spp and related genera. One result of these expeditions is a number of woody legume species that begin to show significant agronomic potential for highly acid soils a condition for which no shrub or tree species are presently available

Lastly a number of brief expeditions was carried out in various Latin America countries in cooperation with National Research Institutions to enlarge the collection of already identified key genera and species such as *Centrosema Stylosanthes* and others

As consequence of these activities initiated over 15 years ago CIAT now holds approximately 22 000 accessions of tropical legumes with a smaller but significant collection of tropical grasses also This collection is paralleled by approximately 4 000 accessions of Rhizobium

In the period since 1986 breeding activities have been concentrated in three main areas An important breeding project initiated in 1981 was completed, aimed at increasing seed yield potential of *Stylosanthes guianensis* while maintaining or increasing anthracnose resistance and plant vigor and persistence under grazing Advanced progenies that show the desired traits are currently under testing at various locations A second important initiative was a series of studies on the cross compatibility between *Centrosema* species in preparation for an eventual breeding project A number of interspecific hybrids was obtained that contributed to improve our understanding regarding interspecific compatibilities This is essential if desirable traits from different species are to be combined Nevertheless, a breeding project has not been initiated pending clearer definition of the potential of this genus in different production environments The third and major breeding activity has been the one

already referred to in relation to *Brachiaria*

Germplasm screening has required a great deal of work aimed at developing and adapting appropriate methodologies Most notable in this regards is the work related to plant pathology and entomology As indicated above the main objective of the Program is to identify tropical pasture species that are resistant to major pests and diseases In this context, a pioneer effort in the identification and assessment of fungal diseases of the main tropical legume species was completed This has been recognized as a major worldwide contribution in an area which has generally lagged behind crop pathology Simultaneously progress was made in evaluating the incidence of some major diseases and in establishing future research priorities regarding a deeper understanding of their epidemiology Some progress has also been made in the development of screening techniques for diseases such as anthracnose rhizotocnia foliar blight and the stem rot nematode

In the area of virology the *Centrosema* genus appears to have the largest number of viruses four up to the present time These are all potyviruses and as such are seed transmitted This then becomes a concern for seed shipments and the consequent quarantine implications Nevertheless good antisera have been developed that make efficient detection possible Also virus free seed has been produced Only one potyvirus, closely related to the peanut mottled virus has been identified in *Arachis pintoi* An antiserum has been developed, and until the present time it is unclear if the virus is seed transmitted The recent identification of a virus in a *Brachiaria brizantha* is an area of concern, and work on its identification is in progress

The most important current grass pest throughout tropical America is the spittlebug (several genera and species including *Anaelomia, Zulia* etc) that affects among others species of *Brachiaria* Screening for spittlebug resistance has traditionally relied on natural infestations which are generally unpredictable and of varying severity Over the last four years a major Program activity has been the

development of reproducible and reliable methods to assure uniform infestation of germplasm under evaluation. The first technique to overcome the above constraints consisted of establishing the tested materials in old pastures of *Brachiaria decumbens* that had a history of repeated insect attacks This was a successful development but it is also highly time and labor consuming if contamination of experimental material with control plants is to be avoided A parallel effort has been carried out to artificially rear the insect in the laboratory and screen house thus assuring an abundant supply of eggs for artificial infestation in the field Successful methods for artificial rearing have been developed that make possible harvesting eggs for mass field infestation of hundreds of accessions The mechanics of successful field infestations is still being researched as there appears to be a large degree of egg predation, at least under some circumstances The observation that some resistant accessions of *Brachiaria jubata* lead to insect malformations and death resembling a hormonal disfunction originated a joint effort with Cornell University and the Biology Research Unit to identify the responsible agent(s) Preliminary work suggested that an ecdysone like compound may be associated with the disturbance which raises the possibility of developing an antibody that would serve as a rapid and efficient screening technique Work in this area is still in progress

An important pest throughout the savannas of tropical America are leaf cutting ants They severely affect the establishment of some key grass species such as *Andropogon gayanus* and also of crops such as rice Progress has been made in understanding their ecology This knowledge is highly relevant to agronomic practices that may depending upon the circumstances destroy ant nests such as time and depth of land preparation. A number of projects some of them in cooperation with the Rice Program are in progress

Germplasm screening in the Program s major centers has made significant progress over the last four years

Work at Carimagua has led to the release by ICA of *Centrosema acutifolium*

cv Vichada and of *Brachiaria dictyoneura* cv Llanero Using similar methodologies ICA also identified and later released *Brachiaria brizantha* cv La Libertad It should be noted that numerous National Institutions have followed a similar approach to ICA s in the sense of using the research strategies and methodology of the Program to evaluate a variety of germplasm beyond that provided by CIAT thus leading to the identification and later release of a number of pasture cultivars A full list of released cultivars is included in the report

At Carimagua, evaluations of Category II germplasm have identified over the last 4 years a number of promising new legume genera and species most of them agronomically little known Highly promising accessions appear to exist in species such as *Calopogonium mucunoides Cratylia argentea, Dioclea guianensis Centrosema rotundifolium and Desmodium velutinum* among others The best accessions of these species will be included in small plot, grazed trials (Category III) to determine palatability persistence and compatibility with grasses in mixtures The above listed legumes include a wide range of species and habits with very different potential uses

On going experiments in Category III include multilocational trials established in various countries and environments to select naturally persistent materials of *Centrosema spp* the evaluation of a woody legume *Flemingia macrophylla* associated with two species of *Brachiaria* and the study of highly promising accessions of *Brachiaria brizantha* and of *Panicum maximum* previously selected for their adaptation to acid soils in association with *Centrosema acutifolium* From the above brief listing of activities it should be obvious that a totally new generation of legumes and grasses has reached an intermediate stage of evaluation.

Work at Pucallpa (Humid Tropics) started in 1986 has led to the evaluation of approximately 800 legume accessions and 250 grass accessions A similar number applies to work in Costa Rica.

Ongoing work at both the Humid Tropics center of Pucallpa and that for Central America, located in three sites of Costa Rica, have confirmed the widespread potential of two key legumes for marginally better soils These are *Centrosema macrocarpum* and *Arachis pintoi* In the former case a large number of accessions appear to be equally promising so that in both locations a physical mixture of accessions will be promoted to grazing trials and for on farm testing by collaborators in the various countries The main issue to be resolved in the case of *C macrocarpum* is its persistence under grazing Closely linked to this issue is the potential role of that legume in more intensive production systems such as dual purpose systems

The widespread adaptation of *Arachis pintoi* to the wetter environments of tropical America has now been amply confirmed Trials at Pucallpa, Carimagua (on heavy soils) the Andean Piedmont, and at various sites in Costa Rica leave no doubt regarding its long term persistence under severe grazing pressure and its compatibility with aggressive grasses such as *Brachiaria spp* and *Cynodon spp* In fact, the remaining issue in grazed pastures based on this legume is management practices that favor the grass, rather than the legume Precisely this aggressiveness is what makes *Arachis* such an attractive legume for cover crops under a variety of perennial tree crops including coffee and rubber where it very effectively smothers weeds An intriguing possibility that needs more studies is the prospect that some accessions may even be adapted to the harsher and drier Cerrado environment, as a recent trial seems to suggest

It is now abundantly clear that *Arachis pintoi* is a highly promising legume but unfortunately the genetic variability that exists in the present collection is extremely limited The Program has identified enlarging the collection of this and related species as a top priority Indeed, an initial collection trip jointly organized with EMBRAPA s CENARGEN was undertaken in 1991 in parts of the States of Minas Gerais and Bahia. Other collection trips are presently being organized

A large variety of woody legumes is being evaluated for the Humid Tropics

with a view towards their potential role in agroforestry Large genetic variability exists in the collection of species such as *Flemingia spp Tadehagi spp Cratylia argentea, Codariocalyx gyroides, Desmodium velutinum* and *Cajanus cajan* It is currently estimated that very good adaptation to extremely acid and infertile soils is available A yet unresolved issue is the nutritional quality of these species since there is evidence for the presence of antiquality factors mainly polyphenols Nevertheless there is also preliminary evidence that at least in some of these species there is genetic variability in this trait also

Lastly significant progress in Category II evaluations is being realized in the Cerrados after several years of slow advances A number of factors has contributed to this changed scenario including the involvement of a much wider range of germplasm than in the past, adjustments in evaluation methodology and recognition of the existence of a variety of environmental niches within the Cerrado There is now little doubt that a wide range of legume and grass species have substantial agronomic potential for the 'varzeas or lowlands of the Cerrados For the larger and most typical Cerrado environment, with its very poor soils prolonged dry season and large disease potential (for some key legumes) legume species such as *Calopogonium spp* hold promise A large collection of this species has been assembled and is being tested There is evidence of large variability in adaptation, productivity and morphological characteristics Some selected accessions of a number of *Stylosanthes spp* including progenies of the breeding project referred to earlier are equally promising and require wider testing throughout that ecosystem Similarly accessions of *Centrosema brasilianum* appear to deserve wider testing in a variety of settings These initiatives await clarification of the mechanisms of cooperation between EMBRAPA CPAC and CIAT that will make it possible to proceed to widespread testing of these materials

Regarding grass species a number of *Panicum maximum* and *Brachiaria brizantha* accessions have been promoted to advanced categories at both Pucallpa and Costa Rica These high quality tropical species hold special promise for the more

intensive production systems envisaged for those regions and for soils of moderate acidity It should be recalled that a large *Panicum maximum* collection was assembled by the Program several years ago from a variety of sources including Orstom, ILCA and others

In the context of the Cerrados a number of *Paspalum spp* is being tested that appear to have significant potential both for the "varzeas and for the high Cerrados Out of an initial set of 250 accessions 12 have been advanced for further evaluation. There is ample evidence of a wide range of d m. yields and, more importantly of differences in regrowth at the onset of the rains Evaluation of the large (>450 accessions) *Brachiaria* collection has continued at CPAC CNPGC (Campo Grande) EMGOPA and at CEPLAC Bahia A small number of accessions approximately 16 have been preselected for resistance to spittlebug and agronomic attributes

Pasture management and utilization

During the period under review the research activities grouped under the above title have gradually evolved from mostly empirical studies to a more balanced mix of both empirical and mechanistic studies

Orthodox grazing experiments have continued at all major screening sites The most exciting results from the Cerrados refer to the long term persistence of selected grass legume associations accompanied by very high weight gains including acceptable animal performance during the long dry season. An experiment initiated in 1987 based on *Andropogon gayanus* and a mixture of *Stylosanthes spp* continues to demonstrate the key role of grazing management in determining animal performance and pasture persistence and stability After four years under grazing the pasture maintains a legume content of 25-40% in a range of grazing systems while other systems have led to drastic declines in legume percentage Legume based treatments have been able to maintain the animal s weight throughout the dry season, whereas animals on pure grass pastures suffered severe weight loss As consequence of this

continuing experiment, there is now solid evidence in support of the feasibility of grass legume pastures for the Cerrado

Nutritional studies carried out in grazing experiments at Carimagua have definitively demonstrated that improved grass species are deficient in protein unless associated with legumes This deficiency leads to lower voluntary intake and weight gain On the other hand animal performance on native grasses is constrained by low voluntary intake of digestible energy In this case the supplementation of native savanna with small areas of sown grass legume associations leads to 40-50% increases in weight gain per head At the same time research begun in 1989 is beginning to quantify the impact of system intensification on the dynamics of native plant populations in savanna These are important studies if it is anticipated that as consequence of market forces production systems will be intensified in the savanna region with the introduction of agricultural crops and sown pastures

Animal performance on some of the newer associations has been very high Individual weight gains of 190 kg per year averaged over 4 years in a *B dictyoneura Arachis pintoi* pasture far outstrip previously reported results for other associations Equivalent gains per ha have reached an average of 600 kg per year

The evaluation of associations for milk production is an initiative implemented in 1988 Results obtained in Quilichao show an interaction between animal genotype and pasture type Cows of medium milk potential (8 10 liters per day) demonstrated a 20% difference in milk yield between associations and pure grass pastures whereas that difference was only 13% or less with crossbred cows milking 5 6 kg/day

A significant amount of methodology has been adapted and developed regarding grazing experimentation. This has been made available to RIEPT via the publication of two manuals Also a workshop on grazing methodologies was held for researchers already active in that area Another area of methodological development

is that related to quality evaluation This is particularly relevant to the screening of woody legume species A number of methods for tannin quantification has been tested and is being applied to a range of different species

Beginning in 1988 the Program begun assembling a multidisciplinary team to investigate mechanistic processes in grazed grass legume pastures with emphasis on nutrient cycling The team is made up of an ecophysiologist a N cycling specialist, a plant nutrition scientist, a ruminant nutritionist and a savanna ecologist The team, with the further support of a soil fertility scientist, has implemented a large central experiment and a number of satellite experiments that begin to yield the first results Since these are still highly preliminary no results are mentioned in the present summary but a detailed analysis is included in the main body of the Annual Report In the meantime substantial progress has been made in understanding and quantifying some of the main components associated with persistence and productivity of grazed systems and some of the interactions present when annual crops are included in the system. Work with a simple N cycling model has pointed out the importance of pasture litter in recyling that element Field work has demonstrated the existence of large differences in litter decomposition rate between legume species whereas little difference exists between the grass species studied so far It has also been demonstrated that at least under some soil conditions (light texture soils) a significant N transfer to the associated grass occurs much earlier than anticipated and in the absence of grazing animals Studies with stable carbon isotopes are beginning to quantify the extent and rate of contribution of C3 legumes to soil organic matter in a number of different pasture associations

The contrasting strategies developed by a wide range of legume and grass species adapted to acid soils is being examined in relation to soil texture and at contrasting levels of fertility It is now obvious that a number of well adapted species preferentially partition the products of photosynthesis towards underground biomass when soils are of very low fertility Also adapted legumes are much more efficient in

P uptake than grasses despite lower root biomass This phenomenon is partly associated with micorrhizal infection and with the presence of acid phosphatase In this respect, it is interesting to note that phosphatase activity decreases markedly in grasses at higher levels of fertility but it is retained by legumes The implication is that edaphically adapted legumes do not show a typically adaptive response to soil fertility By maintaining high phosphatase activity they maintain high levels of P uptake less root biomass and partition more of the dry matter to shoots

Regarding plant growth rates and population dynamics under grazing, a number of theoretical relationships between leaf area, growth and other parameters were developed at the beginning of the period under review Ongoing field experiments have provided a wealth of data. Despite the inherent variability of field data, good progress has been made in fitting data to the theoretical models with a number of grass legume associations which will serve to test hypotheses regarding plant dynamics under a variety of environmental and management scenarios and their physiological responses

Pasture based production systems

The Program has a small team of scientists that deal with the use of improved pastures in both existing and in conceptual production systems

Economic studies have continued to document the importance of beef and milk in the diet of even the poorest segments of Latin American populations These results once again reaffirm the relevance of tropical pasture research in the continent Further studies have addressed the social benefits to be expected from investments in this type of research and have concluded that they may have been significant underinvestment in pasture research in the region as a whole Those results derived from general economic studies have been recently further supported by examining the costs associated with the release of new tropical pasture cultivars in RIEPT in relation to expected benefits accrued from the incremental production of beef and milk These

issues were briefly referred to in the introduction to the present summary

Microeconomic analyses of pasture performance in a farming systems context have been carried out for a variety of settings In general and regardless of the country considered these studies demonstrate the economic attractiveness of improved pastures in relatively more intensive systems such as dual purpose production systems Investments in sown grass legume pastures become even more profitable if a crop can be used to establish them or to renew old degraded pastures In this context, the Rice and Tropical Pastures Program begun in 1988 a joint project to determine the feasibility of undersowing pastures with rice in the high plains of Colombia. This was made possible by the development of adapted low input requiring upland rice lines Three consecutive years of research have clearly demonstrated that this approach was correct High rice yields of over 3 metric tons per hectare have been obtained even when the crop was undersown with fairly aggressive pasture species Following harvesting, the majority of the pastures thus established were ready for grazing This implies a reduction in establishment time from about one year when pastures are established by themselves with pasture fertilization, to about 150 days when they can use the residual fertilizer left by the rice crop Animal performance in these pastures is being monitored The results of the two first years under grazing suggest that they can maintain somewhat higher stocking rates and substantially higher individual weight gains than similar pastures established alone These results also serve to support much earlier findings regarding the potential of some of these pasture species to respond to higher fertility levels

A number of on farm initiatives was undertaken during the period 1986 1991 in cooperation with National Institutions The report includes information on initiatives implemented in a) the plains and the Andean piedmont of Colombia, with ICA and various development banks and other agents b) the Caquetá Department, in the Amazon basin of Colombia, with the local University ICA, a graziers association, a number of government institutions and NESTLE b) northern Cauca, Colombia, in

association with CVC, a nongovernment institution (FUNDAEC) a graziers association and others d) in Guápiles in the Atlantic coast of C Rica, with CATIE and the Ministry of Agriculture e) in Pucallpa, with IVITA, f) in Silvania, Goias Brazil, with EMBRAPA CPAC Also a brief mention is made regarding other initiatives of lesser importance

On farm work in the plains of Colombia has the longest tradition in the Program. Having begun with the aim of testing the bioeconomic performance of grass legume pastures in a reduced number of ranches it gradually evolved to support a Carimagua initiative implemented in 1986 to provide technical support to graziers interested in the new pastures In 1988 ICA institutionalized the project with the creation of an office (CRECED) in Puerto Lopez charged with technology transfer The Program initially provided strong support in training and in field activities involving both the development of seed supplies and on farm pasture establishment and management. Over the period 1988 1991 these activities were gradually and successfully transferred almost totally to the CRECED The continued expansion of these activities has made it difficult to accurately assess the impact on the region, but it is estimated that the project has provided technical support and seeds for the establishment of approximately 20 000 has of sown pastures with grass legume associations representing about 50% of that total The activities regarding seed multiplication have had an equally great impact, leading to the emergence of new seed producers including both established private firms, individual graziers and new institutions that became heavily involved in that effort.

A similar initiative although of less magnitude was implemented in the humid tropics of Peru, around the city of Pucallpa On farm testing of grass legume pastures with small resource poor settlers was begun in 1987 A parallel effort was made regarding seed multiplication, given the total absence of an established seed market and of seed producers On farm testing has demonstrated significant differences in milk production by dual purpose cows between grass legume association and the

corresponding pure grass controls On average differences of about 13% in favor of the associations were found The magnitude of these differences is closely comparable to those found on station at Quilichao Colombia, for animals of similar mean milk yield An important outcome of this project was the significant but unanticipated effect of fire management, as practiced by settlers on the botanical composition of the pastures used Expecting large between and within farm variability a cocktail of promising legumes was used in establishing the pastures It was subsequently found that *S guianensis* cv Pucallpa was able to survive and persist well when subjected to yearly burns whereas other legumes decreased markedly In those cases where pastures were not burnt, other legumes notably *D ovalifolium* have made a more important contribution These results support the use of mixtures of legumes rather than the use of a single species Activities regarding seed multiplication were successful in developing an expanded supply creating what is still only a nascent market, and in identifying and promoting new producers There is evidence that National Institutions supported by an outside donor will be able to take over both the on farm testing and seed multiplication initiatives in the very near future

Evolving opportunities

Despite an essentially Latin American mandate the Program has gained worldwide recognition for its efforts in developing grass and legume germplasm for acid soils Based on the belief that selected materials may have a wide range of adaptation, and that the methodologies developed and adapted during the evaluation process have widespread applicability the Program anticipated the evolution from a regional to a global mandate Thus in 1989 a modest networking effort was undertaken in West, subhumid Africa with the support of IEMVT and in cooperation with ILCA. Along similar lines in 1989 National Institutions from six South East Asia countries agreed to create a regional network. In 1991 and thanks to the financial support of AIDAB the first steps to implement this network were undertaken in cooperation with CSIRO

The Program also successfully anticipated the need for forage legumes different from the traditional herbaceous species Beginning approximately in 1986 a modest effort of collecting woody legume species in acid soils was begun while primarily collecting other more traditional, species The challenge posed by several of the most promising woody species is a familiar one to the Program, namely one of defining potential niches and uses and of screening for quality in addition to adaptation and forage production. Progress along these lines will be found in the present Report

CASSAVA PROGRAM REPORT 1987 1991

EXECUTIVE SUMMARY

This report presents the work and achievements of CIAT's Cassava Program over the period 1987 1991 The period corresponds to one in which total world cassava production rose from 137 million t in 1986 to 150 million t in 1990 a growth rate of 2 3% per annum.

The Cassava Program at CIAT forms part of a global cassava research and development system Together with its sister program at the International Institute of Tropical Agriculture (IITA) the Program generates basic knowledge on the crop and develops improved component technologies trains national cassava researchers and extension leaders and provides an important link between institutions in the developing and developed world

At headquarters the Cassava Program undertakes strategic and applied research of global significance The Program ensures the integration of its activities with those national cassava R&D systems in the Americas Asia and with IITA in Africa through regional collaborative programs and projects

During the period 1987 1991 the number of senior staff positions within the Program increased from 9 to 11 These human resources were complemented by scientific personnel contracted through a number of special projects

HEADQUARTERS BASED RESEARCH

Cassava Germplasm

Collection, characterization and conservation The receipt of cassava germplasm accessions from IITA and from Asian national programs constitutes the basis for cooperation in Africa and Asia. Recent germplasm introductions from Brazil will give proper representation to one of the richest countries in terms of genetic diversity A complete morphological and biochemical characterization of accessions in the germplasm collection is allowing the detection and elimination of duplicates A core collection representing the overall genetic diversity has been defined and will be available in 1992 for duplication in another institution An *in vitro* and field collection of wild *Manihot* relatives has been initiated Some of the species are already included in crossability studies biochemical and molecular characterization

Breeding The ecosystem approach to cassava breeding has been expanded to include semiarid areas, where cassava can contribute to the alleviation of food shortages As a result of a cyclic process of selection and recombination over more than ten years a large

number of elite clones for humid and subhumid lowland tropics and highland tropics have been identified Over the last five years 15 varieties derived from CIAT's gene pools have been released in 9 countries in Latin America and Asia A wide range of genetic diversity has been introduced to Africa from CIAT increasing the potential impact of IITA s cassava breeding program on that continent A promising collaborative effort with Brazilian institutions to develop cassava germplasm for semiarid and subtropical regions of the world has been initiated A participatory research model has been developed in cooperation with national institutions in Colombia, which takes into consideration farmers criteria for selecting and adopting new cassava varieties this has contributed to the refinement of breeder s selection criteria Preliminary experiments on seed treatment and germination have been undertaken as part of a multidisciplinary project to explore the development of true cassava seed as a production alternative

Physiology

Water Stress Research on cassava tolerance to prolonged mid season water stress have revealed that certain physiological and morphological characteristics are associated with tolerance to water stress and with yield stability Most notably the ability to rapidly form and maintain leaf area is of paramount importance Second genotypic characteristics related to better partitioning of biomass between leaf and stem such as high specific leaf area and high leaf area ratio may lead to higher leaf area index without adverse effect on root yield Cassava appears to tolerate prolonged drought by restricting leaf canopy and top growth and by partially closing its stomata while maintaining reasonable CO_2 uptake rates hence reducing water loss and continuing to accumulate dry matter into storage roots Moreover cassava is capable of extracting deep soil water slowly when available These characteristics are advantageous in drought prone areas such as Sub Saharan Africa Northeast Thailand and Northeast Brazil Under dry conditions cassava can produce reasonable yields while most other food crops would fail The ability of cassava to survive and produce under prolonged drought of several months is based on its high water use efficiency as compared to other food crops Screening for low HCN content under water stress has revealed that genotypic differences exist with some clones maintaining low HCN levels under both wet and stress conditions Maintaining low HCN under stress is of a paramount importance when fresh cassava is used for human consumption

Photosynthesis Research on cassava photosynthesis in relation to crop productivity has revealed that cassava s high photosynthetic potential underlies its high productivity under favorable conditions as well as its tolerance to stressful environments Cassava requires high ambient temperature and high solar radiation for optimal leaf development and for the expression of its photosynthetic potential The high sensitivity of photosynthesis to temperature suggests the need for genotypes more tolerant to low temperatures which could be used in the highland tropics and in the subtropics Moreover the positive association of photosynthesis with productivity suggests that selection for high photosynthesis in parental materials may lead to higher yield when combined with other yield determinants In addition to high harvest index leaf area duration and number of storage roots are among

the most important yield determinants Wide ranges of variability in these characteristics exist among cassava clones which could be exploited in cassava breeding programs

Quality

Cyanide The use of the improved enzymatic method of cyanide analysis has resulted in a cheaper and more flexible assay for this important chemical constituent No significant correlation was found to exist between the enzymatic and picric acid methods of cyanide determination A priority has thus been placed on the development of a new method for rapid cyanide estimation for germplasm screening purposes Analysis of some wild *Manihot* species showed high levels of cyanide in both root and leaf samples

Starch quality In addition to starch and sugar content analyses the methodologies for amylose contents microscopic evaluation of starch grains x ray analysis differential scanning calorimetry Brabender viscoamylograms and starch solubility and swelling power have all been developed either at CIAT or in collaborating Colombian institutions Varietal differences in amylose content (range 16 25%) and functional properties have become apparent M Col 1522 which produces high quality sour starch has different structural physical and functional properties from the other varieties so far evaluated

Eating quality An expert taste panel for eating quality evaluation identified the characteristics of high quality cassava Cassava taste and hardness (texture) of fresh boiled cassava were the two most related to preference while no relationship was found between starch properties and eating quality The panel identified significant changes in eating quality due to the pre harvest environment

Effect of pre harvest environment on quality Soil fertility significantly affected root quality The application of potassium reduced cyanide and increased dry matter content, while phosphorus tended to have the opposite effect Drought stress affected root dry matter and cyanide contents with large varietal differences in response

Biotechnology

Molecular fingerprinting Electrophoretic analysis of Esterase (EST) isozymes were developed to identify cassava genotypes Recently more powerful DNA based techniques for the analysis of *Manihot* genetic diversity have been developed Several random amplified polymorphic DNA markers (RAPD) and hte phage M13 probe have been effective in differentiating cassava genotypes EST fingerprinting of cassava is now routine activity in the GRU Both EST and DNA fingerprinting will be useful for genotype identification to assess germplasm relatedness and gene pool origin

In vitro Active Gene Bank (IVAG) and Cryopreservation The conservation of cassava germplasm under reduced growth conditions has been developed in the BRU and recently transferred to the GRU The cassava IVAG at CIAT is probably the largest and most

complete for any crop in the world over 4500 accessions are currently maintained This year consistent recovery of plants from cassava shoot tips cryopreserved in liquid nitrogen (196°C) has been achieved This break through opens the way to a long term, gene bank storage of cassava

Genetic transformation Plant regeneration is necessary for a transformation system in cassava Plant regeneration through somatic embryogenesis on immature leaves and meristem tips has been developed Using a plasmid construct with two selectable markers (bar gene and NPT II gene) and one reporter maker (gus A gene) the transient expression of GUS activity in somatic embryos after bombardment of metallic particles coated with the plasmid on early stage embryogenic callus has been obtained This is an important first step towards a transformation system in cassava.

Molecular mapping A special research project to construct saturated molecular and physical maps of cassava has been initiated Such maps will be useful to tag and eventually isolate and clone cassava genes Pst I and Hind III genomic libraries provided probes with the highest polymorphisms Polymorphism between a cassava cv and a wild *Manihot sp* was dramatically higher than within varieties

The Cassava Biotechnology Network (CBN) The CBN was founded in a workshop at CIAT in September 1988 The general goal of the network is to contribute to the solution of priority constraints in cassava production and utilization which have proved recalcitrant to the application of traditional methodologies The CBN has received wide acceptance This is shown by the number of projects underway on research constraints and technological bottlenecks from 5 in 1988 to 22 in 1991 A proposal for funding critical network activities has been presented to the DGIS the Netherlands The project includes funding for a coordinator scientific and steering committee meetings training for developing country scientists and bridging funds for critical research

Pathology

Etiological studies The following unreported pathogens of cassava were characterized *Scytalidium* sp and *Verticillium dahliae* *Fusarium solani* and *F oxysporum* were also reported for the first time as cassava root pathogens

Epidemiological studies The relationships between mycorrhiza *Phytophthora* and flooding *Phytophthora* incidence were investigated

Control of important cassava diseases Production recommendations have been formulated for the control of cassava bacterial blight (CBB) the *Phytophthora/Fusarium* root rot complex, *Diplodia* root rot and the witches broom mycoplasma disease which cause severe epidemics in 4 important cassava growing areas These recommendations integrate several control approaches to reduce bacterial or fungal infections of planting material and soil and

pathogen dissemination The release of two resistant clones in Brazil with production recommendations has been an outstanding success

Biological control Research on novel biological control strategies is leading to the development of practical applications based on the use of microorganisms for the control of foliar pathogens (CBB and the superelongation disease) and preharvest or postharvest root rots as well as microorganisms capable of producing growth regulators that can promote yield production Advancers have been made in development of the cultural practices which promote beneficial microbial residents in different ecological zones

Endophytes The existence of unreported potentially deleterius endophytes in improved clones was demonstrated for the first time This finding partially explains yield instability in most cassava, and opens up a new potential for development of control measures Similarly the identification of beneficial endophytes could lead to their use as biological control agents plant growth stimulants and inducers of drought resistance

Stake storage A system for the effective storage of cassava stakes was designed for solving problems of establishment and production in areas where this agronomic practice is necessary

Method for interchanging indexed vegetative planting material A new method for the interchange of virus indexed vegetative planting material of cassava was developed to assure establishment of introduced genotypes

Geographic distribution of cassava diseases The geographic distribution and areas of potential risks have been determined for *Phytophthora* root rot *Fusarium* stem and root rot the witches broom mycoplasma, superelongation disease *Diplodia* root rot, and cassava bacterial blight, the most important diseases of cassava in Latin America These were obtained by extrapolating epidemiology studies surveys and agroecological data bases This information will assist scientists in planning research projects strategies for disease control and quarantine regulations

Virology

Frogskin (FSD) and Caribbean mosaic disease (CMD) Progress has been made on the identification of phytoreovirus like agents associated with FSD and CMD Virus like particles and viroplasm like bodies have been found in affected plants Nine ds RNA segments are consistently found in affected plants Hybridization studies provide evidence that the ds RNAs associated with FSD and CMD are either identical or closely related The whitefly *Bemisia tuberculata* appears to be the vector of these phytoreovirus like agents A cDNA probe has been developed to identify rapidly the ds RNAs associated with this disease complex Research on FSD and CMD continues and is centered on confirming the association of the phytoreovirus like agents and the complex of disease symptoms

Cassava vein mosaic virus (CCMV) The sequencing of CCMV is nearly complete The virus is 6400 bases in length and it is most closely related to potato virus X (PVX) Most of the sequencing of CCMV was done at the VRU in CIAT and this is perhaps the first plant virus to be sequenced in Latin America

Cassava vein mosaic virus is most prevalent in the northeastern states of Brazil especially in the hot semiarid zones where it is not unusual to find more than 50% of the plants infected with CVMV Since the virus is not present in Colombia, all work on this virus had to be done in Brazil A cDNA clone to CVMV has been obtained and this will facilitate efforts at molecular characterization and the development of rapid diagnostic tests

African Cassava mosaic virus (ACMV) African cassava mosaic virus is the most destructive cassava virus in the world Efforts are being made to find new sources of resistance through the CIAT IITA cooperative germplasm exchange project The identification of ACMV resistant germplasm adapted to tropical America will be a safeguard against the possible establishment of ACMV in this hemisphere

Other viruses Beside the major diseases there are seven other known viruses that infect cassava most of which are symptomless viruses that are not known to cause disease Diagnostic methods are available at CIAT to the four viruses that cause disease and to the three symptomless viruses found in Latin America These diagnostic methods help assure the safe movement of cassava germplasm and research will continue to develop more sensitive detection methods

The control of viral diseases requires either the identification of resistant germplasm or the implementation of cultural practices that mitigate losses Most viral diseases are controllable with current technology and continued development of rapid diagnostic techniques together with the deployment of resistant germplasm should further reduce the losses caused by viruses

Entomology and Acarology

Host plant resistance Sources of host plant resistance to mites mealybugs whiteflies thrips and lacebugs have been identified and partially characterized for mites and thrips Cassava hybrids with resistance to mites mealybugs whiteflies and thrips have been developed and several have been released by national programs

Cassava mealybugs The geographical distribution of the most important species of cassava mealybugs has been determined Their key natural enemies have been identified Several species of parasites and predators have been evaluated in the laboratory and field for their potential as biological control agents leading to the introduction and release in Colombia of the parasite *Aenasius near vexans* discovered in Venezuela Several species of natural enemies have been sent to IITA in Africa for evaluation and release against the introduced pest, *Phenacoccus manihoti*

Cassava hornworm Effective biological control of the cassava hornworm, a migratory lepidopteran which causes severe defoliation is based on a hornworm specific baculovirus The timing application frequency and optimal concentration of virus prepared from field collected diseased hornworms have been determined and methods for storage of the virus have been developed Application of the virus during the initial stages of a hornworm attack when hornworm larvae are most susceptible results in better than 95% control

Cassava whiteflies Because of recent increases in direct crop damage due to cassava white flies and in their potential importance and impact as vectors of virus diseases higher priority has been given to research on whiteflies High levels of resistance have been identified and incorporated into high yielding hybrids Several species of natural enemies have been identified and are being studied

Burrowing bugs Chemical control of burrowing bugs which attack cassava roots is feasible but requires the use of highly toxic pesticides Ecologically sound alternatives based on cultural practices are being sought Intercropping of cassava with crotalaria reduces pest damage through allelopathy but has not been adopted by farmers Commercially acceptable cultural control systems based on allelopathy are being sought The potential of entomophagous nematodes for biological control of the burrowing bugs is under study and preliminary results have been positive

True cassava seed and dried cassava Research efforts on potential arthropod pests of true cassava seed wild *Manihoti* species and of dried stored cassava have been initiated

Cassava green mite CIATs contribution to biological control of the Cassava Green Mite (CGM) in the Americas and Africa includes 1) extensive surveys for natural enemies in Colombia, Venezuela and Ecuador and smaller scale surveys in Northeast Brazil Trinidad & Tobago Guyana, Peru Paraguay Mexico Cuba, Panama and Nicaragua 2) development of culture packing and shipping methods for natural enemies 3) ecological and biological characterization of predatory mites coleopteran predators and the fungal pathogen, *Neozygites sp* and 4) estimation of field impact of natural enemies As a consequence of the research conducted on behalf of IITA, CIAT characterized the biological and ecological nature of the CGM problem identified by EMBRAPA in Northeast Brazil and developed a strategy for CGM management as part of an integrated crop protection effort

Cropping Systems

Cassava maize intercropping The evaluation of newly released maize varieties for performance in association with cassava indicates that environmental conditions during maize development and the agronomic management of the maize are key factors determining the yield of cassava in the North Coast of Colombia Land use is more efficient when maize and cassava are planted together than when either is planted alone Cassava yields significantly more in association with improved than traditional maize varieties

thereby increasing land use efficiency further In less favorable environments yields of cassava in association with maize were significantly lower than in monoculture

Improved maize varieties allocate more dry matter to the grain than traditional varieties Total nutrient removal in improved maize is greater than in traditional varieties As new varieties replace traditional maize nutrient balance within the farm will be different, since more nutrients will be exported from the system Unless soil fertility is maintained by lengthening fallow periods or by other means yields will decline Maize type did not influence uptake of nutrients by cassava

Since the restoration of nutrients to the farm is vital for the sustainability of the cassava/maize association, chemical fertilization is a possible short term solution in some regions In trials with low levels of fertilization improved maize yielded significantly more than traditional maize Cassava yields were not affected by the level of fertilization applied to maize the highest marginal return in intercropped cassava/maize was obtained with low levels of fertilization

Cassava-cowpea intercropping The cassava/cowpea association is important in areas with prolonged dry seasons Yields of intercropped cowpea are often similar to yields obtained in monoculture however cassava yields are negatively affected by cowpea competition, particularly if environmental conditions favor the early development of cowpea More vigorous cassava clones are less affected by cowpea competition

Pre production trials Farming involves a yearly sequence of events beginning before the onset of planting and ending with post harvest activities Testing of new production practices should be done in this context particularly since the adoption of any technology component depends strongly on the interaction between new and existing technology and labor requirements particularly during peak demand periods Improved technology for the cassava/maize association was tested by farmers over two years on a total of 76 plots Maize yields with improved technology were superior and cassava yields were equal or superior to those obtained with traditional technology Hand labor requirements of the improved and traditional technology were similar Total production costs of the improved technology were 8% above those of the traditional technology

Plant nutrition and soil fertility

Management of low fertility soils Research on plant nutrition and soil fertility management in relation to cassava productivity have revealed that cassava is tolerant to low fertility soil provided that soil organic matter is high Continuous cultivation of cassava for several years in acid soils high in organic matter did not result in large declines in yield in absence of phosphorus and nitrogen fertilizer On the other hand large yield responses to potassium fertilizer were notable in these soils The removal of large amounts of potassium in the harvestable roots leads to gradual depletion of this element To sustain productivity moderate amount of potassium fertilizer should be used Where cassava is produced in

sandy soils low in organic matter and in the absence of a fallow system moderate levels of NPK fertilizer are required to sustain productivity Yield response to NPK fertilizer was notable in these soils Alternatively cassava productivity could be increased by application of surface plant mulch in poor sandy soils Mulch application appears to be beneficial in improving the chemical and physical properties of the soil Moreover mulch can alleviate water stress by reducing water evaporation from the surface soil exposed to high temperature Reducing evaporation is important since these sandy soils are characterized by a low water retention capacity Another advantage of mulching is the large reduction in HCN content of cassava roots in the absence of fertilizer application

Adaptation to low phosphorus soil Screening cassava germplasm for adaptation to low phosphorus soils indicated a wide range of adaptation among the tested materials Several varieties well adapted to low P soils were identified including land races as well as advanced breeding lines Most notably the two CIAT clones CM 523 7 and CG 2177 2 recently released as commercial varieties for los Llanos Orientales of Colombia were among the highly adapted lines to low P soils Research on mechanisms underlying varietal response to P suggested that varietal differences were not closely related to P uptake On the other hand internal use of absorbed phosphorus growth habit and patterns of biomass allocation to tops and roots are more important Varieties that partitioned more dry matter to roots as compared to top growth had higher P use efficiency in terms of yield gains It appears that adaptation to low P soils could be enhanced by selection for both high fibrous root length density and high storage roots sink capacity

Soil conservation

Control of soil erosion Research on soil conservation in cassava based cropping systems on hillsides indicated a high level of soil erosion. Annual soil losses from bare soils exceeded 100 t of dry soil/ha. Since cassava planting usually coincides with periods of intense rainfall, soil loss from steep lands might exceed the tolerable levels unless the soils were appropriately managed Several cropping systems and cultural practices were tested in relation to soil erosion and crop productivity Growing cassava in contour ridges or in combination with live grass barriers greatly reduced soil erosion while maintaining cassava productivity as compared to traditional practice On the other hand growing cassava in down slope ridges resulted in high levels of soil losses and more runoff than any other practices Growing cassava in association with forage legumes was effective in reducing soil loss but cassava productivity varied with the degree of legume competition Reduction in cassava yield ranged from 10 to 40% depending on the legume used and on the intensity of the legume cover The potential of cassava/forage legume systems in controlling soil erosion and in maintaining productivity requires further investigation taking into account both the short and long term consequences

Process and product development

Methodology A 4 stage methodology for cassava process and product development comprising identification of opportunities lab and prototype research pilot scale testing and commercial expansion has been developed in collaboration with national institutions

Dried cassava for animal feed The commercial expansion of dry cassava chip production, introduced by CIAT in collaboration with the Integrated Rural Development Fund on Colombia s Atlantic Coast is now self reliant and autonomous Feedback from this project has resulted in research on improvements in drying efficiency and product quality The production of cassava based chicken feed rations was found to be a viable option at the level of small farmer cooperatives

Fresh cassava conservation Pilot scale testing in the city of Barranquilla Colombia has demonstrated the technical and economic feasibility of the fresh cassava storage technology developed by CIAT and NRI Problems with urban distribution have frustrated large scale adoption of the storage technology However private entrepreneurs are now actively taking on distribution functions and supplying supermarkets restaurants and small shops The storage technology is being successfully used commercially by a cooperative in Santander department Colombia and pilot testing has been successful in Paraguay

Cassava flour The pilot stage of a project to develop high quality flour for human consumption is currently being executed Market studies including industrial trials of the flour have demonstrated that cassava flour will have both price and quality advantages over wheat flour in some market segments (e g cookies and processed meats) A potential market of over 20 000 t/yr in Colombia was estimated The pilot processing plant currently under evaluation is operated by a small farmer cooperative and employs artificial drying of chips produced from washed roots The high quality chips are milled at a wheat flour mill with conversion rates of chips to flour of 90% Current information suggests that the project is economically feasible in Colombia, and that the rate of return is improved if in plant milling is adopted A small scale prototype mill has been designed which will permit in plant production of flour

Cassava starch A CIRAD/CEEMAT CIAT research program on cassava starch started in 1989 focusing primarily on sour or fermented starch Evaluation of existing traditional small scale production units in Colombia identified areas for process improvement to increase efficiency and improve product quality Two pilot plants incorporating process improvements are now under evaluation The characteristic expansion power of sour starch as measured by specific volume correlated significantly with organic acid contents and certain viscoamylogram characteristics The natural fermentation process has been found to be predominantly lactic with CO_2 and lactic acid production and amylolytic enzyme action pitting starch grains Maximum viscosity of sour starch is lower than that of raw starch and gelling ability is reduced

REGIONAL COLLABORATION

Tropical America

Many countries in tropical America have become aware of the important role that cassava can play in providing a vehicle for income and employment generation in the rural sector consequently the last five years has seen a resurgence of interest in cassava activities In addition to direct collaboration with national research programs participation in multi institutional integrated cassava research and development projects in several countries has formed the basis of the Cassava Program s activities in the region, with priority placed on Colombia, Brazil Ecuador and Paraguay These projects aim to link cassava farmers with expanding markets through the introduction of novel or improved cassava processing alternatives thus providing incentives for farmers to increase production

Emphasis in training during the period has been on the support of in country courses with fewer CIAT based production and utilization courses Training at CIAT has increasingly focused on disciplinary in service specialization Networks both specialized and sub regional in nature have been consolidated or established these include the Panamerican Cassava Breeders Network, an Integrated Cassava Projects Network, a Cassava Utilization Research Network and a network for Cassava Development in the Southern Cone countries These networks plays a key role in definition of regional research priorities and identification of opportunities for horizontal collaboration

Colombia

As CIAT's host country Colombia plays an important role in providing situations for the testing and adaptation of component technologies and participatory research and technology transfer methodologies As such it provided the site for the first integrated cassava project initiated in 1981 on the Atlantic Coast Rapid and dynamic growth of both farmer cooperative and private cassava drying plants has occurred over the last two years There are now over one hundred plants located on the Atlantic Coast and expansion of the cassava drying technology to other areas of the country has been achieved through a joint National Rehabilitation Plan/CIAT project The national production of dry cassava is now estimated at 25000 t with benefits accruing to over 5000 families The increased market for cassava has stimulated demand from farmers for improved cassava production technologies

A study on the adoption of cassava production technology components in the Atlantic Coast of Colombia was undertaken in 1991 Preliminary results of a sub-sample of the data shows that

- Cassava varieties Venezolana (M Col 2215) and Verdecita (M Col 1505) have been adopted by 91% and 5% of cassava farmers respectively Together they cover 44 000 ha in the three principal cassava producing departments of Colombia

- Stake treatment and storage technologies have been adopted by 10% and 71% respectively Planting density and weed control technologies have been adopted by 60% and 53% respectively

- Technology adoption has been the principal factor for cassava yield increases Since 1982 cassava yields (cassava/maize intercrop) increased by 52% 56% and 76% in the departments of Bolivar Sucre and Cordoba respectively

- Cassava area has increased significantly as a reaction to improved prices and demand Cassava farmers have increased area planted to cassava decreased fallow area and period and 95% of farmers are harvesting the same area as planted rather than leaving cassava in the ground until markets improve

- As a reaction to improved cassava prices and overall demand cassava farmers have decreased on farm cassava consumption (as share of total production) by some 50% since 1982 Sales to drying plants currently constitute 22% of total cassava production.

- Overall 71% of cassava farmers have adopted at least one production technology component and 80% responded that they have increased their incomes as a result of improved technology and the increased demand and improved market

The data clearly show that cassava drying plants have served as an effective vehicle for cassava technology diffusion

Ecuador

The Ecuador integrated cassava project operates primarily in two coastal provinces, Manabí and Esmeraldas The goal of the project is to unite and integrate the efforts of local, national and international agricultural development institutions engaged in research extension and education in order to identify cassava production, processing and utilization technologies appropriate for low resource cassava farmers

Current project beneficiaries are 18 farmer associations (APPYs) with 350 members in Manabi and 5 with 60 members in Esmeraldas Among the APPYs four have all women members eight have only men and eleven have mixed membership The women s APPYs produce cassava starch exclusively while the men s and mixed associations produce cassava chips which are milled into various flour products The APPYs in each province are organized into unions (UAPPYs) which are responsible for providing the associations with credit training and technical assistance and handle the marketing of processed cassava products

Total output from the UAPPY Manabí increased markedly from 50 t of cassava flour during the initial year of the project (85 86) to 1 346 t of flour and 104 t of starch during the 90 91 processing year

Research conducted within the project until 1989 was primarily focused on adapting cassava processing technology from the Atlantic Coast of Colombia to the agroecological and social conditions of Manabi and Esmeraldas In 1989 an unexpected downturn in the demand for cassava flour as the agglutinant for making shrimp feed pellets caused a dramatic shift in the cassava program Farmer processors demanded assistance in identifying new markets for their existing products technology for producing new products and methods to improve processing quality An intensive market diversification effort was therefore initiated Today the primary markets for the UAPPYs products include cardboard box factories plywood mills and food industries as well as the shrimp feed industry

Farmers now aware of the need for better fresh cassava quality are demanding new varieties with higher dry matter improved drought tolerance and earliness The first new variety meeting these requirements M Col 2215 introduced through CIAT in 1987 will be released by INIAP this year

Countries like Ecuador where farmers are demanding improved production and processing technology and there is no single institution with post harvest research capability require new mechanisms for conducting research The formation of multi institution and interdisciplinary teams with the active participation of trained UAPPY para technicians is proving to be an efficient alternative approach which ensures the continuous involvement of farmer users in the research process

Brazil

Following intensive contacts with Brazilian research and extension agencies through training events and study tours in Colombia and Ecuador an integrated cassava development project was initiated in the State of Ceará in 1989 The project which is executed by the Ceará State Cassava Committee (CCC) is partially financed by the W K. Kellogg Foundation.

One of the principal activities of the project has been the organization of farmers groups for the construction, operation and administration of cassava processing facilities When the project initiated activities in May 1989 12 drying plants already existed By the end of August 1991 the total number of small scale processing plants had risen to 59 and 1380 farmers were benefitting directly from the project

The building up of local institutional capacity and support for the project has progressed steadily and the role of the CCC as the coordinating body for all activities related to cassava development has gained general recognition In addition, five Regional Cassava Committees (RCC) have been established and are contributing to the rapid and efficient decentralization of project activities

The identification of local financial resources for expansion of the project into new areas has been actively sought The total value of resources obtained and allocated to farmers groups to finance the construction of their cassava processing facilities now amounts to

US$347 048 Marketing channels for dry cassava chips have started to consolidate The main consumers of the dry cassava chips have been dairy farmers located in the vicinity of the drying plants In 1990 the total number of purchasers was 410 with 19 (5%) of these buying 62% of the total production

The first results from the 15 pre production plots planted in 1990 have shown that at 15 months average yields of cassava were 60% higher than those obtained by farmers employing traditional production practices

Paraguay

Paraguay is the largest per capita producer of cassava roots in the world and the crop is considered strategic in terms of the country's food security CIAT's Cassava Program has been instrumental in orienting and supporting a young unexperienced but dedicated group of researchers and extension leaders in defining priorities formulating objectives and strategies and executing projects with the objective of maintaining cassava s position as a principal source of carbohydrates for both human consumption and animal feed

The focus of cassava related activities in Paraguay has been centered on (a) sustaining and improving production, with particular emphasis on soil fertility and erosion control and (b) making better use of the crop through improvements in post harvest handling processing and marketing

Since 1985 a project partially financed by the International Development Research Centre IDRC, has concentrated on two important cassava growing areas Paraguari a Department close to the capital Asuncion, where soil degradation has significantly reduced the quantity and quality of the cassava produced with the result that the area is a net importer of roots and Caaguazu a Department where the native forest has been opened for agriculture within the last twenty years and is the principal supplier of cassava for the Asuncion market

The development of technological components to improve cassava production in Paraguarí and Caaguazu have led to the formulation of two complete technical recommendations for farmers The recommendations consist of a set of improved technology components together with the use of traditional technology for those production activities for which no improved technology exist These recommendations are constantly being evaluated in farmers fields in the two localities For Paraguari the recommendation includes improved components for variety (Meza i) stake selection, the use of 20 t/ha of manure before planting plus band application of 300 kg/ha of 12 12 17 2 (NPK and Mg) The land preparation, weed and pest control methods have remained the same For Caaguazu the recommendations presently consist of the same components mentioned for Paraguarí without the use of fertilizers

The fresh cassava storage technology developed by CIAT/NRI is being tested and adapted to conditions in Paraguay Starch is used mainly to make a traditional bread known as

chipa The artesanal and small scale starch extraction processes employed are very inefficient with a recovery of only 60% and the contamination of water sources is a major environmental problem in some localities Work is underway to improve extraction efficiency and product quality and to introduce simple effluent treatment

Seed systems

The opportunities for increased cassava root utilization described above and the demand from farmers for improved production components that will increase productivity and reduce costs has highlighted the need to undertake activities oriented toward the development of organized cassava seed supply systems that will ensure the availability of high quality planting material of either local origin or from improved genotypes This area is seen as a major constraint in the evolution of the integrated cassava projects towards increased and more stable cassava production at lower costs In collaboration with the Colombian Agricultural Institute ICA, the Seed Unit has been developing pilot models for the organization of seed production in different regions of the country which differ according to the user groups and end uses of cassava. The experience gained will provide the basis for implanting similar models in other countries

Asia

In Asia, cassava faces fewer market constraints as compared with tropical America, the crop having made the transition from being purely a starchy staple to a multipurpose carbohydrate source in many countries In addition cassava research programs are relatively stronger with a low turnover in personnel Priorities for research at the regional level have been focused on germplasm improvement and soil fertility maintenance as key elements in ensuring highly productive cassava based cropping systems The promotion of horizontal exchange of information on post harvest processing and marketing has also received attention Training of personnel, the execution of joint projects through research contracts and the formation of a regional cassava research network that meets every three years have been the principal mechanisms for improving national programs research capacity

Cassava varietal improvement

Generation of breeding materials Cassava breeding programs in Asia have benefitted significantly from the availability of selected and upgraded genetic materials from CIAT Since 1975 274 196 hybrid seeds from CIAT Colombia have been distributed to 9 countries The establishment of a joint Thai CIAT cassava breeding program has brought about further progress in breeding for yield high dry matter adaptation to semiarid lowland tropics and improved plant type 47 224 hybrid seeds from this program have been distributed to 9 countries since 1985 and 215 clones have been shipped to 11 countries since 1988

Varietal selection Steady progress in varietal selection has been made by the cassava breeding programs in Thailand China, Vietnam, Malaysia and the Philippines with

promising materials being selected from CIAT and Thai-CIAT introductions and local CIAT crosses In Thailand 7 clones with different adaptive niches have been or are in the process of being released over the period 1984 93 The Thai program is contributing its advanced materials to other national programs

Varietal release A total of 12 varieties in five countries have been released The number is expected to increase steadily in the future with selections from Thai CIAT crosses and Thai CIAT clonal introductions gaining in importance

Adoption Rayong 3 in Thailand and Adira 4 in Indonesia are planted on more than 50 000 ha. The extent and factors affecting adoption of both these varieties are currently being studied in close collaboration with the respective national research and extension programs VC 2 and M Col 1684 (not officially released yet) in the Philippines and Nanzi 188 in China are planted on smaller hectareages

Soil conservation and fertility maintenance research

Priority setting and improving research capacity After the establishment of the Cassava Agronomy Program in Asia in late 1986 a network of cassava agronomists and soil scientists working in national programs in Asia was developed by conducting collaborative research on high priority topics Through frequent visits to the national programs to see the trials and to discuss the results the organization of workshops and training courses and distribution of cassava literature the capacity and efficiency of the research was improved Since 1986 two Regional Cassava Workshops and a Symposium of the International Society for Tropical Root Crops were organized in Asia, while a production training course for Asian cassava workers was held at CIAT headquarters in Colombia.

Agronomy research results Collaborative cassava agronomy research on cultural practices, on erosion control and soil fertility managements has been conducted in nine countries The most promising economically viable erosion control practices were minimum tillage fertilizer application, contour ridging close plant spacing, and intercropping Cassava responded positively to the application of N in short term trials, but required relatively high applications of K for sustained high productivity The crop responded to P application sporadically and soil acidity or lack of secondary or minor nutrients were seldom significant limitations in Asia Practices such as green manuring intercropping, cover cropping and alley cropping generally reduced cassava yields but they may be beneficial for improving the long term productivity of the soil Considerable additional research will be needed to integrate erosion control practices judicious fertilizer use crop rotations green manuring etc in order to manage the crop and the soil for sustained high yields while protecting the natural resource base

Africa

Broadening the cassava germplasm base

A collaborative project between CIAT and IITA is dedicated to the broadening of the cassava germplasm base of Africa through introduction of germplasm from the Americas adapted to specific agroeconomical conditions It commenced in 1990 with the introduction of nearly 90 000 botanical seeds representing 400 families A new seed lot was introduced in 1991 A total of 130 000 seeds (750 families) have now been transferred to Africa being evaluated under humid sub humid semi arid and mid altitude conditions in Nigeria.

Results obtained from the material introduced in 1990 at Ibadan (sub humid) Onne (humid) and Kano (semi arid) show that progenies derived from crosses between Latin American germplasm and IITA s mosaic resistant clones TMS 30001 and TMS 30572 are more resistant to the disease under conditions of high pressure observed at Ibadan

Progenies of crosses involving CIAT germplasm adapted to the acid soil savannas of South America and IITA sources also showed a better reaction to an intense outbreak of CBB in the first 2 months after transplanting

Resistance to cassava green mite was observed in progenies obtained from crosses involving CIAT elite materials adapted to the dry areas of Latin America and resistant to that pest

The population evaluated under the semi arid conditions of Northern Nigeria showed a remarkable performance in terms of root yields and growth after enduring a 6 months dry season which started two months after transplanting A recuperation period of 3 months after the dry season enabled the seedlings to recover and produce yields comparable to those obtained at the humid and sub humid environments Selection in the semi arid location reflects the degree of adaptation of the genotypes to the harsh climatic conditions since no biotic constraints were observed in 1990-1991

Individual selected as promissory at Ibadan, Onne and Kano were cloned and are being evaluated in four location in Nigeria as part of the cassava breeding scheme of the Tuber and Root Crops Program of IITA.

The results obtained so far from this large scale germplasm introduction support the feasibility of such a program and suggests that a preselection of parents based on their agroecological adaptation is a step forward in a germplasm exchange program

Collaborative Study of Cassava in Africa (COSCA)

The Collaborative Study of Cassava in Africa (COSCA) is a joint project, managed by IITA, which aims to provide basic information about cassava in Africa to increase the relevance

and impact of research related to the crop and to help increase income and food security for people in Africa

Implicit in the objectives of COSCA was a geographic characterization of how cassava production and utilization varied across the countries involved in the study CIAT's Agroecological Studies Unit participated in the design of a spatial sampling frame for the project. To do this it mapped cassava distribution in Africa and constructed a geographic database of climatic, demographic and infrastructural information A member of the Unit assisted in training and data analysis for the project s first phase This consisted of a village level questionnaire to elicit qualitative information National teams were trained in sampling and mapping techniques Later the Unit participated in analysis of some of the data, including a description of the distribution of bitter and sweet varieties and relationships between varietal characteristics and environmental conditions

The Unit has used the information that it compiled for the geographic sampling frame to construct a statistical model of the distribution of cassava in Africa This uses population density modified by climatic and edaphic factors to predict cassava distribution in the year 2000 and to identify areas where cassava production is notably higher or lower than might be expected This information has formed the basis for the preparation of an Atlas of Cassava in Africa which will be available in 1992

CASSAVA PROGRAM STRATEGIC PLAN 1992 2002

In the 1990s the Program will continue to promote the integration and consolidation of national cassava research and development systems in tropical America and Asia, and to facilitate linkages between these systems and institutes undertaking advanced research on cassava through the Biotechnology Network Closer collaboration will be sought with IITA to help meet the needs of African programs While maintaining a commodity system perspective the program will emphasize germplasm resource development Crop management, utilization and market research will concentrate on strategic issues of global importance Applied research in these areas will gradually be devolved to national organizations with horizontal cooperation encouraged between countries at the regional level The Program will focus primarily on technology development for the subhumid, semiarid and subtropical ecosystems of the Americas and Asia, interacting closely with CIAT's new Resources Management Research Division on hillside savanna and forest margin ecosystems where an estimated 25%-30% of cassava is produced in tropical America

Overall core resources are projected to decline slightly over the period in terms of actual staff positions and significantly in terms of positions approved by TAC for 1989 1993

EXECUTIVE SUMMARY

The Genetic Resources Unit in 1987 1991
Era of new responsibilities and consolidation

INTRODUCTION

CIAT s Genetic Resources Unit (GRU) has experienced a period of restructuring and consolidation brought by new responsibilities new facilities and an increased emphasis on germplasm research The GRU is now a well organized and productive Unit which is strongly integrated into the work of CIAT s Programs and Units and with national and international organizations

New Facilities and New Responsibilities

Successful gene bank management depends on the availability of specialized and centralized facilities The construction of the following new facilities has helped the GRU to improve CIAT s gene bank services and take on new responsibilities

New seed storage facility

The new seed storage facility donated by the Italian Government began operation in early 1990 The facility includes (a) a long term storage room with a temperature of 20 °C (b) a short term storage room with a temperature of 5 8 °C and 35% r h and (c) a seed drying room at 20 °C and 15% r h The facility has a designed capacity for 100 000 accessions in both long term and short term conservation rooms All *Phaseolus* and tropical forage germplasm have now been transferred into the new short term storage room This new facility enables the GRU to function adequately to take important responsibility for conserving large collections

Tissue Culture Laboratory

A new Tissue Culture Laboratory (TCL) also began operation in the GRU in January 1990 Consequently the responsibility for in vitro cassava germplasm management was transferred from the Biotechnology Research Unit (BRU) to the GRU

Seed Health Laboratory and Electrophoresis Laboratory

A new seed health testing laboratory was completed in April 1991 This laboratory has ample space (124 8 m^2) and is well equipped for the routine checking of seed health status of out going germplasm The former seed health laboratory was converted into an electrophoresis laboratory with a space of 44 m^2 All electrophoretic work (e g fingerprinting cassava germplasm and genetic diversity studies through the use of biochemical markers) is now carried out in this laboratory

Integrating the Tropical Pastures Programs s Germplasm Section

In the past gene bank related activities with respect to the pasture collection were divided between the Tropical Pastures Program (TPP) and the GRU Collection initial multiplication characterization documentation and related training activities carried out by TPP germplasm section Regeneration maintenance distribution and to some extent documentation were handled by the GRU From 1990 onward the GRU took over full responsibility for all forage germplasm conservation related activities

TROPICAL FORAGE GERMPLASM

Germplasm Management

Since 1971 when the first introduction was made CIAT s tropical forage germplasm collection grew to 20 055 accessions of more than 750 wild legume and grass species of which about two thirds are now available for distribution Three quarters of the collection have been assembled by collection with the direct participation of CIAT scientists The particular value of this collection lies in the fact that the majority of accessions originated from regions with acid low fertility soils Nearly 65% of the legumes come from South America which is considered the principal center of diversity Southeast Asia a minor yet very important center of diversity of tropical legumes contributed about 15% to the CIAT collection However most of the grasses (60%) originated from Africa

Acquisition

During 1986 1991 acquisition of new germplasm was strategically focused on filling in geographic and genetic gaps and in response to international requests to specific needs and a total of 5452 accessions were acquired About 48% of them were collected by the TPP in Southeast Asia Africa and Tropical America The GRU assembled another 27% by collection missions to several regions of Colombia

Conservation

Since 1990 the GRU undertook multiplication in CIAT s greenhouses and fields in Palmira Quilichao and Popayan Because of the longevity of most tropical forage species seed has to be continuously hand harvested and this even during several years to obtain sufficient quantity Recently woody legumes received most emphasis in initial seed increase besides the key species identified by the TPP Multiplication averaged about 2000 accessions per year So far two thirds of CIAT s tropical forage germplasm collection have been increased During the move into the new cold rooms 1990 1991 all accessions have been inventoried and checked for quality

Within the CGIAR system CIAT has the international mandate for 11 legumes and seven grass species More than one third of these legumes is now conserved in CIAT s

base collection under long term storage conditions Because of joint collection missions or active exchange of germplasm nearly 50% of these accessions are shared with other important institutions in active duplication

Characterization

In the past germplasm characterization was mainly carried out by the TPP with special emphasis on identified key species During 1986 1991 the GRU also characterized germplasm under multiplication in the field as well as in the greenhouse in Palmira These data still need to be put into CIAT s database and a user friendly access has to be created Recent morphological characterization especially in *Brachiaria* spp and *Arachis pintoi* aimed at developing descriptors and elaborating classification systems for new germplasm by the help of multivariate statistical methods In addition studies on isozyme fingerprinting utilizing PAGE electrophoresis have been initiated for both genera Regarding *A pintoi* polymorphism was found in all four isozyme systems studied (EST ACP GOT and DIAP) and CIAT s eight accessions comprising collection was shown to be genetically different

Documentation and Data Management

Reliable documentation and efficient data management are basic for germplasm management In close collaboration with CIAT s Data Services Unit since 1990 new menus are being developed to improve control over germplasm management activities However more information flow and control are needed to complete the system of integrated data management

Since 1989 the whole passport data are being revised corrected completed and edited and several regional catalogs have already been published Special emphasis was given to the taxonomic identification of species in recent years About 45% of the legume accessions and 21% of the grasses are now represented in the reference herbarium which recently was reorganized Specimens are now stored in alphanumerical order and all samples are inventoried by computer

Distribution

To improve its efficiency a computerized system is being implemented to germplasm distribution since 1990 During 1986 1991 more than 10 200 samples were distributed to the TPP and other CIAT programs and another 6500 samples to 54 countries in answer to 526 requests Although germplasm most frequently distributed belongs to key species defined by the TPP samples of more than 50 genera have been distributed in both years 1990 and 1991

Genetic Resources Research

Because the conservation of genetic resources is a relatively new endeavor many questions arise that cannot be answered on the basis of current knowledge Relevant

research with emphasis on taxonomy and reproductive biology was started in 1990 Within the taxonomic revision of the leguminous genus *Galactia* a key for the determination of those species held in CIAT s collection was elaborated The outcrossing rate of over 30% observed in open pollinated *Centrosema brasilianum* needs consequences how the multiplication of this species will be carried out in the future

Future Prospects

Past constraints related to the lack of greenhouse laboratory and storage space and of personnel have been largely overcome by 1991 Because of the fusion of the TPP s former germplasm section with the GRU s tropical pastures work all germplasm activities are now being organized more efficiently and duplication of efforts can now be avoided

During 1990 1991 computing facilities in the GRU building were greatly improved Access to the database was limited however because of the IDMS/R system presently used by CIAT At present only data requests fitting previously elaborated menus can secure an adequate response in a user friendly way Requests for other information have first to be processed by the staff responsible in the Data Services Unit (DSU) and responses are frequently too slow The recent decision to implement the new ORACLE system at CIAT is very much welcomed by the GRU even though it will require considerable time to adjust the database to the new system

With respect to the pasture collection little data is available on the initial seed viability at storage while even less is known about the germination rate of germplasm which was acquired or multiplied ten or more years ago Recent experience shows that there may still be considerable loss of accessions An alternative location for duplicate base collection deposit has can now be negotiated and an initial deposit of samples already prepared The base collection of key species will also receive prompt attention

As the TPP expands its activities in Africa and Asia germplasm shipments to these continents will increased This will require increased attention to the phytosanitary status of the germplasm and a standard phytosanitary checking procedure will be established

Phaseolus BEANS GERMPLASM

CIAT has had global responsibility for the conservation of the germplasm collection of cultivated species of *Phaseolus* beans since 1976 These responsibilities essentially include assembling maintenance characterization evaluation and distribution of germplasm accessions to CIAT s Bean Program national programs and to bona fide users generally Additional tasks that follow as a consequence of the ones already mentioned are documentation and data management The last in depth reviews of the GRU activities mainly in *Phaseolus* were carried out in 1986 and 1989 during the External Program Reviews (EPR) at CIAT The following highlights summarize the achievements since 1988 with particular focus on the constraints identified in these reviews

Assembling and Present Status

CIAT s *Phaseolus* germplasm collection presently consists of 26 506 accessions already increased and available for distribution *P vulgaris* and its wild ancestors are the major component of this collection (89 5%) followed by *P lunatus* (5 5%) *P coccineus* (2 3%) *P polyanthus* (1 1%) and *P acutifolius* (1 0%) Of the true wild nonancestral species there are 22 species but they form only 0 6% of the total collection In 1986 the collection totaled 21 984 accessions while in 1977 it had 12 690 accessions Documentation during recent years shows that about 50% of the *P vulgaris* collection originated in primary centers of domestication and such material can be considered as landraces

Acquisition

During 1985 1991 a total of 8496 new accessions were introduced of which 6627 were *P vulgaris* 940 other cultivated species and 929 wild species Collecting expeditions were carried out mainly as collaborative projects with the IBPGR and U S Department of Agriculture (USDA) Countries explored were Peru Mexico Argentina Guatemala Colombia Costa Rica and Ecuador Over 2000 accessions were collected of which 75% corresponded to landraces of the domesticated species and 25% to wild species either ancestral or nonancestral

Multiplication

Initial seed increase and multiplication that is to make germplasm available for distribution have been the most demanding responsibility for the Unit in the last 5 years Three locations at different altitudes (1000m 1800m and 2000m) have been used for this task and a total of 35 855 accessions have been increased during the last five years An agreement with the Instituto Colombiano Agropecuaria (ICA) was negotiated and signed to establish a more efficient and safe procedure for accelerating the introduction and increase of germplasm from primary centers of domestication (Central and South America) Additionally through special funds provided by the Japanese Government a quarantine greenhouse has been constructed for ICA near Bogota to speed up the initial introduction of germplasm from countries outside the primary centers i e from Europe Africa Asia and Oceania This new facility will be completely functional by the end of 1991

The year 1991 was a turning point for developing priorities on multiplication A series of studies are underway to develop a system for virus eradication in the seed of the present *P vulgaris* germplasm collection A preliminary trial will soon be carried out to implement the cleaning system which involves visual virus identification and roguing of plants with symptoms at on early growth stage and ELISA tests at advanced plant stages in a quarantine greenhouse followed by a seed increase in an isolated field Special attention will be given to minimizing genetic drift during this process

Characterization

The *available P vulgaris* germplasm in growth habits I and II has been characterized using 30 morphological descriptors *while the whole collection* of this species has now data on the essential descriptors (growth habit and seed type i e color shape size brilliance) Morphological data are not sufficient to allow discrimination at accession level A series of biotechnological techniques are now under study in the search for a practical procedure that will allow accession discrimination with more confidence Probably this procedure will include electrophoresis for the seed storage protein Phaseolin as an indicator of geographical origin together with analysis of molecular markers such as hypervariable DNA A special collaborative research project with the University of California is underway to better define this methodology in *Phaseolus*

Data Management and Documentation

Data files generated at the different stages of germplasm management have been handled by three approaches SAS IDMS/R and through PCs The IDMS/R database has been replaced in 1991 by another relational database ORACLE which has already been tested and promises to solve past limitations for multivariable queries Data on all *Phaseolus* species will be centralized in one file ORACLE is expected to be fully functional by the end of 1991

Documentation of *Phaseolus* has also been a high priority in recent years This task was accelerated to complement CIAT s work on core collection of *Phaseolus* One of the main criteria for the selection of its representative components is based on geographic data Such documentation has helped identify more clearly the origin of many accessions This effort will be more efficient with the implementation of the new database

Germplasm catalogs of *P coccineus/P polyanthus* and *P lunatus* were first published in 1988 and 1991 respectively A catalog of wild *P vulgaris* was published in 1990 and an updated catalog for *P vulgaris* will be published by the end of 1991

Seed Distribution

The continued availability of bean germplasm to bean scientists has been major goal for the GRU Between 1977 and 1991 the GRU has provided 81 252 accessions to national programs universities and other research institutions while for the Bean Program a total of 248 499 individual samples for screening work were prepared Besides making available basic germplasm to national programs the GRU also serves to back up those countries who for various reasons have lost part or all of their national collections CIAT has been able to replace collections in Honduras Iran Peru Mexico and Burundi

Conservation and Duplicating of the *Phaseolus* collection

The major breakthrough of the last 5 years has been the completion of a new seed conservation building All Phaseolus germplasm has now been transferred to the short

term storage CIAT has negotiated safe heaven duplicate storage agreement of *Phaseolus* At the present time the *P vulgaris* germplasm is 90% duplicated in Costa Rica at CATIE and 13% in Brazil with CENARGEN Alternative duplication in the international gene bank when established in Norway is under consideration

Training

During the period 1986 1991 a total of 10 professionals from 6 countries were trained in periods of 1 to 6 months at the GRU

MANAGEMENT OF *Phaseolus* GENETIC DIVERSITY A CIAT IBPGR COLLABORATIVE PROJECT

This project commenced in 1989 Its general objective has been to develop optimal management strategies for maintaining genetic diversity in a large gene bank by providing a better understanding of the genetic structure of *P vulgaris* as it occurs in nature and in the gene bank with the following three specific aims

Effects of Initial Seed Increase Methods on Genetic Drift

A total of 18 isozyme systems were evaluated to select the most appropriate genetic marker system for analyzing the genetic structure of three wild *P vulgaris* populations and for monitoring gene frequency changes during initial seed increase Six enzyme systems were found to demonstrate clear bands and polymorphism

A total of 30 plants of each population were planted in a screenhouse and checked for differences in seed production The experiment was conducted in 1989 and 1990 at Tenerife Colombia using different batches of seed samples Large differences in seed number produced per plant were observed in all three populations over the two years There were some plants which produced no seed whereas other plants from the same accession produced more than 1500 seeds per plant It is clear that initial seed increase in wild germplasm presents a particular risk of genetic drift because of differing fecundity within a quite small population

A simulation study was carried out in collaboration with the Data Services Unit to estimate the effects that different seed increase methods could have on isozyme allele frequencies The simulation study indicated that significant changes in allele frequencies do occur The use of all harvested seeds did not change greatly the original gene frequencies On the other hand it is clear that the size of the original population is of critical importance When only 18 plants are used as is routinely done at CIAT significant deviation can occur in all three accessions The size of initial seed increase plays a key role in determining the fate of low frequency alleles in subsequent seed increase

Comparison of Common Accessions Maintained in Two Gene Banks CIAT and USDA Pullman

There are many accessions which are maintained in common at the CIAT and at the USDA Pullman gene bank The CIAT collection was originally based on several large donations by the USDA in early 1970s It is often assumed that these common accessions have the same genetic content Seven common accessions have been compared for differing morphological traits and isozyme markers in order to estimate genetic drift if any from one bank to the other

Seeds of seven common accessions from the two banks were planted at Tenerife (2000m in Colombia) and seven morphological traits were checked for each plant It was observed that plants and seeds produced from those of Pullman origin demonstrated more infra accession variability in many traits The results clearly indicate that common accessions cannot be assumed to be genetically identical and that some genetic deviation will have occurred Most of the significant differences resulted from the absence of particular traits from CIAT gene bank accessions and/or from significant change of frequency of some traits A reduction in genetic variability in CIAT accessions has to be expected because only a small number of seeds of each accession were initially introduced from Pullman multiplied in a quarantine greenhouse using only a few seeds and then multiplied many times in CIAT fields

Allogamy Frequency of Common Bean

All CIAT s cultivated accessions are grown in fields for seed increase and regeneration If outcrossing (allogamy) occurs during seed increase in the field then some of the seeds harvested will be genetically contaminated

Pigmented hypocotyl in *P vulgaris* is dominant over green hypocotyl Because this trait can be recorded easily in many seedlings it was used as a morphological marker to estimate allogamy frequency of 11 accessions in two Colombian locations (Popayan and Tenerife) Allogamy frequencies were low at the both places Five accessions had no allogamy at either site Average allogamy frequency in the 11 accessions for the two locations was less than 1%

CIAT UNIVERSITY OF GEMBLOUX (Belgium) COLLABORATIVE PROJECT ON *Phaseolus* GERMPLASM

Lima Bean (*P lunatus*) Germplasm Research

This project started in May 1986 and terminated in April 1991 The following major achievements of this very productive project have now firmly established the *P lunatus* collection at CIAT

The first catalog on lima bean germplasm was published in April 1991 covering 1456 CIAT G number accessions This represents about half of all introduced lima bean accessions The University of Gembloux analyzed the hydrocyanic acid (HCN) contents of 1341 accessions of which 700 are from the CIAT gene bank A wide range of variability for this trait was found in both cultivated and wild groups Allogamy studies were conducted to estimate outcrossing rates under different conditions The natural hybridization rate under field conditions in CIAT ranged from 0% to 7 9% with an average of 2 7% An increasing distance between two entries reduced outcrossing rate but outcrossing occurred even between plots spaced 12 m apart The implications for future conservation work in P lunatus are being carefully accessed A total of 570 accessions (459 cultivated 104 wild and 7 weedy) have been characterized by electrophoretic analysis New accessions recently obtained from Ecuador during an expedition have provided additional insights into the understanding of the origin of this species its gene pool definition and the magnitude of the founder effect

Runner Bean (*P coccineus/P polyanthus*) Germplasm

This collaborative project focused on the efficient use of *P coccineus/P polyanthus* in the improvement of the common bean Work started in 1984 and terminated in 1989 The major achievements of the project are as follows

A total of 894 accessions of *P coccineus/P polyanthus* have been successfully multiplied of which 878 have been assigned a G number The first catalog on this germplasm was published in October 1988 including 785 accessions with passport data and agromorphological evaluation descriptors A total of 253 accessions were found to be resistant to ascochyta blight (*P exigus* var *diversispora*) Resistance to the bean fly (*O phaseoli*) and to Bean Golden Mosaic Virus (BGMV) were also found in 37 and 3 accessions respectively Ten promising accessions selected from the total collection were distributed for evaluation by national program scientists in eight countries in Latin America and Africa This provided CIAT with preliminary but valuable information on their relative performance under different agroecological conditions Biochemical markers were successfully used to study the interesting origin of *P polyanthus* Interspecific crosses between *P coccineus/P polyanthus* and *P vulgaris* were made in an attempt to transfer useful traits into common bean Congruity backcrosses and recurrent selection were applied to break linkages with undesirable traits and to increase frequency of favorable genes

CASSAVA GERMPLASM

In Vitro Cassava Germplasm Management

Within the CGIAR system CIAT has accepted global responsibility for conserving cultivated and wild cassava (*Manihot* spp) germplasm This implies an obligation to provide a high level of security for conservation complete characterization and evaluation thorough documentation and a system for effective pathogen free exchange of

germplasm Whereas the Cassava Program continues to manage the field gene bank and characterization the tissue culture laboratory (TCL) of the GRU is responsible for the in vitro cassava germplasm management particularly focusing on three aspects (a) germplasm conservation (b) production of disease free clones in collaboration with CIAT s Virology Research Unit (VRU) and (c) germplasm exchange

Conservation

The in vitro gene bank presently conserves 4788 clones from 23 countries This represents 95% of the total number of accessions in the field In 1987 a total of 3382 clones were conserved in the in vitro gene bank thus an additional 1406 clones have been introduced into the bank during the last four years The slow growth conditions methodology currently used at the GRU allows conservation of in vitro collection for an average of 13 months but this can be as long as 20 months depending on genotype In addition the in vitro bank has 394 genotypes of 29 wild cassava species A recent thesis study identified several culture media which were superior than the commonly used CEC media for managing wild cassava germplasm

Pathogen elimination

Since the initiation of the in vitro gene bank pathogen (especially virus) elimination through meristem culture has been an important initiative So far 958 clones have been cleaned and indexed by using diagnostic technique (ELISA) for cassava common mosaic virus (CCMV) and cassava virus x (CsXY) and 145 clones have been indexed for Frog Skin Disease (FSD) by grafting onto an indicator clone All indexing work have been carried out by the VRU

International germplasm exchange

Since 1979 3070 clones have been sent to 43 countries in response to 205 requests Often the same clones were sent out in different shipments In total 1243 individual clones have been involved in this exchange at different frequencies ranging from 1 to 66

Database management

Since the initiation of the in vitro collection in 1979 information on the handling of all 4788 clones in the in vitro collection was recorded on cards by hand With excellent collaboration from the Data Services Unit the GRU has completed the digitation of all the information in 1991 The computerized database will facilitate organization of the in vitro management and data analysis based on accumulated information

Future prospects

About 20% to 25% of the field collection can now be safely eliminated through duplicates identification This work has already started in 1991 This may lead to

eventual elimination of duplicates from the in vitro gene bank However because the present gene bank has comparatively poor representation of germplasm from Africa and Asia especially from India the final size of the in vitro bank is expected to be around 5000 accessions

The Global Cassava Germplasm Network being planned by IBPGR the International Institute of Tropical Agriculture (IITA) and CIAT will seek safe and efficient ways of cassava germplasm conservation through technical and institutional integration A major issue to be solved by the network is the safe duplication of CIAT s large cassava germplasm at other institution Further refining of the cryopreservation methodology being carried out by the Biotechnology Research Unit (BRU) and the GRU will have a significant impact on CIAT s conservation strategy This latter work was conducted by CIAT in collaboration with IBPGR and represent a major step forward in this technology

A major bottleneck to increasing the number of pathogen tested clones which have been tested for FSD is due to the time consuming grafting procedure presently required By the end of 1992 630 accessions of the cassava core collection awaiting worldwide distribution to many collaborators will be cleaned and indexed Recent progress by the VRU in the identification and purification of FSD s causal agent may lead to a major breakthrough toward developing a simple diagnostic method which will facilitate indexing the whole in vitro collection

The Cassava program and the GRU have made major progress towards establishing a core collection for cassava The creation of the cassava core collection at CIAT will stimulate experimental biologists to carry out basic and strategic research on this important crop This in return will require CIAT to respond to a larger number of germplasm requests

Isozyme Fingerprinting and Genetic Diversity Studies

Biochemical markers such as isozyme have multiple uses in germplasm research The GRU is characterizing in collaboration with the Cassava Program the whole cassava collection for esterase isozyme by using a methodology developed by the BRU Preliminary studies indicated that esterase isozyme are ideal for the above mentioned objectives

Fingerprinting and duplicates identification

In the last 3 years a total of 3971 accessions (about 79% of the collection) have been analyzed and a total of 22 differentiating bands were found All bands have been coded and the existence of each band recorded in a computerized system All fingerprinting work is expected to be completed for the whole collection by the end of 1992

A total of 1705 different combinations of banding patterns were found among the 3270 accessions The number of clones possessing each different banding pattern was

analyzed A large number (1156) of patterns were represented by only one clone while the rest had 2 to 39 clones with the same banding patterns The former group of 1156 clones represents truly unique genotypes because different banding patterns imply real genetic differences The clones in the latter group are the ones where duplicates are most likely to be found combined with other morphological and passport information This will allow a tentative list of duplicates in the collection drawn up

Genetic diversity studies

Data on esterase isozyme were used to estimate distribution of genetic diversity in the collection The frequency distribution of the 22 bands in 3270 accessions coming from 21 different countries and CIAT s breeding program was studied The results show that there is no band which has a clear geographic distribution Many bands with more or less similar frequencies are found in many countries of origin Numerical taxonomy analysis does indicate some grouping of countries It is interesting to note that Fiji is grouped together with Venezuela and Colombia This may indicate that cassava germplasm in Fiji derived originally from a group of germplasm similar to that in Venezuela and Colombia

Knowledge of genetic control of those bands is essential for applying a more sophisticated population genetic analysis to the collection An electrophoretic analysis of inheritance of bands 19 20 21 and 22 which demonstrated very clear and constant presence during electrophoretic analysis was carried out Six segregating populations were produced involving eight clones Observed segregation ratios supported the hypothesis that these four bands were determined by one locus with five different alleles (including one null allele)

A standardized methodology for analyzing wild cassava plantlets coming from the in vitro gene bank has been accomplished A total of 12 isozyme systems were analyzed by PAGE or starch gel electrophoresis Several isozyme systems (EST ACP GOT ME and PGI) were found to be polymorphic and to demonstrate clear banding

SEED HEALTH LABORATORY

The SHL s main responsibility is to test the seed health status of germplasm (beans and tropical pastures) intended for international export The ICA Plant Quarantine Officer stationed at CIAT carries out field and greenhouse inspections and issues ICA s Phytosanitary Certificate which accompanies all out going germplasm from Colombia CIAT provides additional assurances to the receiving country through the routine evaluation by the SHL The SHL uses the methodologies recommended by CIAT s pathologists and virologists to detect pathogens of quarantine significance

During the last 6 1/2 years the SHL has analyzed 17 133 samples from different sections of CIAT with an annual average of about 2600 samples Bean germplasm

occupied the largest portion (more than 90%) followed by tropical pasture germplasm Samples of rice sorghum and maize were also analyzed in recent years

Of the samples infected with viruses bacteria and fungi during the period fungi are the most commonly detected pathogens ranging from 8 4% to 38% over the period Principal problems have been *Macrophomina* and *Rhizoctonia* Viruses were also often found in the samples It is clear that viral infection (BSMV BGMV and BCMV) rates have been dropping in recent years Contamination with bacteria was low in the samples except for 1989 and 1990 *Xanthomonas campestris* pv *phaseoli* and *Pseudomonas syringae* pv *phaseolicola* are the major bacterial diseases detected

THE ROLE OF THE GENETIC RESOURCES UNIT TO SUPPORT STRATEGIC RESEARCH PLANS OF CIAT'S PROGRAMS

The GRU will continue to provide basic raw germplasm as essential building blocks for CIAT and other institution s commodity research and especially for their move into strategic germplasm improvement over the next decade The need to widen the genetic base for crop improvement and recent development of methods for more efficient use of wild germplasm imply major expansion of CIAT s collections This is particularly true for beans and cassava for which the unit will seek to establish comprehensive wild collections

The expanded needs of the Tropical Forages program for multipurpose tree and shrub species for priority ecosystems will require acquisition of their germplasm The GRU will assist also CIAT s Programs to introduce soybean and sorghum germplasm with potential adaptation to acid soils

Research will comprise taxonomy cytogenetics reproductive biology evolution and genetic diversity and establishment of a core collection and germplasm conservation methodologies In almost all instances this work will be done in collaborative projects with other programs or institutions including those in advanced research networks

TRAINING AND COMMUNICATIONS SUPPORT PROGRAM

AND

SEED SYSTEMS DEVELOPMENT

ANNUAL REPORT 1991

EXECUTIVE SUMMARY

Training pursues three institutional development objectives (1) to strengthen national research capacity, (2) to strengthen national links between research and development and (3) to develop subregional training systems For the first, trainees are identified in close interaction with NARS and selected strictly on the basis of research team strengthening objectives personalized training programs are designed for each trainee One hundred forty seven professionals participated in such programs To strengthen national research development links, two lines of action are followed direct training of extensionists and training as part of seed systems development (see below) Training of extensionists is being reduced at the expense of developing subregional teams of trainers who will take over this responsibility Consequently only four in-country courses for extensionists were held in 1991 while the development of three subregional training teams successfully progressed, namely for bean production in Central America, for rice production in the northern Andean countries, and for cassava production and utilization in the Southern Cone The members of the Central American Trainers Team for bean production have already conducted eight courses for extensionists in the Dominican Republic, El Salvador Haiti Honduras, and Nicaragua (four courses) The group of Ecuadorian trainers for rice production will end the year with three courses delivered to extensionists (plus the first one from the whole series held in the previous year)

The Information Unit backstopped CIAT scientists with photocopies of 13 000 documents, 1 100 answers to reference questions, and nearly 1 000 literature searches External users, on the other hand, purchased photocopies of about 12,000 documents, received answers to over 800 reference questions, and were served by more than 2,000 literature searches These are increments, over last year of 6% in the output of photocopies, 21% in reference questions answered, and a striking 116% in automated literature searches The latter two improvements can be attributed to the Unit s technological modernization, and to the implementation of aggressive user awareness and training activities over the last two years.

The productivity of the Graphic Arts Unit, which had trebled from about 4 600 camera ready pages in 1988 to approximately 13 900 in 1990 has increased by another 44% (to 20 000 camera ready pages) Simultaneously due to the advance in desk top publishing typesetting was reduced by 35%

Major books were produced on Tissue Culture in Agriculture Research for Crop Improvement in Common Beans, and Fungal Diseases in Tropical Pastures. Important working documents were published on Integrated Cassava Projects the Contribution of Improved Pastures to Tropical Animal Production, and Pastures Research in Southeast Asia. And, of course CIAT's new Strategic Plan is a watershed publication in the Center's life

Of CIAT's extensive portfolio of publications, nearly 70 000 copies of periodicals were distributed close to 5 000 publications and 6 000 study guides were sold and more than 2 000 items were donated

In 1992 the Training and Communications Support Program, the Seed Unit, and other activities will become the Institutional Development Support Program. In the transition towards the new arrangement, several seed systems development activities conducted by the Seed Unit, the Central American and Andean Bean Projects, the Training and Communications Support Program, and the Tropical Pastures Program have been linked.

Major progress was made in conceptualizing and implementing alternative small scale seed supply systems for crops and other plant species of CIAT's interest which are not served by the established seed industry To derive general principles for the successful establishment and management of such systems real systems are being supported and monitored in six Latin American countries. The development of new systems is encouraged in several other countries Seed processing equipment appropriate to the scale of these systems has been developed or adapted, and deployed at nine sites or institutions in Central America, the Caribbean, and the Andean Region. The sites are a source of feedback on the equipment s suitability and a focal point for further dissemination of the new technology

VIROLOGY RESEARCH UNIT

ANNUAL REPORT 1991

EXECUTIVE SUMMARY

Bean Virology

Viruses remain major constraints to bean production in the tropics due to the introduction of new crops and exotic viral pathogens into traditional bean growing regions Some of the newly introduced crops are also preferred plant hosts to insect vectors or endemic viruses Last, the incorporation of certain genes for virus resistance in improved bean cultivars is creating unexpected pathogenic problems with some of the more recently introduced viruses As examples we can cite the introduction of exotic strains of cucumoviruses (aphid and seed borne viruses of the cucumber mosaic virus group) adapted to leguminous hosts These viruses are now widely distributed in Latin America and have already been detected in bean production countries of Africa and Asia, particularly China These cucumoviruses possess a very broad pathogenicity spectrum in *Phaseolus vulgaris* Also a temperate (northern) virus alfalfa mosaic virus was detected this year for the first time in Chile

Bean golden mosaic virus (BGMV) continues to spread in Latin America as a result of the expansion of export crops such as soybean, tomato tobacco and others which act as preferred hosts to the whitefly vector of the virus This factor together with the occurrence of dry warm conditions often result in excessive virus pressure and significant yield losses even in fields planted to BGMV tolerant cultivars

The deployment of monogenic dominant resistance to bean common mosaic virus (BCMV) has been a productive strategy in Latin America for over two decades Recently however several Central American bean cultivars which possess this type of resistance have been suffering severe attacks by beetle borne viruses of the comovirus group These viruses referred to as the severe mosaic virus complex, consistently induce necrosis and considerable plant distortion in dominant (I) gene cultivars while BCMV susceptible bean genotypes seldom exhibit these severe symptoms We will therefore implement a new breeding strategy for BCMV and comoviruses in general as of next year

Regarding the genetic control of bean viruses the VRU has been actively cooperating with bean breeders in the selection and utilization of new germplasm sources of virus resistance for breeding purposes Additionally and for the first time a bean plant has been genetically transformed by incorporation of three different genes (GUS gene herbicide (Bar) resistance and the coat protein gene of bean golden mosaic virus We are awaiting permission to use transformed bean seeds in BGMV screening tests to evaluate the viral coat protein mediated plant resistance approach engineered by Agracetus (a private biotechnology company) the Plant Pathology Department of the University of Wisconsin, and the Virology Research Unit of CIAT with USAID funding

Cassava Virology

The VRU has the responsibility to investigate the diseases of cassava that are caused by viruses or virus like agents There are four main diseases that are caused by the following viruses or virus like agents They are the frogskin and Caribbean mosaic disease complex (virus like agents) cassava vein mosaic virus (CVMV) cassava common mosaic virus (CCMV) African and Indian cassava mosaic viruses (ACMV & ICMV)

Progress has been made on the identification of phytoreovirus like agents associated with FSD and CMD Virus like particles and viroplasm like bodies have been found in affected plants Consistently nine ds RNA segments are found in the affected plants The hybridization studies provide evidence that the ds RNAs associated with FSD and CMD are either identical or closely related The whitefly *Bemisia tuberculata* appears to be the vector of these phytoreovirus like agents A cDNA probe has been developed to identify rapidly the ds RNAs associated with this disease complex The research on FSD and CMD are continuing and the investigations are centered on confirming the association of the phytoreovirus like agents and the entire complex of disease symptoms

The sequencing of CCMV is nearly complete The virus is 6400 bases in length and it is most closely related to potato virus X (PVX) Most of the sequencing of CCMV was done at the VRU in CIAT and this is perhaps the first plant virus to be sequenced in Latin America.

Cassava vein mosaic virus is most prevalent in the northeastern states especially in the hot semiarid zones where it is not unusual to find more than 50% of the plants infected with CVMV Since the virus is not present in Colombia, all work on this virus had to be done in Brazil A cDNA clone to CVMV has been obtained, and this will facilitate efforts at molecular characterization and the development of rapid diagnostic tests

African cassava mosaic virus is the most destructive cassava virus in the world Efforts are being made to find new sources of resistance through the CIAT IITA cooperative project The identification of ACMV resistant germplasm adapted to tropical America will be a safeguard against the possible establishment of ACMV in this hemisphere

Beside the major diseases there are seven other known viruses that infect cassava most of which are symptomless viruses that are not known to cause disease Diagnostic methods are available at CIAT to the four viruses that cause diseases and to the three symptomless viruses found in Latin America. These diagnostic methods help assure the safe movement of cassava germplasm, and research will continue to develop even more sensitive detection methods

The control of viral diseases requires either the identification of resistant germplasm or the implementation of cultural practices that mitigate disease losses Most viral diseases are controllable with the current technology and continued development of rapid diagnostic

technics together with the deployment of resistant germplasm should further reduce the losses caused by viruses

Rice Virology

The genomic characterization of RHBV is progressing with the completion of the *in vitro* translation experiments and the successful cDNA cloning and sequencing of RHBV A 20K protein encode by the RNA 3 and a 17K protein encoded by RNA-4 were identified by the *in vitro* translation experiments The 17K protein was shown to be the inclusion body protein.

A complementary DNA (cDNA) library to RHBV has been prepared and approximately 3 000 bases of the RHBV genome has been sequenced Non structural proteins on RNA 3 and 4 have been identified and share 50-60% direct amino acid homology with the equivalent proteins encoded by RStV and MStV

Analysis of the *in vitro* studies and the sequence indicates that RHBV has a genomic organization that is similar to other members of the tenuiviruses The genomic organization of RNA 3 and 4 appear to be ambisense Each species encodes one protein from the ss RNA that is encapsidated in the virions They also encode a protein on the complementary strand which makes both species protein encoding (sense) strands From the *in vitro* data, it appears that the RNA 1 and 2 encode proteins on only one strand and that the negative sense strand are the encapsidated ss RNA species

The cloning and sequencing of the RHBV RNA 2, 3 and 4 are expected to be completed during the next year This will nearly complete the primary molecular characterization of RHBV and will be a basis for a better understanding of the diversity epidemiology and effective control strategies of RHBV

Tropical Pastures Virology

Potyviruses are ubiquitous pathogens of tropical forage legume species such as *Centrosema* spp *Arachis pintoi* and *Stylosanthes* spp Consequently CIAT has developed reliable serological techniques to detect the various potyviruses detected to date in these species Using these techniques potyvirus free seed or asexual reproductive material has already been produced under screenhouse conditions This year a survey of *A pintoi* field plots planted with virus free reproductive stock produced at CIAT showed that it is possible to establish and maintain a virus free forage legume field as concluded from the absence of potyviruses in these fields We expect to plant similar trials with four *Centrosema* species next year

A viral disease was detected for the first time in a forage grass *Brachiaria brizantha* The causal agent was shown to be an aphid borne potyvirus which induces streaking and ring formation in susceptible accessions This virus can also establish latent infections in some *Brachiaria* sp accessions A preliminary survey suggested that this potyvirus has a wide geographical distribution, and current research seeks to establish its relationship with previously reported potyviruses of *Brachiaria* spp such as sugarcane mosaic and maize dwarf mosaic viruses

BIOTECHNOLOGY RESEARCH UNIT
ANNUAL REPORT 1991

EXECUTIVE SUMMARY

In 1991, the Biotechnology Research Unit (BRU) has successfully continued to integrate efforts with CIAT's programs in the constant pursuit of developing germplasm well adapted to selected agroecosystems, the specific role of the BRU being the application of modern biological and biochemical technology to address critical research constraints in productivity and stress tolerance The activities of the BRU can be subdivided into the following interrelated areas (1) characterization and utilization of genetic variability, (2) research on crop productivity, (3) mechanisms of plant adaptation to the environment, (4) institutional building

1 Characterization and Utilization of Genetic Variability

1 1 Molecular Mapping of Crops

A solid basis has been worked out for the upcoming project of the molecular mapping of the cassava genome A basic set of polymorphic markers from cassava genomic libraries has been selected within the frame of an IBPGR sponsored project Now, with support from the Rockefeller Foundation, we are going into the generation of the linkage map using these markers The map will be useful in the characterization of genetic variability in cassava, and will assist in future breeding projects

A hundred clones from a common bean cDNA library have been selected to complement the existing bean maps generated by C E Vallejos (Gainesville FL) using genomic clones (this map contains about 200 markers by now), and P Gepts (Davis, CA) The saturation of the map is an important goal as it is a prerequisite to get tight linkages in future gene tagging projects The level of polymorphism of the selected clones is currently being analyzed using selected parental lines The genome of tepary bean will be mapped as part of a project, in collaboration with the University of Ghent, Belgium which includes the characterization of resistance factors against bruchids in beans RFLPs (Restriction Fragment Length Polymorphism) as well as RAPDs (Randomly Amplified Polymorphic DNA) will be used for this purpose

The genome size is an important parameter in mapping studies In a collaboration with the Rice Program (C Martínez) and the University of Cornell, flow cytometry was used to assess nuclear DNA contents of *P vulgaris*, *P acutifolius* and *P lunatus* The genome size seems to be smaller than expected Differences were observed between wild and cultivated accessions, while no relationship was found between genome and seed size as had been speculated

The mapping of Brachiaria has been recognized as a high priority project by the Pastures Program, apomixis being one of the targets for gene tagging Contacts have been established with the Salamini group at the Max-Planck-Institute in Cologne for this mapping project We will start by selecting parentals and providing a set of polymorphic markers The RAPD technique will be used to generate a primary map

1 2 Molecular Fingerprinting of Pathogenic Microorganisms

The fingerprinting of rice blast (*Pyricularia oryzae*), which is a cooperation between Rice Pathology and Purdue University, has been a very successful project opening the doors to detailed studies on genetic variability and stability of the rice blast fungus

Another very successful ongoing project is the fingerprinting of *Xanthomonas campestris pv phaseoli* utilizing molecular probes, developed through a cooperation between Bean Pathology and Wisconsin

Both projects are being continued at CIAT in close collaboration with the BRU The results achieved so far and the experience gained by the programs have led to new initiatives concerning three fungal pathogens, which are the causative agents of Angular Leaf Spot Disease and Anthracnose in beans, and Anthracnose in Stylosanthes, respectively The high degree of observed variability of these pathogens justifies the efforts being undertaken A better understanding of the epidemiology and phylogeny will assist in the design of new resistant varieties and integrated pest management

1 3 Cryopreservation

Cryopreservation has reached a very advanced stage now We are able to regenerate up to 70% of material stemming from frozen shoot tips The experimental development of this IBPGR sponsored project was successfully finished this year We have gone now into testing the applicability of the methodology to multiple genotypes of the collection The importance of this project resides in the stable long-term storage of such a unique germplasm collection as CIAT's, thus solving a logistic problem and conserving potentially useful germplasm for future breeding programs

2 Crop Productivity Research

2 1 Gene Tagging

The final application of any genetic map is its use in breeding We have been very successful in using molecular markers from the rice map (acquired from S Tanksley Cornell University) to map resistance loci for the Rice Hoja Blanca Virus (RHBV) and Rice Blast For tagging resistance genes to blast, bulk analysis of susceptible and resistant doubled haploids was performed The RAPD markers linked to blast resistance are currently being checked on larger F2 populations and additional doubled haploid lines from the same cross We have gone very early into the utilization of brand new techniques, e g RAPD, which are very promising as to their direct applicability in breeding programs, because of their simplicity and their potential to handle large numbers of crosses, a major constraint to other technologies

In beans we are aiming at tagging the resistance loci against BGMV and the Common Bean Weevil Another important issue will be the merging of the bean maps generated by Vallejos (Gainesville FL) and Gepts (Davis, CA), which will lead to a more saturated map The RAPD technique, combined with the bulk screening method, is currently being used to tag the resistance locus to the Kappa race of anthracnose

2 2 Interspecific Hybridization

The introgression of tepary bean (*Phaseolus acutifolius*) characteristics into common bean using a congruity backcross approach has advanced further this year The fourth congruity backcross generation (CBC4) has now been crossed with *P vulgaris* and the first resulting embryos from that cross are presently being grown in vitro The goal of this recurrent crossing scheme is to force recombination between the two genomes as to attain fertile and commercially useful plants with important tepary bean traits, like drought and heat tolerance, as well as *Empoasca* and bacterial blight resistance We have already morphological and biochemical evidence for stable introgression of tepary bean into common bean

2 3 Genetic Transformation

Genetic transformation is a prerequisite for the non-classical introduction of useful traits into plants Such traits include at the moment genes for insect resistance, protection against viral infection, and herbicide resistances Sources of resistance against fungal pathogens, genetic manipulation of protein contents, genes leading to cold-tolerance these are some of the upcoming new possibilities for the future

The forage legume *Stylosanthes guianensis* has been successfully transformed for the first time in our laboratory using a construct which includes two selectable marker genes that confer resistance to an antibiotic and a herbicide and a scorable marker gene whose expression can be detected by a histochemical assay Regenerated plants have conserved their herbicide resistance trait The mendelian segregation of the trait is presently being studied in the F1 progeny in the greenhouse

Another pasture, *Brachiaria*, is passing through the first step that is needed for successful transformation regeneration *Brachiaria* has responded very well to preliminary experiments dealing with somatic embryogenesis, thus we can now start phase number two, which is the introduction of foreign DNA and selection of the transgenics Another crop that is responding well to preliminary regeneration experiments is rice In a collaboration between the Rice Program and the BRU, viable protoplasts have been successfully isolated from indica type rice embryogenic suspension cultures stemming from mature seeds Regeneration experiments are underway Protoplasts are amenable to direct DNA transfer, and have been used to produce transgenic rice of the japonica type

In beans we have adapted a powerful regeneration protocol starting from cotyledonary nodes The organogenic meristematic ring in the cotyledonary area will be a target for Agrobacterium-mediated or direct DNA transfer Virulent Agrobacterium strains have been selected after a meticulous screening procedure, as well as susceptible bean cultivars Adventitious shoot formation has been histologically demonstrated Transient gene expression of a scorable marker gene has been detected after infection with *Agrobacterium* and after particle bombardment with DNA coated tungsten microprojectiles

Cassava can be regenerated from secondary embryos forming on embryogenic calli stemming from apical meristems This is presently our target tissue for transformation experiments using *Agrobacterium* and the particle gun

2 4 Doubled Haploids

The incorporation of pollen derived doubled haploids into breeding programs reduces the time to obtain fixed lines to two generations of selection without affecting genetic variability and stability The Rice Program is using anther culture to introgress early grain maturity and good grain quality into cold tolerant germplasm, to increase the recovery of useful recombinants from wide crosses, to facilitate the transfer between savanna and irrigated materials, and to produce fixed lines for the mapping of resistance gene loci We have been able to achieve a 35 fold enhancement in the production of green plants from indica types, which had proved unresponsive to anther culture up to now This has been a constraint particularly in the breeding for irrigated rice

2 5 Somaclonal Variation

14 *Stylosanthes guianensis* somaclonal lines generated through in vitro regeneration have been tested for their agronomic performance A main goal is the search for plants tolerant to acid soils Some of the lines have shown superior agronomic performance than the check, others have shown some special morphological

characteristics, like dwarfism, chlorotic foliage, 1-2 leaflet leaves, and one tetraploid line These traits have shown to be inheritable through four generations

2 6 Utilization

Another topic that is related to productivity, is the fermentation of cassava starch to produce bitter starch This artisanal product is very important for Colombia, and needs input with respect to well defined parameters and possibly inocula, to enhance starch quality and reproducibility of the process Together with the Cassava Utilization Unit in a collaborative project with CIRAD/CEEMAT (France), the BRU has been working on the characterization of microbial amylolytic activities involved in the process This results, added to the studies being done at the microbiological and physicochemical levels, will provide a more accurate picture of the fermentation process, which is not a simple one, as we are dealing with a solid state fermentation and mixed microbial populations

3 Mechanisms of Plant Adaptation to the Environment

3 1 Resistance to Pests

A major constraint in bean storage is the bruchid *Acanthoscelides obtectus* or Common Bean Weevil Very few resistant accessions have been found in wild beans collected in only a small number of locations in Mexico Resistance has also been found in wild lima and tepary beans A few years ago resistance to the Mexican Bean Weevil (*Zabrotes subfasciatus*) was found in a similar way After identification of the factor involved, a protein from the lectin family named arcelin an immunoassay was developed that accelerated breeding enormously We have set for the identification of the factor involved in the resistance to the Common Bean Weevil Some promising results have been obtained with a protein fraction stemming from the resistant accessions, that leads to high mortality rates in insects feeding on artificial seeds enriched with this fraction Other approaches include the analysis of inhibitors of digestive enzymes, as well as other types of biomolecules, using separation techniques like HPLC and other analytical tools, combined with enzymology and feeding experiments

In a similar way we are looking for an antibiotic factor involved in the resistance against the spittlebug in *Brachiaria*, together with the **Pastures Entomology** group A phytoecdysteroid has been postulated as the putative resistance factor, due to the observed effects on the insect, which resemble ecdysone action on the development of the insect We are trying to develop an immunoassay for positive identification of the substance as well as for the development of a screening procedure to assist in breeding programs

3 2 Photosynthesis

Cassava is well known for its drought and heat tolerance Together with the **Cassava Physiology** group, we are interested in the adaptation mechanisms of cassava for dealing with this climatic constraints without loosing productivity Cassava has shown some photosynthetic characteristics that range between typical C3 and C4 plants Additionally to the physiological experiments being performed, we want to analyze possible compartmentalization of photosynthetic enzymes in the leaf by in situ hybridization, using labelled gene probes We have shown that a high degree of homology exists between maize and cassava photosynthetic genes by hybridization techniques (maize clones from T Nelson, Yale) We are in the process of generating a genomic cassava library from where we want to fish out the correspondent cassava clones, as heterologous probes are not useful for in situ hybridization A mechanistic explanation of the phenomenon will aid us in searching for better-performing genotypes in the cassava collection as there is variation of the physiological parameters among them

4 Institutional Building

4 1 Networking

Financiation of the Advanced Research Network for Cassava by the Dutch Government has been confirmed The budget includes the position of a coordinator, who will be placed at CIAT, the publishing of a newsletter, and bridging funds for the initiation of projects A meeting of the members of the network is scheduled for 1992 in Cartagena

Some members of the Steering Committee of the Advanced Phaseolus Beans Research Network (founded in September 1990) met at the BIC Meeting in November in Nebraska, to discuss the needs of the network A recommendation was made for CIAT to actively seek for potential donors for the network

4 2 Training

Four PhD students have been doing practical research at the BRU **Alvaro Mejía** (Bonn University, FRG, funded by the BMZ), who is working on the tepary bean introgression into common bean using congruity crosses and embryo rescue techniques, and on regeneration from embryogenic suspension cultures **Martine Korban** (McGill University, Montreal, funded by IDRC), who has been working on bean regeneration and transformation **Bill Welsh** (University of Manitoba, Winnipeg, funded by CIDA) is working on the characterization of recombinant inbred lines from crosses between Mesoamerican and Andean gene pools **Rodrigo Hoyos** (Michigan State University) spent some time working on regeneration of bean plants from embryogenic suspension cultures

It is already a tradition for biology and agronomy students from the Universidad del Valle and the Universidad Nacional de Colombia, Seccional Palmira to do their thesis research at the BRU Their one year research work usually reaches levels of MSc thesis elsewhere

The BRU has organized introductory courses to Molecular Genetics for CIAT's programs, as to acquire a common language that will facilitate exchange of ideas, and to make clear what kind of contributions the BRU could make to their specific problems On the other hand, we have been offered introductory courses to different areas of the programs, like breeding and pathology, for the same purpose

4 3 Biosafety

The BRU assumed a major responsibility in the editing of the Institutional Biosafety Guidelines These have been approved by external highly qualified reviewers, thus representing the state-of-the-art situation of biosafety regulations in the world We are already in contact with representants of the Colombian government, in order to develop national regulations in the spirit of reaching uniform regulations all across Latin America, observing the highest standards of developed countries

Special Project

FARMER PARTICIPATION IN TECHNOLOGY DESIGN AND TRANSFER PHASE II (1990-94)

'INSTITUTIONALIZING LOCAL LEADERSHIP FOR FARMER PARTICIPATION IN TECHNOLOGY DESIGN AND TRANSFER IN RURAL COMMUNITIES

Annual Report

1991

Special topic Farmers perceptions of soil conservation techniques

SECTION ONE PROJECT SUMMARY

A. Expected outcomes of the Project

The overall goal of this project is to improve the welfare of small farmers in poor rural communities by institutionalizing their active role through participatory methods in generating appropriate agricultural technology for their community

The development of local leadership for farmer participation in agricultural technology development requires the project to build skills experience and confidence among all participants in order for farmers to be recognized by the scientific community as capable partners in adaptive technology testing

Implementing participatory methods for adaptive technology testing at the community level will generate documented experience and systematic methodology which the project distills into training materials These materials are the basis for disseminating and multiplying the approach

Another outcome of this project is the implementation of a community based organizational strategy for farmer participation in adaptive technology testing, involving the creation of farmers local agricultural research committees Setting up sustainable farmer committees for adaptive research in rural committees requires the project to construct a completely new methodology for the organizational model or 'blueprint for farmers committees

This organizational model could be called a social technology which the project is developing As such the organizational model can be (and indeed already is being) adopted by other institutions Experience is suggesting that the organizational model is the indispensable or necessary condition for building a truly participatory and sustainable

community based capacity for managing technological innovation in agriculture and that this will be a very significant output of the project

CIAT expects that farmer participation will improve access to new technology for an estimated 1 600-3 200 farm families during the life of the project Improved welfare of small farmers and farm communities will result from direct food and income benefits generated by adoption of locally adapted technology

B Strategy and activities

The project s strategy is to implement farmer participation methods for adaptive technology testing with community committees of experimenting farmers and to link these committees with public sector agricultural research agencies (like CIAT) via intermediate organizations (like NGO s and farmer cooperatives)

The project strategy envisages expanding the number of communities linked into farmer participation in agricultural technology generation via community to community transfer and training, supported by NGO s Training farmer and staff of NGO s and other organizations in farmer participation methods for this purpose is part of this strategy The training anticipates development of an innovative training package to better prepare farmers for taking part in experimental research

Technology testing with farmer committees is in three main areas varietal testing soil conservation and integrated pest and disease management

The integration of community based technology testing with marketing is an important element in the project s strategy This approach is being tested first with bean varietal selection, bean seed production and marketing and commercial grain production and marketing

Formation of Farmers Local Agricultural Research Committees

The project proposed to create up to six farmers Local Agricultural Research Committees (Comités de Investigacion Agrícola Local CIAL) in each of three types of institutional setting informal groups linked with NGO s in local government structure and in local farmer associations or cooperatives

Six CIAL were initiated in member associations of a regional farmers marketing organization, CORMAC sponsored by the Coffee Growers Federation Of these two committees did not continue because there was friction in the communities over control of the committee However three other associations of CORMAC have since requested CIAL

Five CIAL were proposed in informal groups of agricultural NGO s The regional development NGO CORPOTUNIA, sponsored by the Carvajal Foundation of Cali (Colombia) set up a new program called Programa CIAL. in mid 1991 It undertook the formation of eight CIAL together with the project

In the local government setting the project has encountered complete resistance by farmers to the idea of linking their community CIAL to local government Instead farmers want to form their own associations and to sponsor a CIAL as a nucleus of this effort The project formed CIAL with five communities on this basis with an understanding with the Carvajal Foundation that the Programa CIAL might take on these CIAL if the communities so wish It appears that this is not an auspicious time to test the CIAL with local government in the pilot site and that this situation is not likely to change in the short run.

BEAN PROGRAM 1991 EXECUTIVE SUMMARY

Introduction

All the research and training activities of CIAT in collaboration with national programs have the clear goal of leading to increased sustainable productivity of beans Great progress has been made and national programs have selected and released improved varieties from CIAT that now cover some 400 000 ha, and in 1990 had a value of increased production of well over $50 000 000 Attributing just half of the benefits to CIAT investment in CIAT bean research for Latin America since the program s inception in 1974 has yielded a rate of return of 15% while in 1990 benefits were almost four times total Bean Program expenditures

Adoption studies show clear evidence that new technologies are coming out of national programs and are being utilized by farmers In Rwanda over 10 000 hectares are estimated to be sown in the ISAR released climbing bean variety Umubano The increased annual value of production due to this variety introduced by CIAT covers the annual cost of ISAR bean research plus all costs of CIAT operations in the Great Lakes region

In Brazil EMGOPA OURO distributed by EMBRAPA CNPAF and bred at CIAT has achieved such a volume of production that it is now recognized as a major market class in the Sao Paulo commodity exchange Farm level surveys confirm widespread farmer sowing of this variety Moreover other modern varieties from CIAT have been selected by EMBRAPA and are now being widely grown in Espiritu Santo and Rio de Janeiro states

Benefits will continue to increase in the future In 1991 new varieties from CIAT were distributed to farmers by national programs in Bolivia, Brazil Colombia, Ecuador Rwanda, Tanzania and Venezuela

Research Highlights

In keeping with CIAT's Board and TAC approved strategic plan, the Bean Program is intensifying its work on abiotic stresses and further exploiting the potential of new biotechnology techniques

Screening of germplasm accessions including wild and weedy types has identified a number of materials adapted to low phosphorus soils Low P tolerance has long been known to exist in the Mesoamerican gene pool but recently CIAT has discovered good materials in the evolutionarily distant Andean gene pool The mechanisms conferring low P tolerance could be distinct in the two pools and Andean germplasm has never before been used for this purpose An initial cross including both Andean and Mesoamerican parents produced the highest yielding F_3 population under P stress This suggests that there is indeed great potential in the Andean material and that there is significant promise in undertaking difficult crosses between the different gene pools

Substantial progress is also being made in the improvement of bean genotypes for biological nitrogen fixation Low fixing cultivars have been brought up to the level of good fixers through a scheme of inbred back crossing In other work, efforts are being made to improve fixation of best fixers Here the approach is relying on combining different traits associated with BNF This year it was found that early and late nodulation are both heritable traits Furthermore it was shown that early nodulation and maximum nodulation are controlled by different genes Thus it is now clear that different traits associated with BNF are heritable and genetically distinct clearly opening the way to improve BNF plateaus through combining the different traits

For the first time lines bred for water deficit/drought adaptation have been coded In two seasons these SEQ lines have outyielded tolerant checks by as much as 500-1000 kgs under water deficit stress Moreover for the first time significant narrow sense heritability (h^2) for yield under drought has been observed ranging as high as 75 Thus

the potential for making breeding progress against water deficits has been strongly confirmed

Common bean is considered a short day crop in that it completes its life cycle under a 12 hour day length Under long days many bean cultivars show an intermediate to highly sensitive reaction by delaying flower or not flowering at all Neutral lines however flower normally under long or short day lengths The inheritance of photoperiod response in beans was studied using two sets of dialled crosses tested under 12 and 16 h day lengths Neutral by intermediate and intermediate by sensitive crosses each showed a single gene mode of segregation, where the intermediate response was dominant over neutrality and the sensitive response was dominant over the intermediate Neutrality was inherited as two recessive genes one of which was apistatic over the other Crosses between neutral Mesoamerican and Andean lines showed no segregation for photoperiod response indicating that the genes controlling neutrality in the two gene pools are the same

This year the Bean Program cloned the DNA for the angular leaf spot fungus and developed a recombinant plasmid library The library was partially screened for DNA probes for the detection of RFLPs between isolates of the fungus So far 24 probes have been found identifying polymorphisms all of which indicate a clear division of isolates infecting bean cultivars in the Mesoamerican gene pool and cultivars from the Andean gene pool This finding supports the hypothesis of coevolution of beans and angular leaf spot, which could have significant implications for the deployment of resistance genes

A major break through occurred in early 1991 when foreign genes were successfully introduced into beans through genetic engineering In a collaborative project between CIAT and the University of Wisconsin, Agrocetus Inc utilized a particle accelerator to incorporate viral DNA into beans This project offers the promise of improving resistance to Bean Golden Mosaic Virus as well as illustrating the practical effectiveness of a biotechnological technique for generating transgenic plants

The important bean pathogen common bacterial blight has not been known in the past to possess distinct races or to be highly variable Last year though it was reported that CBB has sufficient variability to class into XCP xanthomonads separately from XCPF xanothomonads in bean breeding In 1991 additional work with RFLPs clearly demonstrated that there is substantial genetic variability present in the two populations of pathogens Pathogenicity tests also confirmed that the populations are not clonal The existence of this previously undetected variability in the pathogen could have implications for bean breeding and the probes developed in this project can be useful in identifying different isolates of the pathogen

Soil borne pathogens are becoming a greater constraint to bean production in the Great Lakes region of Africa Cultural practices are an essential component of any effective strategy to overcome root rots Last year it was reported that organic amendments to the soil in the form of leucaena leaves and twigs were effective in the greenhouse in reducing root rot severity and raising yields On farm trials in two seasons in Rwanda confirmed this year that in actual farmer conditions leucaena green manure significantly reduces root rot incidence and increases bean yield 40 60% Further on farm trials are now being conducted in Rwanda to find the minimum quantity of leucaena needed to be effective against root rots

In work on the bean stem maggot, the principal insect pest of beans in Africa, of 29 lines previously reported as resistant or tolerant eight were confirmed as superior and will advance for further testing Almost all of the lines demonstrating resistance so far have been introduced to Africa by CIAT In order to improve the reliability of BSM screening mass rearing procedures are being developed to permit controlled artificial pressure

Steady progress has been made in increasing overall levels of tolerance in common beans to the leafhopper Empoasca kraemeri by utilizing a breeding strategy where yield under leafhopper attack is the principal selection criterion Significant yield increases

have been obtained not only in the tolerant small seed cream and black types but also in the difficult large and small seeded red and white colored beans The tolerant lines also have high yields in the absence of insect attack

Productivity of beans in alternative agroforestry systems is being assessed in trials carried out in Tanzania Macrocontour lines or vegetative strips of grasses or legumes can be effective in soil conservation, but their competitive effects on crop yields will also be taken into account by farmers in their adoption decisions Vetiver grass local Olkokola, and Tripsacum were observed to have the least negative effect on bean yields while Sesbania and Pennisetum most decrease bean yield In a separate trial Tripascum was superior in reducing soil losses

Weed control has a high labor requirement in small scale African production systems where there are often constraints on labor availability A study was conducted in Uganda to determine the morphological characteristics of beans related to ability to compete with weeds In trials over three seasons it was found that both bean leaf size and leaf area index were significantly associated with reduced weed biomass Including these two factors as additional criteria in cultivar selection should make feasible improved ability to suppress weeds

Changes in bean production systems between 1975 and 1989 have been assessed in Colombia as a case study to shed light on farmer demand for technology Use of agrochemicals among small farmers has increased dramatically Even where small farmers use new varieties they do not rely on a single variety but spread their risks by planting a set of varieties Labor use has declined substantially over the period indicating the importance of seeking technologies to increase the productivity of labor

Farmer preference for planting a wide range of cultivars was also observed in an economic survey carried out in Uganda. Farmers were found to sow over 100 different cultivars about equally divided by small medium and large grain types Eighty five

percent of varieties are bush type and the most common colors are white/creams reds browns and black These findings suggest breeders face considerable flexibility in acceptable grain types among Ugandan farmers

Extensive studies of seed distribution channels are being undertaken in Rwanda It was found that poorer farmers are more likely to have to obtain seed from sources outside their farm A test marketing study showed that farmers were very willing to purchase small quantities of seed on an experimental basis A seed quality study found no clear advantages of seed produced by public sector official organizations compared to seed produced by farmers Efforts are being made on a pilot basis to see whether low cost farmer produced seed marketed locally in small packets can increase rates of spread of improved varieties

Regional Developments

Future planning for bean research was a major concern in the Africa Regional Program. A participatory planning workshop for the SADCC region of southern Africa was held in Malawi in March This successful workshop planned the broad strategy directions for the regional network for the next seven years Namibia joined the SADCC network this year

A major input was made to national bean planning workshops in Ethiopia, Kenya, and Uganda. Research priorities were critically evaluated and significant clarifications and changes were made

CIAT took the initiative among international centers to propose consideration of an inter IARC consortium to work on resource management issues in the well watered mid altitude region in eastern and southern Africa This region is favorable for agriculture and consequently supports a very high population density that is creating stresses that may undermine the sustainability of production in the bean banana based

cropping systems of Burundi Rwanda, Uganda and significant parts of Kenya, Tanzania and Zaire Agreement has been reached among Center Directors to explore with national programs a collaborative approach integrating soil fertility cropping systems and socioeconomics

Training and Workshops

The regional bean research workshop for the Andean Zone (RELEZA) was held at CIAT Colombia, in June organized by ICA, Colombia Over 100 researchers participated and 79 research papers were presented

The International Bean Trials Network met in Cali in October to address research challenges to improve bean production in different cropping systems Sustaining productivity in favored monoculture in favored mixed cropping and in fragile environments was assessed

A Spanish medium multidisciplinary course for bean researchers was held in Cali in February March The target group for this course is young scientists who have recently joined national bean research programs

A very active training program was pursued in Africa, including a research methods course for Kenya and an on farm methods course for the southern Africa SADCC region, held in Tanzania. A Pan Africa course in farmer participatory methods for senior on farm and bean researchers was held in Tanzania, to expose researchers to the opportunities that participatory methods offer

Continuing the training for trainers strategy in Central America, a team of experienced national program scientists has been built up in the region, and now is principally responsible for training in the region which included agronomy courses in the

Dominican Republic El Salvador Honduras and Nicaragua It only remains to devolve the organization of these courses from the CIAT Training Support Program

Training in the Andean region moved into a highly specialized mode focussing on advanced internships to meet specific national program needs

Program Developments

The Great Lakes Regional Network was reviewed by a Swiss Development Cooperation team which strongly endorsed the activities of this outstandingly successful network. The Eastern Africa Regional Bean Research Network received a highly favorable evaluation of a USAID led review team Parts of the reviews were conducted jointly by the two teams and an inter donor meeting was held in Nairobi with CIDA, SDC and USAID to harmonize support to bean research in Africa

This support was given a boost by a grant of $800 000 for the Eastern Africa network on an interim basis by USAID for an additional 15 months until September 1992 The SDC has provided a grant of $1 056 000 this year for an additional three years support to the PROFRIZA Andean regional research network IDRC made a grant of $190 000 to support a project on integrated pest management in Latin America

Staff Developments

Dr Shree P Singh was awarded a meritorious service award for recognition of a lifetime of service to bean research by the United States Bean Improvement Cooperative in 1991 Dr Singh also received this year the award for outstanding scientific publication at CIAT

Dr Vas Dev Aggarwal was named breeder and initiated CIAT's presence in Malawi in collaboration with Bunda College in the SADCC network Dr Wayne

Youngquist, also a breeder, was appointed to work in Arusha, Tanzania, also in the SADCC network. Dr. Geoffrey Msumali of Tanzania was a Regional Research Fellow at CIAT during 1991, working on biological nitrogen fixation.