SRE

Annual Review

Executive Summaries

December 1992

**For Internal Circulation
and Discussion Only**

CIAT
Centro Internacional de Agricultura Tropical

ANNUAL PROGRAM REVIEW 1992

30 November - 6 December 1992

Kellogg Auditorium

Monday, 30 November:

08:00-08:05	Introductory Remarks	*Gustavo A. Nores*
08:05-08:15	Comments on Behalf of the Program Committee	*Richard Flavell*

Bean Program

The Crop and Its Context — **Chair: R. Vera**

08:15-08:45	People, Problems and Priorities	*D. Pachico*
08:45-09:15	Networks: Evolution in Work with Partners	*R. A. Kirkby*
09:15-09:45	Insuring a User Perspective	*L. Sperling*
09:45-10:15	Discussion	
10:15-10:30	**Coffee Break**	

Strategies for Genetic Improvement I — **Chair: C. Iglesias**

10:30-11:15	Utilizing Germplasm	*S. Beebe/J. Tohme*
11:15-11:45	Genetic and Environmental Variability	*O. Voysest*
11:45-12:15	Discussion	
12:15-13:30	**Lunch**	

Monday, 30 November: (continued)

Bean Program (continued)

Strategies for Genetic Improvement II **Chair: J. Miles**

13:30-14:00	Physiology of Yield	*J. White*
14:00-14:30	Genetics and Selection in Meso-American Gene Pool	*S.P. Singh*
14:30-15:00	Genetic Improvement for Andean Gene Pool	*J. Kornegay*
15:00-15:15	**Coffee Break**	
15:15-15:45	Genetic Deployment in Africa	*H. Gridley*
15:45-16:15	Seed Systems to Reach Small Farmers	*U. Scheidegger*
16:15-17:00	Discussion	

17:00-17:30	Presentation of "A Fragile Paradise"	*T. Hargrove*
17:30-18:30	Meeting of BOT with Outposted Staff Group I (to be confirmed)	

Tuesday, 1 December:

Bean Program (continued)

Overcoming Abiotic Stresses in Less Favored Environments	**Chair:**	*R.Thomas*
08:00-08:30	Nutrient Efficiency in Poor Soils	*S. Beebe*
08:30-09:00	Adaptation to Water Deficits	*J. White*
09:00-09:30	Integrated Fertility Management in Africa	*C. Wortmann*
09:30-10:00	Discussion	
10:00-10:15	**Coffee Break**	
Intensifying and Sustaining Cropping Systems	**Chair:**	*R. Moreno*
10:15-10:45	Managing Fertility in the Savanna Ecosystem	*M. Thung*
10:45-11:15	Climbing Beans: A Case Study of Intensification	*L. Sperling*
11:15-11:45	Discussion	
11:45-13:00	**Lunch**	
Overcoming Biotic Stresses	**Chair:**	*S. Lapointe*
13:00-13:30	Pathogenic Co-evolution and Genetic Diversity	*M.A. Pastor-Corrales*
13:30-14:00	Integrated Management of Soil Pathogens	*R. Buruchara*
14:00-14:30	African Bean Stem Maggot	*J. K. Ampofo*
14:30-15:00	Integrated Pest Management	*C. Cardona*

Tuesday, 1 December: (continued)

Bean Program (continued)

15:00-15:30	Discussion		
15:30-15:45	**Coffee Break**		
The Way Ahead		**Chair:**	*R. Best*
15:45-16:15	Future Strategy		*D. Pachico*
16:15-16:45	General Disussion		
16:45-18:30	**Meeting** of PC, EC and the Program Leader (PL) of the **Bean Program** to discuss points needing **clarification**		

Wednesday, 2 December:

Institutional Development Support

Training, Communications and Information/Documentation **Chair:** *F. Kramer*

08:00-08:15	Introduction	*G. Häbich*
08:15-08:55	Information/Documentation From serving commodity programs to germplasm development and resource management research programs	*E. Goldberg*
09:00-09:40	Communications New messages, audiences, and media	*T. Hargrove*
09:45-10:00	Project Design	*R. Ruggles*
10:00-10:15	**Coffee Break**	
10:15-10:40	Discussion	
10:40-11:10	Development of National Capacities for Commodity-Specific R&D	*G. Häbich*
11:10-11:40	Development of Subregional Capacities for the Training in Commodity Production Problem-Solving	*V. Zapata*
11:40-12:00	Discussion	
12:00-13:30	**Lunch**	

Institutional Development **Chair:** *R. Best*

13:30-13:40	Introduction	*G. Häbich*
13:40-14:20	Case Presentations	
	Mexico-Tropical Pastures	*C. Lascano*
	El Salvador-Beans	*S.H. Orozco/M. Lopez*
	Venezuela-Rice	*A. Fischer*
	Brazil-Cassava	*C. Lozano*

Wednesday, 2 December: (continued)

Institutional Development Support (continued)

14:20-15:00	Analysis of Case Studies. Implications for "Devolution" and Resource Management Research	*G. Häbich*
15:00-15:15	**Coffee Break**	
15:15-16:00	General Discussion	
16:00-16:30	Meeting of PC, EC and the Associate Director, **IDS**, to discuss points needing **clarification**	
17:30-18:30	Meeting of BOT with Outposted Staff Group II (to be confirmed)	

Thursday, 3 December:

Biotechnology Research Unit

Chair: *A. Bellotti*

08:00-08:20	Introduction	*W. Roca*

Characterization of Genomes and Mechanisms for Genetic Manipulation

08:20-08:55	Molecular Markers for Genome Analysis	*J. Tohme*
08:55-09:30	Host plant-biotic interactions	*J. Mayer*
09:30-10:00	Discussion	
10:00-10:15	**Coffee Break**	

Broadening the Genetic Base and Germplasm Conservation

10:15-10:40	Genetic Transformation	*Z. Lentini*
10:40-10:55	Gene Pool Development	*W. Roca*
10:55-11:10	Cryopreservation	*W. Roca*
11:10-11:40	Discussion	
11:40-11:55	The Way Ahead	*W. Roca*
11:55-12:15	General Discussion	
12:15-13:30	**Lunch**	

Thursday, 3 December: (continued)

Virology Research Unit

Chair: *S. Kelemu*

13:30-13:40	Introduction	*F. Morales*

Germplasm Development Aspects of Plant Virus Research

13:40 - 14:00	Genetic Control of Bean Viruses in Traditional and Changing Agricultural Environments.	*F. Morales*
14:00 - 14:20	The Potential Importance of Plant Viruses in the Establishment of Native and Exotic Tropical Forage Legumes.	*F. Morales*
14:20 - 14:35	Discussion	
14:35 - 14:50	**Coffee Break**	
14:50 - 15:10	Novel Approaches to the Characterization and Genetic Control of Rice Hoja Blanca Virus.	*L. Calvert*
15:10 - 15:30	Solving the Riddle of Cassava Virus Complexes in Tropical Latin America.	*L. Calvert*
15:30 - 15:45	Discussion	

Germplasm Conservation Aspects of Plant Virus Research

15:45 - 16:00	The Role of Plant Virology in the Collection, Evaluation, Preservation, and Utilization of Genetic Resources.	*F. Morales*
16:00 - 16:10	Future Research Plans	*F. Morales*
16:10 - 16:30	General Discussion	
16:30 - 17:20	**Meeting** of the PC, EC and the Unit Head of the **BRU** to discuss points needing **clarification** (Board Room)	
17:20 - 18:25	**Meeting** of the PC, EC and the Unit Head of the **VRU** to discuss points needing **clarification** (Board Room)	

Friday, 4 December:

Intellectual Property Rights

Chair: M. Iwanaga

08:00-08:40 Presentation *G. Häbich*

08:40-09:30 Discussion

ORPA Presentation

10:00-10:15 Presentation of the 1992 Outstanding Research Publication Award (ORPA)
G.A.Nores/R.Flavell/L.Vaccaro

Closing Remarks

10:15-10:30 APR Closing Remarks by BOT-PC Chairman *R. Flavell*

10:30-10:45 **Coffee Break**

10:45-12:15 **Meetings** of the PC and EC **with principal scientists** of BRU, VRU and IDS (in separate meetings) (Board Room)

12:15-14:00 **Lunch**

14:00-15:00 **Meetings** of the PC and EC **with principal scientists** of the Bean Program (Board Room)

(Note: Afternoon free for all Senior Staff not involved in discussions)

Saturday, 5 December:

08:00-12:00	**Meeting** of the PC, EC with PLs, AD, DDGs, and the DG **to discuss the overall outcome** of the review process
12:00-14:00	**Lunch**
14:00-16:30	***Meeting*** of the PC **to finalize the PC report** together with the ECs
21:00	Staff Christmas Party at Dr. and Mrs. G.A. Nores' residence

Sunday, 6 December:

Departure from Cali of Board members and ECs

(Doc.APR92.PRO)
Updated: 27 November 1992

Draft

Institutional Development Support

Executive Summary and Introduction

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

December, 1992

CONTENTS

EXECUTIVE SUMMARY

1. Institutional relations and development (**IRD**) refer to (1) CIAT's linkages with donors and partners, with science and technology, and with the Center's broader institutional environment; and (2) CIAT's developing and strengthening organizational assemblages for agricultural and resource management and development.

2. IRD is a center-wide function. However, there are specific areas at CIAT, such as communications, documentation, training, etc., which give specialized support to IRD.

3. Initially, this specialized support was scattered in various sectors and units. A first grouping, in 1987, merged the former Communications and Information Support Unit with Training and Conferences into a TRAINING AND COMMUNICATIONS SUPPORT PROGRAM (TCSP). In early 1992 the TCSP evolved into the short-lived INSTITUTIONAL DEVELOPMENT SUPPORT PROGRAM. From this emerged **INSTITUTIONAL RELATIONS AND DEVELOPMENT SUPPORT (IRDS).**

4. IRDS is a grouping which (1) focuses the support given to CIAT's linkages with its stakeholders, shareholders, and partners to attune it to CIAT's overall strategies for fulfilling the Center's mission; and (2) deals with the development and strengthening of organizational assemblages for agricultural and resource management research and development.

5. Operationally, IRDS comprises: (1) an Information and Documentation Unit; (2) a Communications Unit; (3) a Project Development Office; (4) an Institutional Relations Area; and (5) a Professional Development Area.

6. The full Review-Report includes an introduction; six self-contained documents (Nos. 2-7) on IRDS operational units or parts thereof; one document (No. 8) on CIAT's experience with the development of organizational assemblages for research and development (**R&D**); and a brief look into the future. The executive summary will follow the same sequence.

7. **The Information and Documentation Unit** helps CIAT's scientists access world scientific literature, both at CIAT and elsewhere. Since 1989, the Unit has progressively modernized its services. State-of-the-art technology has been incorporated to maximize effectiveness and efficiency in serving users.

8. A shift toward automation was implemented systematically throughout the Information Unit. Bibliographic databases on CD-rom were acquired. End-user work stations for direct access to internal and external databases were installed. Card catalogs were automated with the aid of a standard software (Micro CDS/ISIS) for

indexing and cataloging. Newly incorporated desk-top publishing technology facilitates production of bibliographies and other publications. The number of microcomputers was increased to reap the benefit of technologies such as electronic text scanning, machine translation, and electronic reference books and working tools for technical processing and delivery of user services.

9. Networking for sharing resources (locally, regionally, and internationally) complemented automation. Participation in FAO's cooperative database, AGRIS, increased. Connection to telecommunications networks such as CGNET and BITNET improved linkages with research institutions and information banks worldwide.

10. New, user-oriented, publication series such as National Bibliographies and Quick Bibliographies were launched, while established series (e.g., *Bibliographic Bulletin*) were modernized.

11. Outreach activities included training NARDS members in organizing, managing and accessing scientific information; exhibits at congresses and meetings; and orientation of hundreds of visitors seeking technical advice on information management.

12. Modernization, new and improved services, and outreach activities are probably causally related to a dramatic increase in the public and technical services workload. For example, bibliographic database searches increased elevenfold, from 272 in 1987 to 3194 in 1991.

13. About half of the services rendered by the Information and Documentation Unit were for CIAT staff. The rest were for external users, mainly agricultural researchers, especially from Colombia and Latin America. Users from Africa and Asia were a small minority.

14. Relevance, effectiveness, and efficiency of information services have been evaluated: relevance and user satisfaction rated highly. Process improvement for greater efficiency has been ongoing. Stretching the productivity of human resources to the limit, services output increased substantially even as personnel was reduced by more than 20%.

15. CIAT's document collections and databases on cassava and beans were compared with the world's three largest bibliographic databases, AGRIS, AGRICOLA, and CABI. To a large extent, CIAT's collections complement the other three; and, for Latin American researchers, they are more accessible.

16. The Information and Documentation Unit is facing difficult challenges. The demand for services has grown exponentially; personnel has been reduced substantially; purchasing power of static core funds is eroded by increases in costs of scientific literature, which are more than ten points above average U.S. inflation; and a newly

established Resource Management Research Division has information needs that differ qualitatively from those of CIAT's established Programs and Units.

17. Approximately half the services of the Information and Documentation Unit are rendered to NARDS. To cease attending this clientele, although saving resources, would be undesirable because NARDS can ill afford replacing the services from elsewhere.

18. To cut costs, generate income, and provide alternative services, some options under consideration or in early implementation are more focused alert services; increased use of external databases; the inclusion of information services among the costs of special projects; special projects on information and documentation; bringing in new partners to share the workload; further automation; and cutting back on dispensable services.

19. In 1992, the former Publications Unit and Public Information, together with Graphic Arts, were joined, under a newly recruited head, becoming CIAT's **Communications Unit**. This eliminated inefficiencies rooted in excessive compartmentalization.

20. From 1987 to 1991, 104 scientific publication were produced and 25,000 copies distributed, mostly to NARS in Latin America.

21. Graphic Arts almost quadrupled production of camera-ready pages from 1988 to 1991 with the introduction of computerized desk-top publishing technology. In-house printing reached five million pages per year in 1990 and 1991. About 90% were technical materials.

22. CIAT, like most CGIAR centers, previously maintained a low profile in public awareness and did not seek media coverage. This attitude changed as competition intensified for scarce funds. CIAT's Communications Unit is making public awareness a major activity.

23. Twenty-six press releases were written, and 30,000 copies distributed from January through October 1992. Results are beginning to show. In 1992, CIAT appeared in the press at least 55 times in Colombia, and a dozen times internationally. The prestigious German paper *Frankfurter Allgemeine Zeitung*, in its 21 October 1992 edition, published a major feature on CIAT's work on erosion control in cassava production on Andean hillsides. It was adapted from a CIAT press release. CIAT was also featured in the London Financial Times.

24. CIAT is the focus of two international TV programs filmed in 1992. *Fruits of the Earth* is an educational series on the world's major food crops, produced by a Swiss company for a German TV network. It is broadcast worldwide in six languages. A

Fruits of the Earth crew spent 10 days at CIAT and across Colombia in November, filming a special feature on beans. *The New Explorers* program popularizes science, especially for young people. It goes on U.S.Public Broadcasting Network, and then to high schools and colleges across the USA and Canada where it is used as a classroom resource. An *Explorers* crew will film CIAT cassava research in December 1992. In Colombia, CIAT was featured on about 10 television programs broadcast across the country in 1992.

25. In 1992 CIAT produced its first video for public awareness. *A Fragile Paradise: The environmental challenge of Latin America* focuses on environmental problems in the region, and strategies of CIAT and cooperating national programs to increase food production in an environmentally sustainable way. Shot in Costa Rica, Haiti, Brazil, and across Colombia, the film includes dramatic sequences on deforestation in the Amazon.

26. *A Fragile Paradise* will be made available for television broadcast in developing nations at no cost. Permission has been granted to Pacific Mountain Network (PMN), based in Colorado, USA, to use the film in their "classroom channel" for 10,000 public schools. PMN also formally expressed interest in showing the film through its network of 207 broadcasting stations. With its affiliate networks, PMN's potential audience is 93 million households in USA and Canada. A Spanish edition is being made available to TV networks across Latin America.

27. A **Project Design Office (PDO)** was established in 1992 to improve the quality of proposals submitted to donors, and to increase CIAT's knowledge of donor programs and priorities. It assists program staff to design projects and prepare proposals.

28. The PDO's main activities are to coordinate the project proposal preparation process; train CIAT staff in project design and proposal writing; liaise with and collect information on donors. About 30 proposals, meeting high standards of technical quality and effective communication, are to be produced yearly. Standard procedures and methods for project development have already been established. From March to November 1992, 12 proposals with requested funds totalling US$18 million have been submitted to donors; six were approved, one was rejected, and five are still under donor review.

29. **Conferences** are an important mechanism for face-to-face communication among people. IRD support to CIAT conferences includes planning, logistics, and assistance in facilitating participant interaction. From 1987 through 1991, 2850 participants took part in 73 CIAT conferences on strategic and operational planning; networking; exchange of scientific information, and discussion of research issues; linkages with farmers; and miscellaneous matters.

30. The Center's conference facilities are also the venue of many in-house meetings, and meetings of external users. Events on record in 1991 numbered 1234 with a total of 5779 room-hours use. Use in 1992 dropped to 968 events and 4823 room-hours because of reduced training activities and fewer meetings among CIAT staff.

31. CIAT's **Visitors Office** programs meetings for visitors with CIAT staff; provides guided tours of CIAT; furnishes general information on the Center; arranges transport and excursions; and provides linkages with housing, banking and travel. During October 1989-September 1992, 10,082 persons visited CIAT. Seventy-eight were from donor agencies or related to the donor community; 1021 were from partner institutions or related to them (705 from Colombia; 316 from other countries); and 8983 were from other communities related to CIAT's interests (8516 from Colombia; 467 from other countries).

32. **Training** NARDS researchers and technology intermediaries is a major CIAT input to institutional development. From being supply driven, CIAT training shifted gradually to being demand led. Consequently, individual trainees were increasingly selected as part of targeted institutional development efforts where the focus was on enhancing research teams or more complex entities such as integrated interinstitutional R&D programs.

33. Training at CIAT comprised (1) introductory commodity research and production courses; (2) individualized on-the-job training; (3) specialized courses; (4) combinations thereof; and (5) research programs leading to M.Sc. or Ph.D. theses.

34. Introductory R&D courses and their combination with individualized training were for entry-level researchers, and technology transfer specialists who would interact with researchers. Individualized training, specialized courses, and higher degree training usually were for more advanced researchers. However, some development workers received individualized training, and some entry-level researchers proceeded straight to higher degree training.

35. CIAT organized, or collaborated in, short in-country courses (of one to two weeks' duration) which addressed the use of new technologies.

36. The total number of NARDS members trained at CIAT from 1987 through 1991 was 1067. Most were from Latin America and the Caribbean (91.2%). However, for training in beans and cassava, about one in every five trainees came from outside the region. Another 2515 persons (mostly university graduates) participated in 131 in-country training events held in Latin America and the Caribbean with CIAT participation.

37. An account of the impact of this training on institutional development is presented, country by country for each of CIAT's commodity research programs, for seeds, and biotechnology, in Document No. 6 *Training for Tropical Agricultural Research and Development*.

38. Routine evaluation during training showed that CIAT's training standards are high. However, effects on trainees' job performance and career development need to be assessed over the long term. In a 1992 survey of 1987-91 alumni, ex-trainees acknowledged that training at CIAT had substantially increased their (1) overall job performance; (2) capacity to relate their work to farmers' needs; (3) capacity to innovate in their jobs; and (4) capacity to train their support staff. Also acknowledged was less intense, but positive impact on alumni's leadership capacity; the performance of their teams; and the teams' capacity to relate their work to farmers' needs.

39. Training at CIAT gives young agricultural scientists from industrialized countries the opportunity to obtain first-hand experience in international agricultural research. Thirty-seven such candidates came to CIAT between 1987 and 1991.

40. Between 1987 and 1991, 64 scientists completed higher degree research programs at CIAT. About two-thirds were from developing countries, the rest from industrialized countries. Of those from developing countries, two-thirds followed M.Sc. programs; whereas, four-fifths of those from industrialized countries followed Ph.D. programs.

41. In Colombia, a research thesis is a requisite for obtaining a first degree in agriculture. CIAT offers Colombian students the opportunity of doing their thesis research at the Center, under joint supervision of a University and CIAT scientist. In 1987-1991, 189 such research projects were completed.

42. Gender distribution among CIAT trainees from NARDS varied among research disciplines. The percentage of women was 50% in biotechnology; 39.6% in social sciences, biometrics, and information and documentation; 33.9% in mainly laboratory-oriented disciplines; 10.1% in seed-related activities; 9.0% in disciplines where field work predominates; and 7.1% in nonspecialized commodity research and production courses. Among Colombian undergraduate research students and postgraduate trainees from industrialized countries the gender ratio was close to 1:1 (48.7% and 51.4% women, respectively).

43. CIAT's in-country training aimed at extensionists and other technology intermediaries. However, the Center's comparative advantage is training researchers and, furthermore, the number of extensionists who need training exceeds CIAT's capacity to meet such needs. CIAT has therefore developed a strategy of developing national and, especially, **subregional training capacities**, so that they may assume responsibility for training extensionists.

44. The end-product of developing training capacities has three components: (1) a legitimized training body; (2) a cadre of trainers with subject-matter expertise and command of adult education methodology; and (3) appropriate training materials.

45. Legitimization has been provided either by an international network such as the Central American Bean Research Network PROFRIJOL, or by a national interinstitutional mechanism such as the National Consultative Rice Council in Venezuela.

46. The process of training trainers is as follows: first, subject-matter specialists with an inclination and, preferably, talent for training are identified from an interinstitutional and international pool of human resources. These specialists are then helped to acquire a command of communication skills and adult education (andragogy) techniques. As an integral part of their andragogic training, the future trainers prepare their own training materials, which respond to the priorities identified by their mother institutions.

47. The trainers continue being active in research and/or extension. Thus, they maintain first-hand experience of what they help others to learn, while continuing to be a research and/or extension resource. By having first-hand experience, they overcome a major drawback of Latin American superior agricultural education: the teaching of subjects in which the teachers lack experience.

48. Small countries can hardly have fully fledged extension training facilities of their own, with trainers having first-hand and high-quality experience of the training contents. In contrast, regional bodies have this capacity and can allow small countries access.

49. Training materials, prepared as part of the trainers' training, respond to individual countries' extension priorities shared--by consensus--across countries.

50. The training materials are called *learning units*, in congruence with the basic philosophy of helping others to learn rather than teaching them. Each unit contains a sequential text, guidelines for practical exercises, instructions for evaluating the learning process, and visual aids (slides and overhead projection transparencies). All parts are bound in loose-leaf binders for easy updating and introduction of location-specific adjustments.

51. A *mother* learning unit deals with the principles of adult education, assessment of learning needs, facilitating learning, including how to establish learning sequences and design and produce learning units.

52. Three subregional training teams have been established. The oldest, on beans for Central America and the Caribbean, has already delivered nine courses and has obtained external funds for a project to train 1000 extensionists over a five-year

period. The second one, on rice in the northern Andean region is up and running. And the third one, on cassava in the South American subtropics, is in the final stages of development.

53. CIAT has taken on a wide range of **institutional development targets**: disciplinary research teams; multidisciplinary commodity research teams; commodity research networks; integrated commodity research and development systems; farmer-centered participatory research; commodity-specific training bodies; and advanced research networks.

54. CIAT applies a wide range of activities to institutional development: training; advising and counselling; joint research; information and communications support; supply of germplasm; research and development promotion; inter-institutional convening; role modelling; and even the management of new institutional models (e.g., networks). For any particular case of institutional development, the specific circumstances define which activity is brought into play, and the relative intensity among activities.

55. Document No. 9, *A retrospective and prospective view of CIAT's activities in institutional development for tropical agricultural research and development* attempts to take stock of CIAT's institutional development experience. After taking an inventory of the types of institutional development in which CIAT has engaged, it deals with **farmer-linked research and development** (FL-R&D).

56. A distinction is made between two situations:

(a) Peasant farmers; small production units; often low-value products; difficult access to credit and purchased inputs; poor links with markets; lack of organization into common interest groups.

(b) Commercial farmers; larger size production units; products of varying value, often decreasing; may have access to credit and purchased inputs, but input costs often rising; links with markets; often members of well-organized common-interest groups, such as growers' associations.

They are referred to as **peasant farming** and **commercial farming**. The former is typical of bean and cassava production; the latter of rice production (especially under irrigation) and certain livestock production systems.

57. In peasant farming, two R&D approaches converge on farmers: on-farm research (OFR) and farmer participatory research (FPR).

58. In OFR, researchers, extensionists, and social scientists interact with farmers to diagnose and prioritize constraints to the farmers business. Available solutions--usually technological-- are tested on - farm (with variable farmer participation). If solutions are lacking, feedback is given to off-farm research for their development. The approach is technology driven, relying on off-farm research, and is usually commodity specific. Technological solutions are frequently components for existing production systems; they are often seed-embodied technologies, complemented with management techniques. Farmers involved in OFR benefit from quick solutions to specific (usually biophysical) production problems.

59. FPR aims at improving farmers' lot through enabling them to improve their socioeconomic situation. It is socially rather then technologically driven. It brings together farmers and off-farm researchers to jointly design technological solutions to farmer-felt needs. It also links other players, who may help farmers in dimensions other *than* technological, and link them with their institutional environment, including markets. It initiates an open-ended *process* of farmers' social development.

60. Integrating insights from OFR and FPR, some conclusions for **peasant-farmers-linked R&D (PFL-R&D)** emerge.

(a) Technology generation for peasants is best done with farmers on-farm, thus including their rationale of optimizing resource utilization, which cannot be adequately simulated in on-station research.

(b) Small teams (2-4 persons) of well-trained and motivated researchers have been found to be effective for OFR and FPR.

(c) OFR-FPR teams should be linked to off-farm research, to articulate farmers' demand for technology when it exceeds OFR-FPR's capacity to innovate; and to remain cognizant of opportunities for innovation that may be outside farmers' and FPR's horizons.

(d) Peasants need to be linked to a market, to prime a cycle of technology demand and utilization, which should lead to a sustained process of social development.

(e) PFL-R&D does not arise spontaneously, nor is it self-organizing. Promotion and coordination are necessary to initiate and maintain PFL-R&D modules. Strong proactive coordination is evident in successful cases, whereas lack of suitable promoters doomed others. Responsibility for promoting and coordinating is expected to shift over time as farmers become self-reliant.

(f) Some emerging issues are how to ensure successful leadership succession; how to replicate PFL-R&D modules in large numbers; how much linkage to off-farm research do new modules need; and how should off-farm research deal with growing demands from increasing numbers of PFL-R&D modules.

61. **Commercial-farmers-linked R&D (CFL-R&D)** clearly differs from PFL-R&D:

(a) On-station research and on-farm technology validation have been effective and efficient in solving relevant production problems. For this to occur, farmers' needs must be clearly formulated and properly addressed by research.

(b) On-station research and on-farm validation of technology can be effectively performed by small research teams, whereas technology dissemination needs a large number of technology intermediaries. Seed-embodied technologies can spread without such manpower, but integrated crop management, combining seed-embodied and management techniques, needs actively advising farmers to spread.

(c) Linkages among farmers, research, technology validation, and dissemination need close coordination. Successful cases usually have an interinstitutional mechanism with a strong representation of farmers' organizations. Such mechanisms have brought together public sector research, universities, and public and private sector extension.

(d) Teams for training extensionists have been institutionalized by interinstitutional CFL-R&D coordinating bodies. Thus the need for training large numbers of field advisors is being met.

(e) Noticeable examples of CFL-R&D are the collaboration on rice between ICA, FEDEARROZ, the University of Tolima, and CIAT in Colombia; and the National Consultative Rice Council in Venezuela, which brought together public, private, and nonprofit organizations to implement a National Rice R&D Plan. The integration of public and private institutions and nonprofit organizations, and the strong participation of end-users clearly distinguish this model from the traditional model of public sector research and extension.

62. Some of CIAT's experience in developing integrated institutional assemblages for commodity-specific R&D is illustrated with six case histories in Document No. 9, *A retrospective and prospective view of CIAT's activities in institutional development for tropical agricultural research and development*.

63. An appraisal across the six cases assessed the extent to which most common shortcomings of agricultural research in developing countries had been overcome. For each case, the appraisal looked at whether (1) it was orientated toward end-users; (2) planning, monitoring, and evaluating mechanisms had been established; (3) research and development were balanced; (4) interinstitutional integration existed; and (5) the new institutional assemblages were likely to be sustainable. Considerable variation in these different aspects is part of the richness of CIAT's experience.

64. CIAT's experience in institutional development is enormous, involving many types of institutional assemblages, many types of interventions, the R&D of very different commodities, and manifold countries and institutions. CIAT can build on this strong foundation as it faces new and evermore challenging needs of institutional development for resource management research and development.

65. In-depth case studies of CIAT's institutional development experience would undoubtedly broaden and deepen present insights, as well as surfacing highly useful operational aspects. This might be the subject for a special project. The output, in the form of easily accessible information, would be widely distributed among potential users, particularly for those involved in the so-called "devolution" of CIAT's activities to other institutional players.

66. IRDS moves confidently into the future. The course for action is set by CIAT's Strategic and Operational Plans. Human resources are able and committed. Emerging technologies are expected to greatly enhance information management and communications. Participatory methods facilitate face-to-face communication and the synergistic collaboration among people and institutions. To stay effective and efficient, IRDS is determined to stay at the forefront of information and communications technology, and the latest developments in interpersonal communication.

67. CIAT must work with new partners, some of whom will differ from those met before. The new set of institutional players will come together in interinstitutional arrangements, some of which will be without precedent. All the partners' contributions will be vital for the overall outcome. Failure by any partner may jeopardize the common enterprise. Inevitably, some partners will be weak, whereas harmonious and effective collaboration with others will be difficult to achieve. IRDS is aware of the entailed risks, and is ready to tackle difficulties with prudence and determination.

68. Finally, IRDS is not without concerns. With the advent of resource management research, new users expect new activities and outputs. At the same time, many former activities will continue for germplasm development research. Despite increasing demands, no growth of IRDS' core budget is foreseen.

69. Creative innovations are already being presented and implemented to adjust to this difficult situation. Labor-saving technology has been incorporated wherever possible, and more will be brought in whenever possible. But hardware and software acquisition needs capital; and there are limits to substituting hardware for people. When these limits are reached, probably soon, resources commensurate with the task at hand will still be needed. With due respect, IRDS would like to share this concern with CIAT's governance and management.

INTRODUCTION

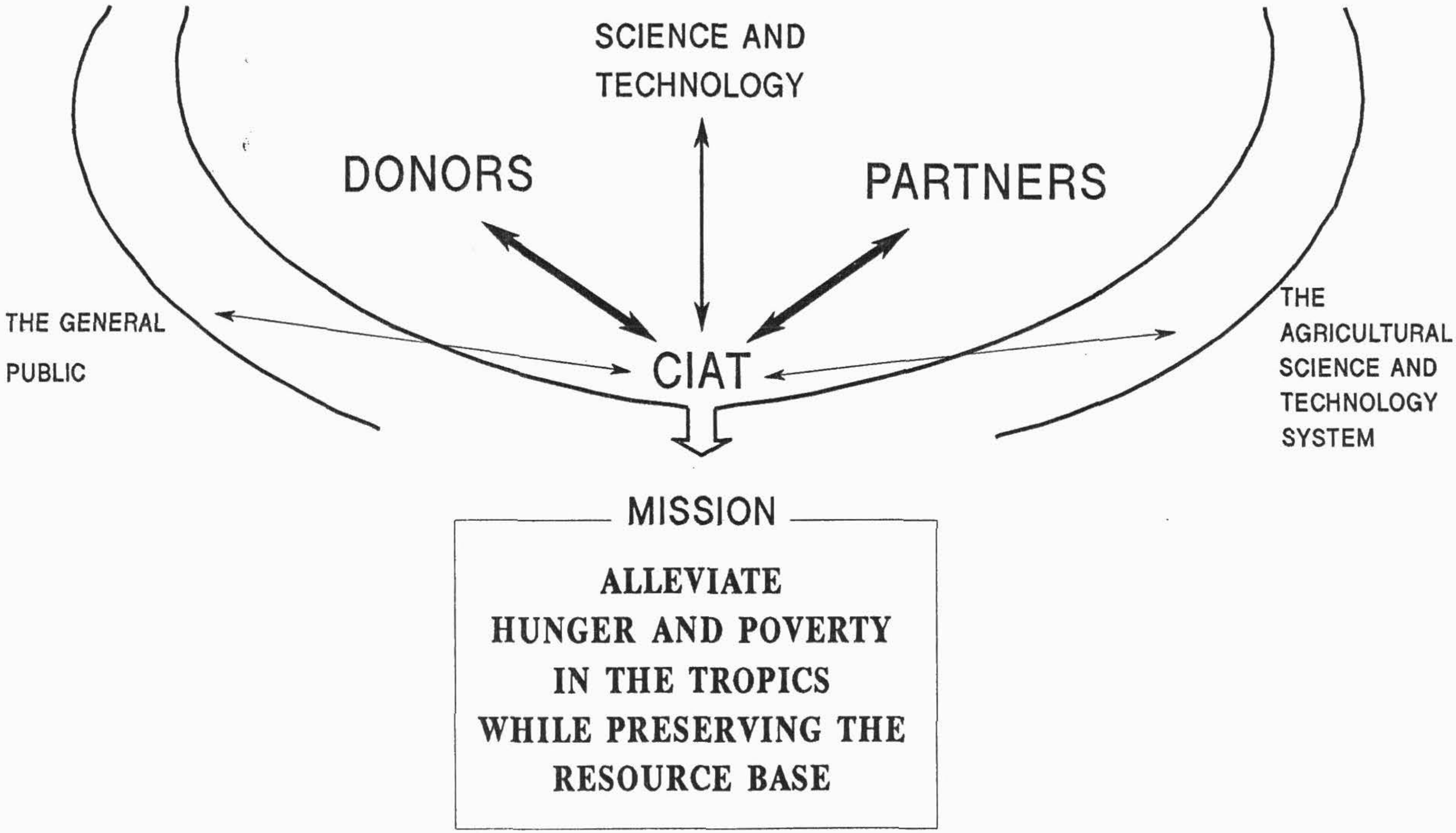
Institutional relations and development is about (1) CIAT's linkage to its donors and partners, to science and technology, and to the Center's broader institutional environment (Figure 1); and (2) strengthening agricultural research and development systems or components thereof.

Institutional relations and development is a center-wide function. All managers and scientists participate in it. They link-up to varying degrees with partners, donors, science and technology, etc.; and they contribute to the development and enhancement of agricultural R&D.

However, there are specific areas at CIAT, such as communications, documentation, training, etc., which give specialized support to institutional relations and development. Initially they were scattered in various sectors and units. In 1987, a first grouping merged the former Communications and Information Support Unit with Training and Conferences into a TRAINING AND COMMUNICATIONS SUPPORT PROGRAM (TCSP). In early 1992 the TCSP evolved into the short-lived INSTITUTIONAL DEVELOPMENT SUPPORT PROGRAM. From this, finally, emerged INSTITUTIONAL RELATIONS AND DEVELOPMENT SUPPORT (**IRDS**), a grouping which (1) focuses the diverse linkage support components and activities to attune them with CIAT's overall strategies in fulfillment of the Center's mission; and (2) deals with organizational assemblages for agricultural and resource management research and development.

This prologue will introduce IRDS' various specialized linkage support services, and the support to institutional development. It will also present IRDS' organizational arrangement and personnel.

FIGURE 1. CIAT'S MAIN LINKAGES



LINKAGES

SCIENCE AND TECHNOLOGY

Science and technology worldwide is the repository of scientific knowledge and methodological know-how. Researchers permanently draw on this resource and, symmetrically, they contribute to it with the results of their endeavors (Figure 2). The IRDS' Information and Documentation Unit helps CIAT scientists to tap the world's scientific information resources. The Communications Unit supports the Center's scientists in communicating their research output to the world. Documents No. 2 and No. 3 respectively report on the Information and Communications Units.

DONORS

CIAT's links with donors have to do with (1) propitiating a favorable attitude towards the Center; (2) securing funds; and (3) accounting for the Center's use of resources, and for its achievements and impact (Figure 3). The IRDS' support to fostering CIAT-donors links is embodied in the Communications Unit (propitiating and accounting), and in the Project Development Office (fund raising). Documents No. 3 and No. 4, respectively, report on the Communications Unit and the Project Development Office.

PARTNERS

CIAT's partnership with other institutions refers to jointly pursuing CIAT's mission. There are three main types of relations between CIAT and its partners (Figure 3). (1) Collaboration in joint endeavors. (2) Mutual complementarity, where the outputs of CIAT's activities serve as inputs to partner institutions or viceversa. (3) Enabling, by which CIAT contributes to improving the performance of partner institutions.

A wide range of IRD activities supports CIAT-partner linkage:

* The Communications Unit attends communication through media (Document No. 3), while both the Conferences and Visitors offices facilitate face to face communication (Document No. 5).

* The office of the Associate Director provides information and advice on interinstitutional mechanisms.

* Improved performance of partner institutions is enabled through training (Documents No. 6 and No. 7), provision of information (Document No. 2), and support on interinstitutional mechanisms.

FIGURE 2. CIAT'S LINKAGES TO SCIENCE AND TECHNOLOGY

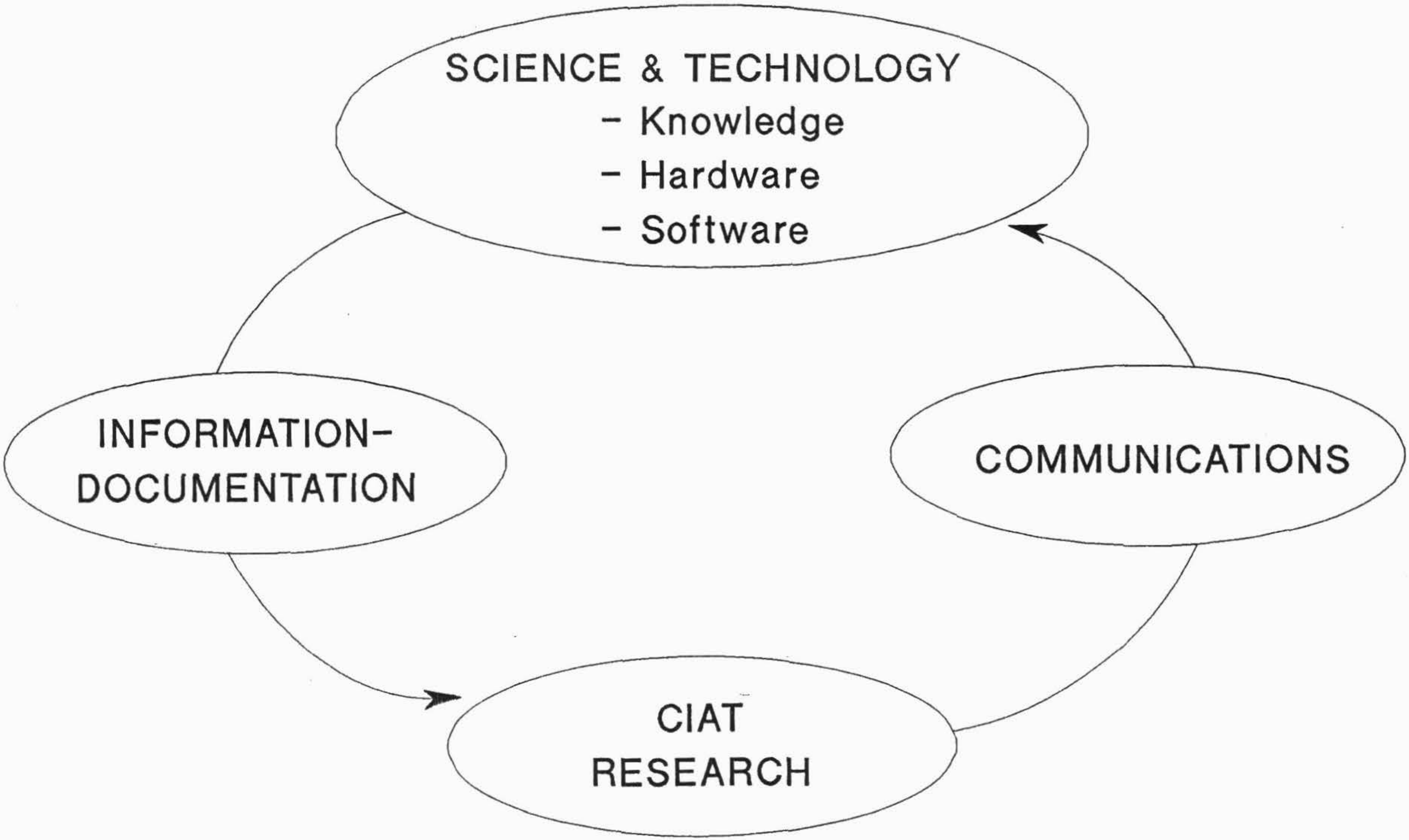
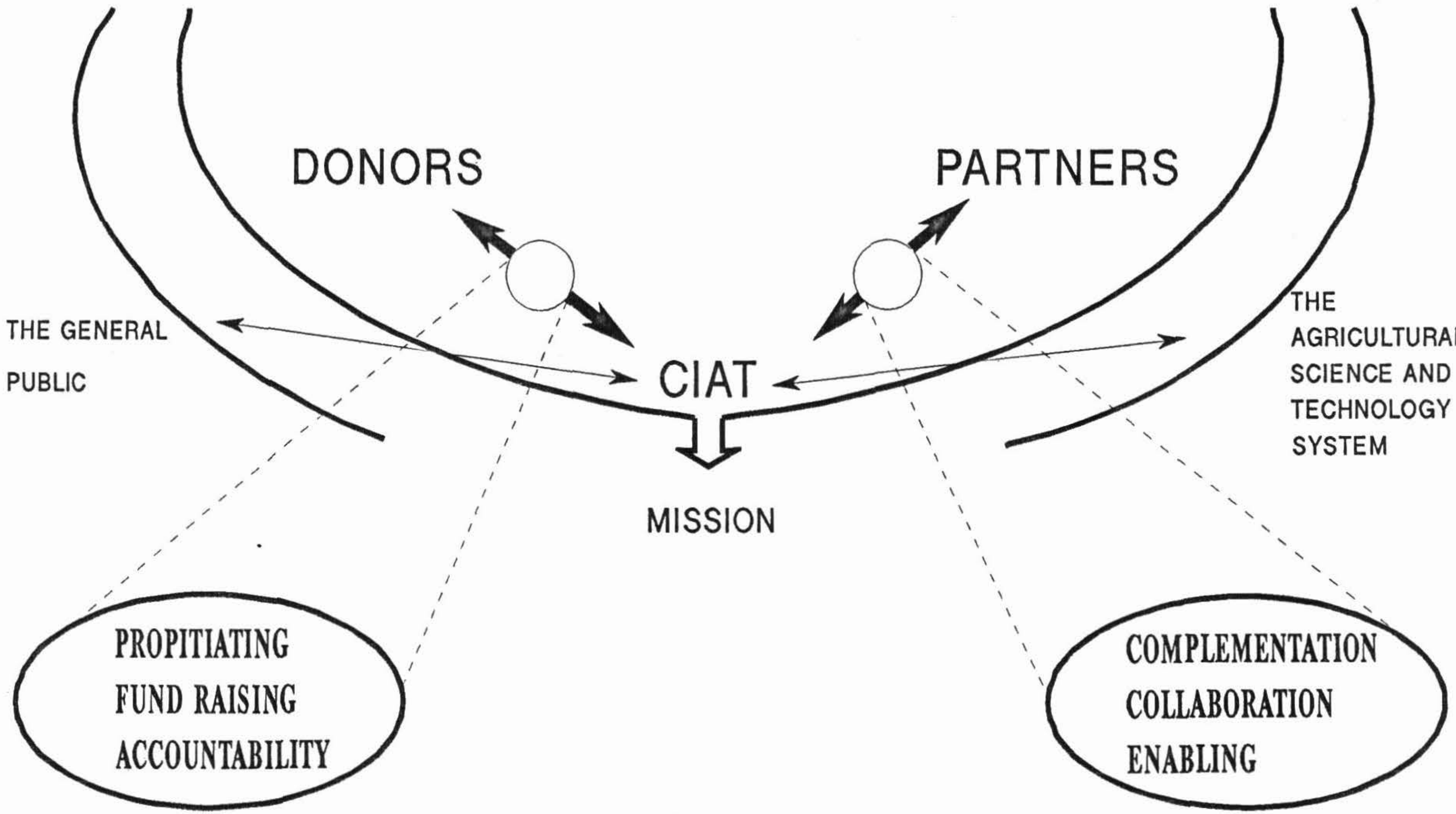


FIGURE 3. CIATS FUNCTIONAL LINKAGES WITH DONORS AND PARTNERS.



THE AGRICULTURAL SCIENCE AND TECHNOLOGY SYSTEM

Linkage to the agricultural science and technology system beyond CIAT's partners and donors (Figure 4) is maintained through media produced by CIAT's Communications Unit. These media foster the awareness of agriculturalists on technical progress, trends, and opportunities related to CIAT's mandated sphere of influence.

THE GENERAL PUBLIC

Awareness of the general public on CIAT's mission, goals, activities, achievements, and impact is promoted by media from the Communications Unit.

THE COLOMBIAN COMMUNITY

CIAT's linkage with the Colombian community (local, departmental, national) is a special case. Three elements are key to this linkage: CIAT's recognition of Colombia's hospitality; a symbiotic and synergistic relation between CIAT and host-country institutions; and a need to maintain Colombia well informed on CIAT and its meaning for the host-country.

The IRDS' contributions to the tightness of CIAT-Colombian links include:

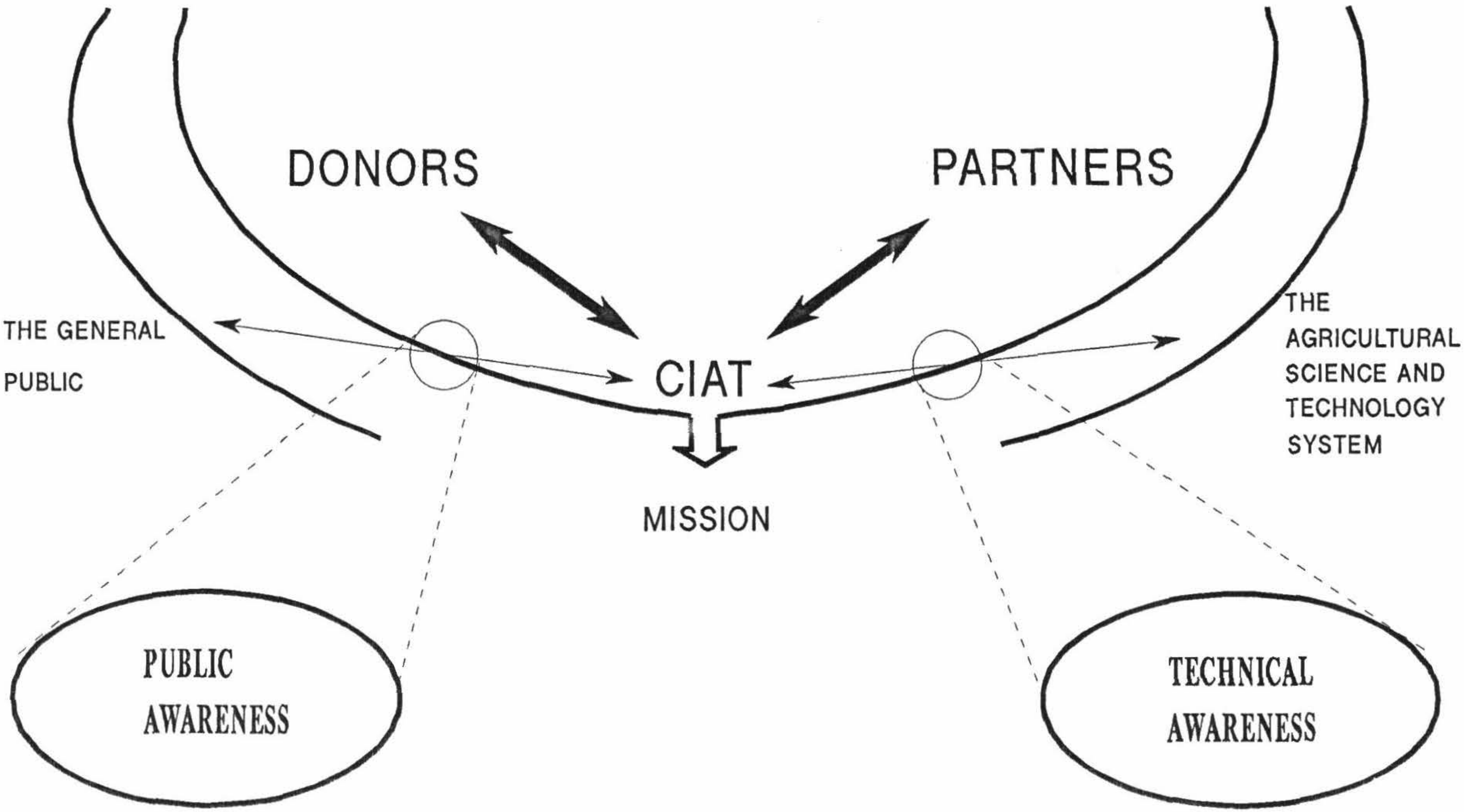
* communication through media (Document No. 3);

* visits to CIAT (Document No. 5);

* preferential service to the Colombian agricultural sector in training (training of university students close to graduation; advantages in the proportion of Colombians in CIAT's research training [Document No. 6]); and

* wide sharing of CIAT's information-documentation resources (Document No. 2).

FIGURE 4. CIATS FUNCTIONAL LINKAGES WITH STAKEHOLDER AND THE GENERAL PUBLIC.



INSTITUTIONAL DEVELOPMENT

CIAT has for many years provided training, communications, and information support to the development of commodity-specific national research programs and international research networks. However, when the former Training and Communications Support Program was transformed into an Institutional Development Program, and shortly after into INSTITUTIONAL RELATIONS AND DEVELOPMENT SUPPORT, additional support functions were recognized and legitimized: (1) the synthesis of CIAT's experience in the development of real institutional models; (2) the transfer to NARDS of such integrated knowledge on institutional models; and (3) support to CIAT's assembling real institutional models.

Document No. 9 is a first attempt at synthesizing part of CIAT's institutional development experience, and at envisaging the application of such experience to the Center's new interinstitutional research paradigm.

AN INFORMATION SYSTEM

Coordinating, planning, monitoring, accounting for, and evaluating (1) the manifold linkage activities targeted at the large variety of CIAT's stakeholders and audiences, and (2) the Center's involvement in institutional development, would be extremely difficult, if not impossible, without an effective information system. Modern technology makes such a system feasible. IRDS is well underway in setting up such a system which is unique in its kind (Document No. 8).

COVERAGE OF REPORTS

The period covered by the different documents varies. The long established units and areas, such as Information and Documentation, Communications, Conferences, and Training report back until 1987. Other IRDS components, which are either newer or have been incorporated more recently, start their reports at later dates. Case-histories reported in Document No. 9 go back beyond 1987. Finally, Documents No. 6, on Training, and No. 5, on Conferences, report through 1991 rather than 1992, because the last year was one of transition towards new ways of operating, as well as one of exceptional and temporary reductions in activities due to CIAT's shortage of funds.

ORGANIZATIONAL ARRANGEMENT AND PERSONNEL (December 1992)

ORGANIZATIONAL ARRANGEMENT

IRDS comprises: (1) an Information and Documentation Unit; (2) a Communications Unit; (3) a Project Development Office; (4) an Institutional Relations Area; and (5) a Professional Development Area (Figure 5).

The Communications Unit; the Information and Documentation Unit; and the Project Development Office, are described in the respective reports (Documents No. 2, No. 3, and No. 4). Each of the three components is headed by a senior staff person who reports to the Associate Director, Institutional Relations.

Professional Development is described in Documents No. 6 and No. 7. The training of researchers from the NARDS is coordinated directly by the Associate Director. The development of national and subregional training capacities--for the training of extensionists in commodity-specific technologies--is led by a senior research fellow.

Institutional Relations encompasses two functions: Interinstitutional Mechanisms, and Institutional Liaison.

Interinstitutional mechanisms is about

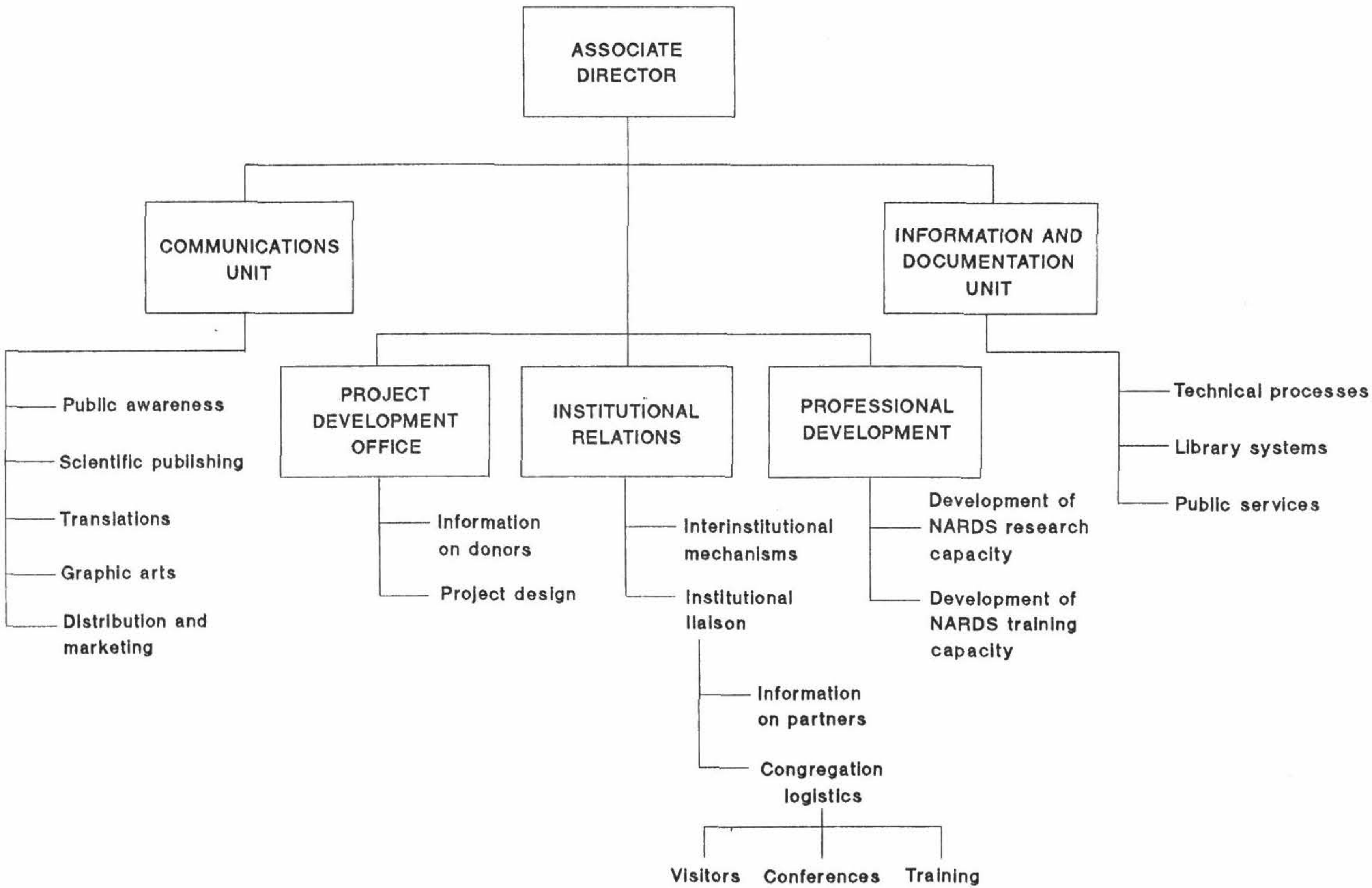
* synthesizing CIAT's experience on institutional development (Document No. 9);
* facilitating the transfer of that experience to NARDS; and mainly
* supporting the assemblage of interinstitutional bodies which are key to the implementation of CIAT's strategy for the 1990s and beyond.

This function is in the Associate Director's office.

Institutional Liaison deals with information management about partners (Document No. 8, p. 8), and with the logistics of moving, and looking after, trainees, visitors, and conference participants (see Document No. 6, p.10, functions of the former Registrar and Orientation Officer; and Document No. 5). A General Administrative Staff position is responsible for Institutional Liaison.

FIGURE 5. THE ORGANIZATIONAL ARRANGEMENT OF

INSTITUTIONAL RELATIONS AND DEVELOPMENT SUPPORT



PERSONNEL

<u>Communications Unit</u>

Thomas Hargrove, Unit Head

Vacant, Head Scientific Publishing

Walter Correa, Head Graphic Arts

Vacant, Translations

Bill Hardy, Editor Scientific Publications, English
Francisco Motta, Editor Scientific Publications, Spanish
Elizabeth de Páez, Editor Scientific Publications, English
Alberto Ramírez, Editor Scientific Publications, Spanish
Ana Lucía de Román, Editor Scientific Publications, Spanish

Claudia Muñoz, Public Awareness Assistant, National Press
Alexandra Walter, Public Awareness Assistant, International Press

Gladys de Ramos, Editorial Assistant

Enrique Umaña, Publications Distribution Supervisor

Jorge Mauricio Antoverza, Photography Department Supervisor

Mario Holguín, Print Shop Supervisor

Julio Martínez, Graphic Design Supervisor

José Alejandro Valencia, Production Assistant

Information and Documentation Unit

Elizabeth Goldberg, Unit Head

Luz Marina Alvaré, Technical Processes Coordinator

Zeneire Cadena, Documentalist
Marlene Cárdenas, Bibliographer
Patricia Cruz, Documentalist

Jorge López, Lybrary Systems Coordinator

Mariano Mejía, Public Services Coordinator

Lynn Menéndez, Documentalist
Alicia Misas, Documentalist
Nora Rizo, Reference Assistant

Institutional Relations

Alfredo Caldas, Institutional Liaison

Myriam B. de Cobo, Visitors Office

Rodrigo Chávez, Assistant, Visitors

María Eugenia Cobo, Conferences Office

Marco Antonio Rodríguez, Systems Analyst

Project Development

Robin Ruggles, Project Development

Tito Franco, Administrative Associate

Professional Development

Vicente Zapata, Coordinator, Development of National and Subregional Training Capacities

Carlos Flor, Training Associate
Carlos Vicente Durán, Training Associate
Marceliano López, Training Associate
Jesús Antonio Reyes, Training Associate

Lucy García, Didactic Media Assistant
Juan Carlos Londoño, Didactic Media Assistant
Patricia Perdomo, Didactic Media Assistant
Yolanda Romero, Didactic Media Assistant

ACKNOWLEDGMENT

Institutional Relations and Development is, by definition, a support area for CIAT's essential business: development-oriented research. It is a privilege to be able to complement and support the work of CIAT's Research Programs and Units in the noble mission of ALLEVIATING HUNGER AND POVERTY IN THE TROPICS WHILE PRESERVING THE RESOURCE BASE.

We are grateful to CIAT's management, and to all CIAT scientists, for making our work challenging and rewarding, in an atmosphere of frank collaboration and collegiality.

We are indebted to our colleagues in the NARDS, for they have allowed us to join in the struggle to improve the living conditions of their people. From them, and with them, we learn about institutional development. And through our NARDS colleagues, we keep the lifeline open to the end users of our joint efforts to generate technology: the people on the land.

Our heartfelt thanks to our support staff. Without their commitment to the task, and their excellence on the job, the work reported in the attached documents would not have been possible.

SAVANNAS PROGRAM
ANNUAL REPORT 1992

EXECUTIVE SUMMARY

Program implementation

The Savannas Program became operational on July 1, 1992 when its leader and part of the staff assumed the new positions created in the Program. Four Senior staff, including the leader, one Associated Member of the Senior Staff and one Senior Research Fellow were transferred from the former Tropical Pastures Program. Later in the year, an additional Associate Member of the senior staff and a Postdoctoral Fellow joined the Savannas Program. The only core-budgeted vacancy at present is that of an Agricultural Economist shared with the Rice Program.

Research activities in the Savannas Program benefited from existing projects previously implemented jointly by the Rice and Tropical Pastures Program in the Llanos of Colombia, a long-term research project jointly designed and established with EMBRAPA-CPAC and from a number of initiatives begun a year earlier by the Savannas Working Group aimed at characterizing the Brazilian Cerrados.

Progress in developing research strategies

A number of research strategies have been identified as relevant to the Savannas Program and have been implemented, whereas others await additional input, particularly from the Social Sciences, and/or special project funding. All of these will be briefly discussed below, and some highlight results are mentioned for specific cases.

Pending further studies underway, the total surface area of Savannas in Tropical America is estimated to cover approximately 250 million hectares. The majority of that area is represented by the Brazilian Cerrados that, according to the latest estimates produced by Brazilian researchers, cover some 230 million ha. Additional areas of savannas are found, in decreasing order of magnitude, in Venezuela and Colombia followed by Bolivia (part of the Santa Cruz Department), savannas intrusions in the Brazilian Amazon rain forest (e.g. Amapá), and lastly, Guyana and Suriname.

Given the relative magnitudes and socioeconomic importance of these savanna areas, and CIAT's institutional presence and previous experience, it was earlier decided (CIAT Strategic Plan) that the Savannas Program would conduct hands-on research at possible two or at most, three, sites in each of Brazil and Colombia respectively. The other savanna areas would be covered through a network approach. Regardless of the region, it was also decided that all research would be of an inter-institutional nature, although recognizing CIAT's comparative advantages in specific sites. A related decision implied that research would be primarily of a strategic nature and that possibilities for wide extrapolation would hinge on it being conducted in sites representative of the mandate area as characterized by appropriate classification studies.

Agroecological characterization

Consistent with the Strategic Plan of the Resource Management Division, the initial step in the research process has been the agroecological characterization of the mandate area.

The first initiative in following this process referred to the Brazilian Cerrados and begun in mid-1991. An inter-institutional working group composed of representatives of EMBRAPA's Cerrado Center and the Rice and Beans Center, and CIAT's Agroecological

Studies Unit (currently the Land Use Program) and Savannas Working Group met regularly, initially to discuss the methodology to be pursued and to identify relevant sources of secondary information, and later to refine the analyses as they begun to be produced. This was a highly iterative process. The final product was a document entitled "Area Classification and Mapping for the Cerrados Region of Brazil". In summary, 6 climatic variables, 7 for soils/topography, and 22 variables derived from the censuses carried out in 1970, 1975 and 1980, were used to classify the Cerrados regions for which reliable information existed, into 18 different agroecological classes, subsequently reduced to 11 classes of significant importance. The document was then complemented with socioeconomic information derived from the 1985 census, unavailable at the time that the agroecological classification was performed. In parallel, Brazilian researchers identified 12 areas of potential interest based on EMBRAPA's institutional knowledge and experience in working in some of them. Operationally, these were defined as circles of 60 km radius, where the area of each is approximately equal to that of a LANDSAT image, that would eventually be used to provide a spatial model in a geographic information system. The 12 case study areas were then put in the context of the Cerrados as a whole, and a detailed description of each, in terms of the agroecological classes previously identified, was produced. A parallel study was subcontracted by CIAT to a private, not-for-profit, Brazilian institution, the Instituto Sociedade, Populaçâo e Natureza (ISPN) that provided a socioeconomic characterization of both the Cerrados and Amazon regions, based on secondary information.

In August 1992 a workshop co-hosted by EMBRAPA-CPAC and CIAT took place in Brasilia with the aim of determining the interests of different EMBRAPA National Centers in carrying out research on sustainable agropastoral systems for the Cerrados, and to identify areas where this type of research would be implemented.

The classification of the Cerrados, and the ISPN study previously referred to, served as the basis for discussion. The workshop was well attended by Directors and/or Technical Directors of the following EMBRAPA National Centers: Cerrados, Rice and Beans, Soybeans, Maize and Sorghum, Milk, and Beef. By the end of the three-day workshop, priorities were assigned to the 12 case study areas. Top priority was given to four of them, namely those around Uberlandia, Campo Grande, Rondonópolis and Río Verde. The decision was taken to carry out an inter-institutional rapid rural appraisal (RRA), coordinated by EMBRAPA, in each of them to identify demands for research, evaluate and classify existing farming systems, and to identify local institutions interested in sustainable agricultural development. These RRAs were scheduled for the period November/December 1992.

A similar process has been proposed for the cases of Colombia and Venezuela. In Colombia, the Instituto Colombiano Agropecuario (ICA), Instituto Geográfico Agustín Codazzi and the meteorological institute, HIMAT, have been approached, and the first planning session will be held in December 1992. In the case of the Venezuelan savannas, the national research institute, FONAIAP expressed interest in the subject, and it is expected that a joint project to characterize the Llanos will begin in early 1993.

Monitoring farming systems

As indicated in CIAT's Strategic Plan, one of the objectives of all agroecosystem programs is to contribute towards the design of productive farming systems that preserve or even enhance, natural resources. A most important complementary objective is to document biophysical and economic trade-offs made as a consequence of contrasting land uses. The operationalization of these objectives imply the need for significant on-farm research, the development of farming systems models and the design and testing of new systems. A modest amount of work on the first of these approaches has commenced.

A small number of farms in one of the high priority areas of the Brazilian Cerrados, Uberlandia, are using relatively high inputs (especially fertilizer inputs) in agropastoral systems that appear sustainable, highly productive and are clearly economically viable. These farms, located on fragile, light-textured, soils have detailed records of input use, crop yields and periodic soil analyses, that should make possible a historical analyses of land use to examine the consequences of land allocation and use of different agricultural technologies on current soil conditions. The small sample of farms being monitored includes a case of a farm located in the same region that shows evidence of active degradation of the soil resource. Intensive sampling of selected paddocks differing in previous use, complemented with the analyses of existing records is expected to contribute to the identification of parameters that may be useful as indicators of biophysical sustainability. Similarly, the analyses of the systems' inputs and outputs is expected to yield useful indicators of economic sustainability and clues regarding the effect of land use decisions made in the recent past on current biophysical and microeconomic trends. Lastly, it is expected that both the biophysical and microeconomic studies being conducted will contribute to the formulation of new research hypotheses.

The introduction in 1991-2 of newly released soybeans and rice varieties for the acid soils of the Colombian savannas is promoting a rapid change in traditional farming systems of the region. This process was documented via a survey jointly conducted with the Tropical Forages Program in early 1992 that indicated that in the sampled area of 1.07 million hectares, 67% of the farmers interviewed were already informed about the newly developed crop-pasture systems, 48 percent had seen examples of these systems and 7 percent had experience with them.

A number of farmers are actively experimenting with the new materials and with existing and new forage crops. As in the case of the Cerrados, this situation affords the opportunity to monitor a selected, small, sample of farms located in contrasting conditions of soils and topography with similar objectives as those stated above.

Experimentation in farming systems

As indicated in the previous section, farmers in both the Colombian Llanos and the Brazilian Cerrados have been identified that are actively experimenting with cropping systems that integrate crops and pastures for cattle in different arrangements. This suggests a unique opportunity for performing on-farm experimentation, using the natural inclination of these farmers to test different alternatives.

In the case of the Cerrados, three broadly different scenarios have been tentatively identified. The first, and most traditional one, is the continuing conversion of lands covered by native vegetation to crops and pastures. Given the extent of intervention that the Cerrado has suffered in at least, some of the candidate case study areas, this is a scenario of decreasing importance. A second, and extremely important situation is that of degrading grass-alone pastures, mostly Brachiaria decumbens, that are subject to rehabilitation via crops, or directly through various combinations of mechanization and fertilization. Lastly, some areas within existing farms have been monocropped consecutively for a number of years, generally using high fertilizer inputs, and will eventually be used for pasture establishment. These three highly contrasting conditions are been utilized to set up simple, short- to medium-term on farm experiments involving different cropping systems, including a farmer control. They also afford the germplasm programs of both CIAT and the National Institution to set up multi-locational varietal trials in different environmental conditions. In the Cerrados, this approach is being tested with the Tropical Forages Program. Other germplasm programs are being approached with the same purpose.

A similar strategy is being planned for the Colombian eastern Llanos, and the Venezuelan western Llanos for implementation at the beginning of the 1993 rainy season. In the latter case, a preliminary set of research projects has been agreed upon with scientists from the Universidad Experimental de los Llanos Ezequiel Zamora, UNELLEZ, in the State of Barinas. In Colombia, the Savannas Program assumed CIAT's responsibility in an agreement signed between ICA, CIAT, and FEDEARROZ, and implemented in early 1991. It is aimed at on-farm testing of two contrasting cropping systems, namely, upland rice monocropping and rice-pasture systems respectively in a wide range of farms. The role of CIAT in these studies is that of technical advisor.

Strategic research

The Savannas Program has continued to participate in, and in some cases, to run, a number of long-term strategic research projects in the Cerrados of Brazil and Llanos of Colombia.

In 1991 a large and long-term project was setup at CPAC to study the effect of different cropping systems established after native Cerrado vegetation, on soil biophysical properties and system productivity. Treatments involve a wide range of cropping systems, ranging from monocropping to grazed grass-legume pastures and various rotations. This is a project implemented and run by a large interdisciplinary group of Brazilian scientists. Researchers of the Savannas Program were involved in the design phase, and financial resources were made available for some aspects of its implementation.

Nutrient cycling and pasture productivity

At the CNI-Carimagua experiment station in the Llanos of Colombia, the Program is involved in a large and long-term experiment set up by the former Tropical Pastures Program, aimed at studying nutrient recycling and primary and secondary biomass productivity in grazed grass-alone and grass-legume pastures in two soils of contrasting texture. The experiment now is a collaborative project with the Tropical Forages Program.

The objective of the project is to understand the mechanisms involved in nutrient cycling, soil organic matter dynamics, plant-soil relations, the dynamics of the components of legume-grass pastures, and animal selectivity, intake and production. Based on this understanding, it is planned to model the system in sufficient detail that the outcome of various management options may be forecast without the need for empirical experimentation.

The legume component has had a remarkable impact on animal liveweight gains compared with a pure grass pasture or with the native savanna, especially on the sandier soil. However, after a establishing very well, the legume Centrosema acutifolium on the sandy soil disappeared early in the wet season, after two years, and animal performance has started to decline. It is planned to follow the changes that occur in these pastures as they degrade to document the process, which parallels that commonly seen on farms in the savannas. The population of Stylosanthes capitata on the sandy soil is also falling as the original plants die, and although seedlings germinate well, they do not develop. Preliminary results of some small plot studies suggest that they are suffering from potassium deficiency. The problem will be investigated in the coming year, with a view to devising appropriate management strategies to deal with it.

In contrast to the sandy soil, C. acutifolium is persisting very well on the clay soil, and animal performance reflects its contribution. Arachis pintoi established poorly, and while its population is steadily increasing, it has not yet made much contribution. The problem of slow establishment of A. pintoi is under investigation in collaboration with scientists of the TFP.

Pure grass pastures have a much larger amount of roots than the legume-grass swards. In the latter, while the legume contributes only about 20 percent of the total root biomass, the combination is able to extract more nutrients per unit root biomass than the pure grass.

A multiple linear regression has been developed from litter bag studies to predict rates of decomposition of forage litter and crop residues in an oxisol. The regression uses the initial lignin:N ratio of the litter or residue and the amount of rainfall and suggests that these two factors account for 82 percent of the variation, or formally:

% organic matter remaining = 1.09 x lignin:N ratio - 0.022 x mm rainfall + 52.5 ($r = 0.82$, $p < 0.05$).

Rates of litter production in the experiment at Carimagua decreased as stocking rate increased on the clay soil but were unaffected by stocking rate on the sandy soil after 16 months grazing. The presence of a legume in the pasture increased the rates of return to the soil of N, P, K and Ca by up to 3-4 fold mainly via increased nutrient concentration in the litter.

Rates of nitrogen fixation by Arachis pintoi, Centrosema acutifolium and Stylosanthes capitata varied from 1-67 kg N/ha in

16 weeks at Carimagua. The low rate of fertilizer used in the main experiment having a large negative effect on the legume population compared with the higher rate. However there was little effect of fertilizer on the proportion of the plant's nitrogen derived from fixation which averaged 89% across soil type, fertility treatment and species. The data demonstrate that, when in competition with a grass, legumes derive almost 90% of their N from fixation on differing soil types and fertility levels appropriate for pasture or agropastoral systems in the savannas.

A second set of long-term research activities are conducted in a private farm (Matazul). This set of trials was initiated by a joint initiative taken in 1989 by CIAT's Rice Program and the former Tropical Pastures Program. Initially, a Delphi survey was conducted among informed farmers and professionals operating in the area that identified four alternative cropping scenarios for the well-drained savannas. These four conditions were the establishment of pastures undersown with rice, the reclamation of degraded grass pastures via a rice crop, rice monocropping and rice-soybeans rotations respectively. A set of trials was established in 1989 involving all four systems, to measure above and below ground biomass, yields of crops and their components, animal yields, nutrient balances, changes in soil total organic matter, trends in selected soil physical properties and the dynamics of weed populations in some of those systems. Data on the different biophysical parameters is now available for four consecutive years.

The same experimental site is being used by CIAT's and ICA's Rice Programs to evaluate advanced experimental lines, and by ICA's Soybeans Program to test bred materials. Similarly, the Tropical Forages Program is using the site to conduct research on seed multiplication of Arachis pintoi, and a joint TFP-Savanna experiment is examining the feasibility of commercial seed production in rice undersown with _S. capitata_ and _B. dictyoneura_, to decrease the costs of forage seed multiplication and increase their yields.

CASSAVA PROGRAM ANNUAL REPORT 1992

SUMMARY OF HIGHLIGHTS

Introduction

1992 was a year of transition for the Cassava Program as CIAT faced the challenge of reorienting its activities in accordance with the new strategic plan: "CIAT in the 1990s and Beyond". The move towards an integrated systems approach, which combines commodity and resource management research, together with severe centerwide financial restrictions, has led to a phasing out of core-funded regional cassava agronomy research both in Latin America and Asia and of process and product development activities at HQ. Intensive efforts are being made both to seek complementary funding and to identify appropriate institutional arrangements that will permit the continuance of these activities as they are seen as fundamental in ensuring a balanced approach to cassava technology development. In line with the strategic changes occurring at CIAT, the Program is placing greater emphasis on cassava genetics and quality research as a means of deepening our knowledge of basic crop characteristics and consequently accelerating the development of gene pools for specific environments and end uses.

Goal and objectives

The Cassava Program and its partner institutions in both the developing and developed countries seek a common goal: to increase incomes and agricultural sustainability in less favored rural areas by improving the level and stability of cassava production and quality for different end uses. The Program's principal contribution to achieving this goal is through the development and supply of germplasm that is adapted to the biotic and abiotic conditions and end use requirements of the tropical and subtropical environments where cassava is produced. The Program also interacts with and provides support to national cassava research and development programs in the development of crop management, processing and marketing components of the commodity system. In addition, the Program plays an important catalytic and convening role in bringing together the diverse range of institutions involved in cassava research and development. Support to national programs and regional and global networks is provided through training and information exchange activities and participation in joint R and D projects. The operational objectives of the Program are:

- To generate basic knowledge on the cassava crop;
- To develop technology components for sustainable production in major cassava-growing ecosystems;

- *To contribute to the consolidation and integration of national, regional and global* cassava R and D systems.

The following summary highlights the major progress achieved during 1992 related to each of these objectives.

Basic knowledge generation

Germplasm collection, characterization and conservation
The core germplasm collection of 630 accessions is proving to be a more manageable sample for the evaluation of the total genetic diversity present in the whole collection. The collection has been screened for root quality traits at CIAT and screening for agronomic traits is underway. Further screening will take place in the 2 other locations where the core collection has been planted. Indexing of the core collection is complete and arrangements are being made for its duplication at CENARGEN, Brasil and FCRI, Thailand.

Half of the 5263 accessions that make up the whole germplasm collection have been checked for duplicates. More than 200 have been confirmed as duplicates at the field level. Before removal of these duplicates, further checking will be carried out at the biochemical and molecular level.

Conservation of cassava pollen at low temperatures (-12°C and -70°C) to facilitate pollination work and germplasm conservation and exchange has not produced favorable results. Cassava pollen appears to be recalcitrant to conservation methodologies.

Intermediate levels of polymorphism have been demonstrated among cassava clones, indicating that a large number of segregating progenies from crosses between the most polymorphic parents will be required in order to construct a highly saturated molecular map for cassava. As was to be expected, evaluation of the genetic diversity among wild relatives of cassava has shown a higher degree of polymorphism than for cultivated cassava for three isozyme systems studied.

Physiology
Screening cassava core germplasm for photosynthetic capacity has revealed a wide range of variation among genotypes, with the highest capacity in Argentinean materials.

Basic research on the biochemistry of cassava photosynthesis has confirmed that cassava has elevated activities, as compared to typical C_3 species, of the C_4 enzyme PEP carboxylase. The ratio of the PEPC/RUBPC activity was intermediate between that of typical C_3 and C_4 species. The activities of the C_4 decarboxylating enzymes, NAD malic and NADP malic were also higher in cassava than in typical C_3 species.

Research on cassava response to prolonged early, midseason and terminal water stress has confirmed that once the crop is established prolonged water deficits would not seriously limit productivity. This fact points to the great potential of cassava in the seasonally dry and semiarid tropical and subtropical regions where other food crops would fail.

Plant nutrition

Cassava germplasm with high level of adaptation to low-P and low-K soils have been identified. Among the new genotypes adapted to low-P were CM 489-1 and CG 913-4, both are CIAT clones. The genotypes with high level of adaptation to low-K soils were CM 507-37, a CIAT clone and M Ven 25, a local variety.

Studies on the mechanisms underlying genotypic differences in response to low-P soils have shown that cassava yield depends on the balance between top growth and storage root sink strength. The clone CM 489-1 showed high adaptability to low-P as well as good response to fertilizer application suggesting better P use efficiency. On the other hand, M Col 1684 was less responsive to P application and with lower P use efficiency.

Initial studies on the agronomic feasibility of a true seeded cassava crop have shown that early vigor is enhanced by coating with rock phosphate and that the positive effect was reflected in final root yield. This suggests that placing less mobile elements and potential growth stimulators close to the seed could enhance the ability of a true seeded crop to compete with weeds and cover the soil at an early stage.

Quality

The characterization of the core germplasm collection for cyanogen content, DM and % amylose has identified 10 clusters representing interesting combinations of desired characteristics (e.g. high dry matter but low in total cyanogens) that require further evaluation. From these clusters it will be possible to select potential clones of interest to breeding programs and research materials for in depth study of specific root quality characteristics.

Significant differences have been found between mean values of 15 high and 15 low cyanogen content clones for all starch viscosity variables, ease of cooking, gel instability and gelification index. However, the % amylose did not very between the high and low cyanogen clones. The results suggest a relationship between root cyanogen content and starch functionality that requires further investigation.

An evaluation of the variability among elite clones for postharvest physiological deterioration has demonstrated that there exists a range of genetic diversity that will allow to select materials with minimal deterioration after 8 days storage. This opens ups the possibility for a program of recurrent selection to extend the shelf-life even further.

Cassava diseases

Clones that maintain excellent resistance stability to the mycoplasm witches' broom disease have been identified and introduced both to CIAT and CNPMF, Brazil for the production of hybrids. Furthermore, a technique to identify mycoplasm like causal agents using light microscopes has been developed. This method is feasible for scientists working in most developing country plant pathology labs.

One of the most important problems encountered in the use of fluorescent pseudomonads as biocontrol agents of root rots is their survival on a substrate that facilitates their handling and commercialization. *Pseudomonas fluorescens* (c-58) and *P. putida* (f-44) remained viable for three months when maintained on a powder mixture of sorghum, peptone and sucrose.

Field trials in a soil naturally infested with the root rot pathogen *Fusarium solani* showed a significant increase in cassava yield in plots treated with the mycoparasite *Trichoderma harzianum*. The biological control of *F. solani* provided by *T. harzianum* was much more effective when cassava was planted on ridges.

Cassava viruses

Cytological studies undertaken in the search for the causal agent of frogskin disease (FSD) have revealed viruslike particles 80 nm in diameter and inclusion like bodies in FSD infected plants. Consistently nine ds-RNA segments are found in the affected plants. Based on the morphology of the viruslike particles and ds-RNAs, the virus associated with FSD should be classified in a new genus of the reoviruses. Screenhouse studies have confirmed that the whitefly *Bemisia tuberculata* is the vector of the reoviruslike virus; infected plants expressed typical FSD symptoms.

The primary molecular characterization of cassava common mosaic virus (CCMV) has been completed. The complete sequence of CCMV is 6387 in length and encodes for six proteins. Most of the sequencing of CCMV was carried out at the VRU in CIAT and this is perhaps the first plant virus to be sequenced in Latin America. The coat protein gene of CCMV has been successfully introduced into *Nicotiana benthamiana*, at the SCRIPPS Institute, San Diego. These plants show almost complete immunity to CCMV. Once transformation and regeneration protocols for cassava are available, coat protein mediated cross protection will be an additional method for developing CCMV resistant germplasm.

Cassava pests

Continued characterization of lines that show resistance to the cassava mealybug indicate that, rather than true resistance, a tolerance mechanism is involved. Vigorous, high yielding varieties, combined with biological control may be sufficient to maintain cassava mealybugs below economic injury level.

Studies with whitefly resistant clones have revealed antibiosis, indicating in this case, the presence of true resistance. This opens up the possibility of genetically transferring this trait to commercial varieties.

Further indication that root cyanogen levels are a factor in the development and behavior of the burrowing bug has been made evident through a comparison of ovipositional rate on maize and cassava. Egg laying was reduced by 44.5 and 98.6% on low and high cyanogen clones respectively.

Nematodes offer a potential method for the biological control of the burrowing bug. Parasitism has been obtained with commercial entomopathogenic nematodes in laboratory studies. A collection of native nematode species has now been established through field sampling at several locations. These species are being identified and will subsequently be evaluated for their parasitic effectiveness.

Technology component development

Germplasm

Genotype by environment interaction studies has demonstrated that the selection of elite clones at specific sites has increased adaptation to the predominant conditions at those sites, while maintaining flexibility for adaptation to the conditions prevailing at other sites that are not as representative of a given ecosystem. Testing at sites representing a range of conditions within a given ecosystem has resulted in germplasm with broader adaptation.

Cassava bacterial blight continues to be a sporadic but nevertheless serious production constraint for seasonally dry environments. The germplasm being tested on the Colombian North Coast has shown a range of reactions to the disease which has permitted the selection of elite clones with good levels of resistance. For this ecosystem, Program selections outyield local clones but it is still difficult to consistently improve root quality parameters to levels above those of the local materials.

A large number of elite clones were selected this year with good adaptation, yield potential and quality traits for the lowland tropics, with the acid soil savannas representing the gene-pool with the most consistent improvement during the last few years.

The genetic base for highland cassava germplasm has been expanded with the introduction of materials that show good adaptation to intermediate altitude (1400 masl.).

Evaluation of cassava germplasm under semi-arid conditions in NE Brazil has resulted in the selection of clones combining resistance/tolerance to mites, yield and dry matter accumulation potential and low levels of cyanogens in the roots.

The Thai-CIAT regional breeding program at Rayong is proving to be a major gene-pool source for the semiarid lowland tropics of Asia. Hybrid populations prepared at Rayong using Thai clones and locally selected CIAT materials as cross parents show superior germination, survival ability after planting, plant type and root DM content compared to CIAT/Colombia populations. Transfer of these materials, both in the form of hybrid seed and meristem culture, is providing the basis for promising varietal selection in Vietnam, Indonesia, Philippines and China.

Kasetsart 50, a hybrid prepared by Kasetsart University, Thailand using cross parents provided by the Department of Agriculture and CIAT, was released in 1992. In 60 on-farm and regional trials Kasetsart 50 outperformed Rayong 1, the predominant local cultivar in Thailand, in every agronomic trait.

From the 1990 introductions of botanical seeds from CIAT to IITA, 538, 311 and 474 clones were advanced to the clonal evaluation trials at Ibadan, Onne and Kano/Zaria, respectively in 1991. At Ibadan and Onne, where selection pressure for ACMV is very high, 9 and 17 of these clones were selected during 1992 for establishment in preliminary yield trials. Between 70 and 30% of these selections respectively were from crosses with elite IITA materials. At Kano and Zaria, where ACMV is not as limiting a constraint, 38 and 53 materials were selected and 100% of these materials were of pure Latin American origin. This confirms that for areas where ACMV is not limiting, direct introductions from Latin America can provide potentially promising selections.

Of the 1992 introductions to Africa, 13,863 seeds representing 147 families were sent to Mzuzu, Malawi in coordination with the East and Southern Africa Root Crops Research Network. Families to be tested in Malawi are potentially adapted to semiarid and high altitude areas. Through this introduction mechanism it is hoped to accelerate the selection of promising materials for these important cassava growing ecologies in Africa.

Crop management

A network for research on the control of cassava root rots has been organized, with trials at 19 different sites throughout N and NE Brazil and Colombia. The results of these trials have allowed the identification of:

- Resistant clones for several root rot pathogens. This year the clone EMBRAPA-8 was released in cooperation with EMBRAPA-CPAA and CNPMF for the varzea region of the Amazon. This clone has yielded 80% more than farmers' best variety over three consecutive cycles;
- Several cultural components for integrated control of root rots. These have been grouped as universal (recommended to be implemented in all affected cassava plantations) and as regional (recommended for cassava plantations affected by one or more pathogens controlled by specific methods).

Establishment of the cassava mealybug parasite *Aenasius vexans* has been achieved in Villavicencio, Colombia. This parasite is potentially important for the control of the mealybug in NE. Brazil and further studies on the interaction of parasite and prey population density are required in order to determine an appropriate release strategy.

Successful biological control of the cassava green mite (CGM) requires an appropriate methodology for predator release and establishment. The multiplication of *Neoseiulus idaeus* and *Typhlodromalus tenuiscutus* in field cases prior to release has proved to provide greater flexibility in timing release and a means of adapting laboratory reared phytoseiids to field conditions. *N. idaeus* may suppress native phytoseiid fauna, a factor that should be taken into consideration before releases in areas where an alternative strategy may be to enhance the effect of the native natural enemies of CGM. This latter strategy can be achieved through manipulation of the habitat so as to increase the relative humidity in the leaf canopy. Vigorous plant type favored phytoseiid population increase and inhibited CGM; low and intermediate planting densities favored CGM and phytoseiids respectively.

Research on soil-crop management systems in poor sandy soils at La Colorada, North Coast of Colombia, has revealed that cassava yields could be greatly enhanced by the application of moderate levels of NPK fertilizer or plant mulch. Mulch appears to be beneficial in improving soil fertility as indicated by the build up of organic matter and K over the years. Moreover, mulch alleviated heat and water stress in the surface soil and has led to a dramatic reduction in the level of cyanogens in cassava roots at final harvest. Clones CG 1141-1 and CM 3306-4 had higher yields and higher dry matter content, with or without application of fertilizer, compared with local varieties.

Research on soil conservation practices for hillside or upland cassava-based cropping systems has continued both in Colombia and several Asian countries. This work centres on the identification and evaluation of appropriate forage legume cover crops and live barriers. The effect of cassava plant type on erosion has also been studied.

In Santander de Quilichao, Colombia, *Centrosema acutifolium* and *Zornia glabra* provided the best soil cover in the first year with yield reductions of cassava in the order of 25%. In Pluak Daeng, Thailand, *Indigo* and *Mimosa inrisa* developed a rapid soil cover but competed heavily with cassava. *Z. glabra* was the only cover crop to increase cassava yields significantly, however its establishment was slow.

A number of live barriers materials are effective in reducing erosion. *Brachiaria decumbens, Stylosanthes guianensis, Citronella, Vetiver* grass and lemon grass once well established have all proved to be useful materials either in Asia or Colombia. The selection of the most appropriate barrier will depend on the particular production circumstances at each site.

Plant type can also have a significant effect on soil losses. Varieties with early vigor and more rapid canopy closure cover the soil more rapidly after planting thereby preventing soil erosion. This characteristic, associated with high productivity, would be an important additional selection criteria for hilly areas.

Preliminary results of erosion trials on farmers' fields in Rayong Province, Thailand have demonstrated that farmers in that area are already using many practices that minimize soil erosion, such as fertilizer application and the use of high plant populations.

Utilization and marketing

The development of high quality cassava flour for human consumption in Colombia has now entered a semi-commercial phase with batches of flour being sold to a number of food industries with excellent acceptance. The flour is principally being employed in the preparation of processed meats. Price and cost information required to formulate a full feasibility study on the expansion of this new rural agroindustry will be available during 1993.

Further improvements to traditional small-scale starch extraction equipment have been made. An improved root grater increased starch recovery from 81 to 90% and modifications to the traditional cylindrical water extractor has improved the starch extraction rate by 10%. Studies on "sour" starch quality have confirmed the influence of solar drying on the functional behavior of these modified starches. Baking power increased during the solar drying step with specific volume of breads increasing from 2.2 to 6.1 cm^3/g.

An interinstitutional project involving research institutions from France, UK, Colombia, Brazil and Argentina and funded by the EEC has been initiated to expand cassava flour and starch process and product development. CIAT will be directly involved in the areas of (a) raw material and process effects on quality of cassava starch and flour and (b) market research for new cassava products and markets.

Consolidating and integrating cassava research and development systems

Latin America

The first three year phase of the cassava integrated production, processing and commercialization project in the State of Ceara, Brazil has been concluded. There are now 158 producer group organized around dry cassava agroindustries. 75% of these groups were established during the final year and have yet to be consolidated. The long term sustainability of the project will depend on:

- further strengthening of local institutional and farmer organizational and operational capacity;
- consolidation of marketing channels for dry cassava and the identification of additional market opportunities for cassava;

- advances in the design testing and adoption of cassava production components that stabilize or increase yields, reduce costs and maintain or improve the productivity of the natural resource base.

A second phase of the project, which is being formulated for presentation to the Kellogg Foundation, will address these issues. Based on the successful institutional model developed in Ceara, EMBRAPA/CNPMF has prepared a project for the expansion of the cassava integrated project concept to Bahia, Pernambuco and Paraiba.

The Ecuador Integrated Cassava Program based in Manabi Province has made significant progress an a number of fronts during 1992. The first new cassava variety Portoviejo 650, was released by INIAP's Tropical Roots and Tuber Program. This variety, introduced from Colombia, has achieved rapid acceptance by farmers because of its higher dry matter, earliness and better yield under low rainfall conditions.

Studies on the potential of cassava flour in a number of industries has opened up several new market opportunities, one of these being for the fabrication of ice cream cones. The UATAPPY (farmers' union) has negotiated an initial contract to sell 600 t of white cassava flour to Colombia with further contracts to follow. The UATAPPY, with support from FUNDAGRO and CIAT, are actively seeking international financial support for the diversification of their agroindustrial activities.

The third Integrated Cassava Projects Network meeting was held in Fortaleza, Ceara from 28 September to 2 October. The meeting brought together 50 participants from 8 countries representing 12 projects. The principal outcome was the identification of the needs of individual projects in terms of methodological, technical, organizational and financial support. It is intended to develop the network to respond efficiently to these needs, taking advantage of the expertise already existing in current projects.

Activities within the framework of the Southern Cone Cassava Development Network included two training of trainer events. From 27 April to 8 May 36 Brazilian, Paraguayan and Argentinean professionals participated in a first phase workshop held in Argentina, in which six learning units were prepared. These units were reviewed and revised and subsequently used as instructional materials during the second phase workshop and course that was held in Paraguay from 12 to 30 October. A further course using the materials will be held in S. Brazil during 1993.

<u>Asia</u>

The Second Asian Cassava Advisory Committee Meeting was held in Malaysia on 15-17 June, 1992. Each country representative briefly reviewed research progress and outlined future priorities. The need to seek special project funding to be able to continue the CIAT supported regional program of research on soil-crop management was discussed and endorsed by the Committee. No immediate need was seen for shifting the present emphasis on breeding and soil fertility/erosion control research at the regional level. The focus of the next Asian Cassava Research Workshop, which will be hosted by India in November 1993, will be technology transfer.

The Second National Chinese Cassava Research and Technology Workshop was held 19-24 October, 1992 in Hainan. The workshop brought together research and development workers from Guangxi, Guangdong and Hainan provinces who presented papers on the cassava situation in different regions and progress in breeding, agronomy and utilization research. A decision was taken at the meeting to initiate a series of socioeconomic studies to better characterize the cassava sector given the present dynamic situation and the good future prospects for growth in cassava production and utilization.

The First Vietnamese Cassava Workshop was held in Hanoi from 29 October to 1 November, 1992 with the objective of presenting and analyzing the results of the socioeconomic "benchmark" studies carried out to characterize cassava production, processing and marketing in Vietnam. The studies confirmed cassava's role as an important secondary staple and highlighted the constraints associated with its potential transition to a multipurpose carbohydrate source.

Global networks

An international workshop on cassava genetic resources cosponsored by CIAT, IITA and IBPGR was held at CIAT from 18 to 22 August 1992 with the purpose of evaluating the current status of the conservation and use of cassava germplasm and the possibility of establishing an International Cassava Genetic Resources Network. 14 scientists from 12 national programs in Latin America, Africa and Asia reviewed the global situation with respect to *Manihot* germplasm collection, characterization, conservation and exchange. Recommendations were made for furthering research in each of these areas through a networking approach.

The First International Scientific Meeting of the Cassava Biotechnology Network (CBN), which was held in Cartagena, Colombia from 24 to 28 August, 1992, brought together 125 scientists from 28 countries. Advances were reported in methods of germplasm conservation using cryopreservation techniques, germplasm characterization and use, construction of molecular maps, and a repeatable protocol for cassava transformation and regeneration. New information was presented on the biochemical basis of root-quality factors, in particular cyanogenesis. The meeting provided an important forum for information exchange between scientists from both developing and developed countries and contributed to the initiation of closer ties between many institutions working on similar problems.

Program Development

Raul Moreno, cassava agronomist for the Latin American region since 1984, was transferred to CIAT's new Hillsides Program as from 1 September 1992. Merideth

Bonierbale joined the Program on 15 October 1992 to take up the position of cassava geneticist and Ann Marie Thro was appointed coordinator of the Cassava Biotechnology Network on 1 August 1992. Dominique Dufour of CIRAD-SAR joined CIAT on 3 November 1992 as an associate member of senior staff in the Cassava Quality/Utilization Section to replace Gerard Chuzel who will move to UNESP, Sao Paulo in January 1993. Gerard O'Brien of NRI, United Kingdom, joined the Cassava Program as a post-doc, also in the Cassava Quality/Utilization Section, on 20 January 1992.

TROPICAL FORAGES PROGRAM

A PERSPECTIVE OF THE NEW PROGRAM

The present Tropical Forages Program (TFP) is essentially the core germplasm evaluation and improvement component of the previous Tropical Pastures Program. That Program was intensively reviewed in 1991 and the presentations made to the Review Team have just been published in book form[1]. They highlight the progress that had been achieved in identification and improvement of grass and legume forages for acid soils of the humid and subhumid tropics and which provided the foundation for the 'new' TFP. You are encouraged to request a copy of this attractive and readable publication.

The reason for the change in the nature of the operation of the TFP is that CIAT itself has been restructured to undertake two main areas of research - Germplasm Development Research and Resource Management Research. There will be four Programs in the Germplasm Development Division, namely, Bean, Cassava, Rice and Tropical Forages, and four in the Resource Management Division, namely, the Hillsides, Forest Margins and Savannas Agroecosystem Programs and the Land Use Program.

The TFP was restructured in line with the new mandate to become a germplasm evaluation and improvement program and to allow some resources to be transferred to the area of Resource Management.

Specialist positions retained in the TFP were: Germplasm/Genetic Resources, Genetics/Plant Breeding, Pathology, Entomology (shared with the Rice Program), Plant Nutrition, Seed Biology and Animal

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1 CIAT. 1992. Pastures for the tropical lowlands: CIAT's Contribution. Cali, Colombia, 238 p.

Nutrition/Feed Quality with Regional Evaluation positions in Brazil and Costa Rica. Positions transferred to the Savannas Program were in areas of Nutrient Cycling, Ecophysiology, Farming Systems and Economics. Two Regional Evaluation positions were made redundant.

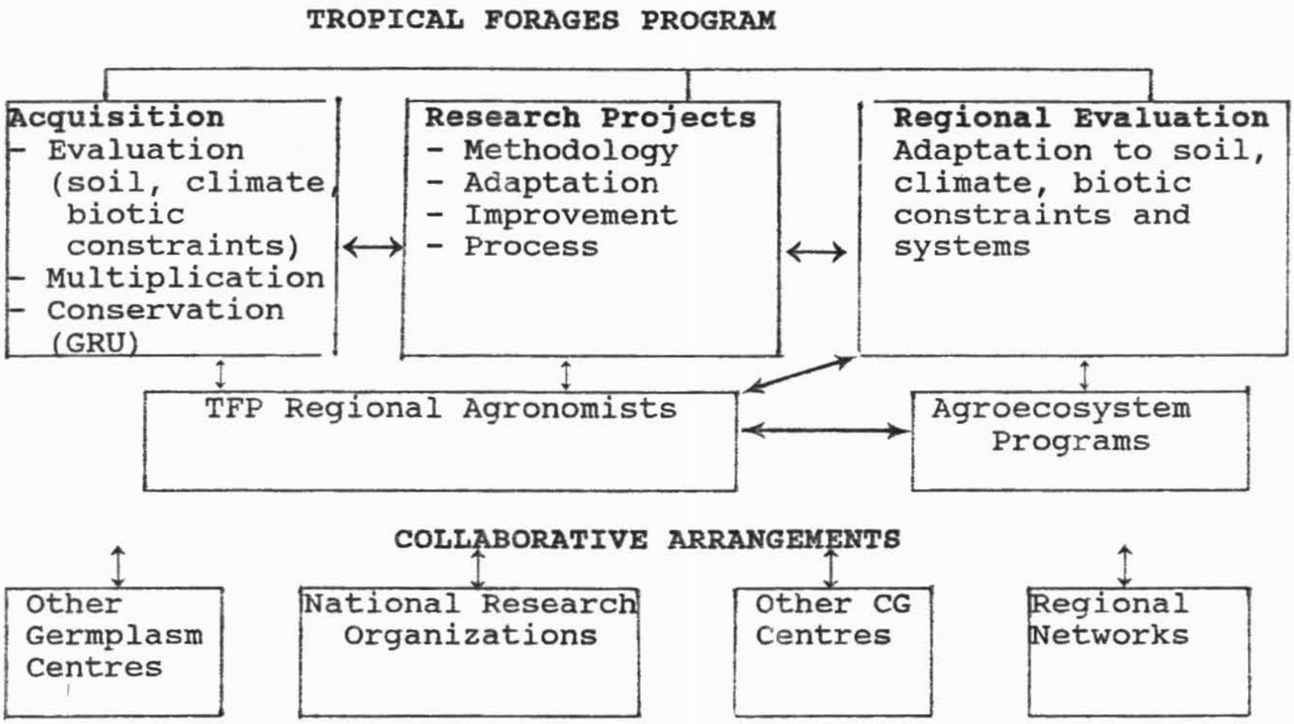
The new TFP has a mandate to 'deliver germplasm' and will not be directly involved in research on pasture production. This latter activity will be taken up by the Agroecosystem Programs where it is considered to be appropriate or will devolve to National Organisations.

The Goal of the Tropical Forages Program is:
To identify and develop grass and legume accessions adapted to acid soils in the humid and subhumid tropics,
to contribute to
- increased meat and milk production
- soil improvement
- erosion control

for different agroecosystems.

The objectives to achieve this goal will be to:
- identify productive forage germplasm
- develop improved forage plants of selected species
- define factors influencing adaptation and productivity (i.e. to assist the achievement of the above objectives), and
- deliver germplasm for different agroecosystems.

This will be implemented by concentrating activites in three areas as shown in the following figure, namely, Acquisition and Primary Evaluation, Research Projects on Specified Topics and Regional Evaluation.



Acquisition and evaluation

Acquisition and primary evaluation of germplasm will be the responsibility of the TFP-Germplasm Specialist and carried out with assistance of the Regional Agronomists. However, the characterization of new germplasm, initial increase of seed, conservation of germplasm, distribution of germplasm and documentation of germplasm activities will be carried out by the CIAT Genetic Resources Unit (GRU) with the cooperation of the TFP-Germplasm Specialist, with the latter person having authority for distribution of seed.

Evaluation of germplasm in the old Tropical Pasture Program was characterized by selection of germplasm for very acidic and infertile soils. This emphasis on adaptation to acid soil conditions will continue but recognition will also be given to selecting germplasm for less acidic and more fertile soils which occur in the research areas chosen by the Agroecosystem Programs.

Such areas include more fertile soils found in the Hillside and Forest Margin situations and in cropping areas in the Savannas which have been well fertilized and where there is now a need for a pasture rotation phase. Consideration will also be given to selection of germplasm for soil fertility improvement and erosion control and more emphasis will be placed on possibilities for use of multipurpose forage shrubs.

Research Projects

Previously research activities have been concentrated in areas of scientific disciplines but with considerable cooperation between disciplinary areas to solve particular problems. In the future it is intended to consolidate these cooperative endeavours by organizing research activities on particular projects. This will focus attention on priority areas and make the most efficient use of our now limited resources. It will also foster collaboration with the other Programs within CIAT and with scientists working in national institutions on similar problems.

Research projects are being developed for the following areas:

- Evaluation of herbaceous forage germplasm
- Evaluation and feed quality of shrub legumes
- Improvement of *Brachiaria*
- Improvement of *Stylosanthes*
- Improvement of *Panicum*
- Biology and agronomy of *Arachis*
- Adaptive mechanisms for persistence under grazing
- Biological control of diseases and pests of forage plants

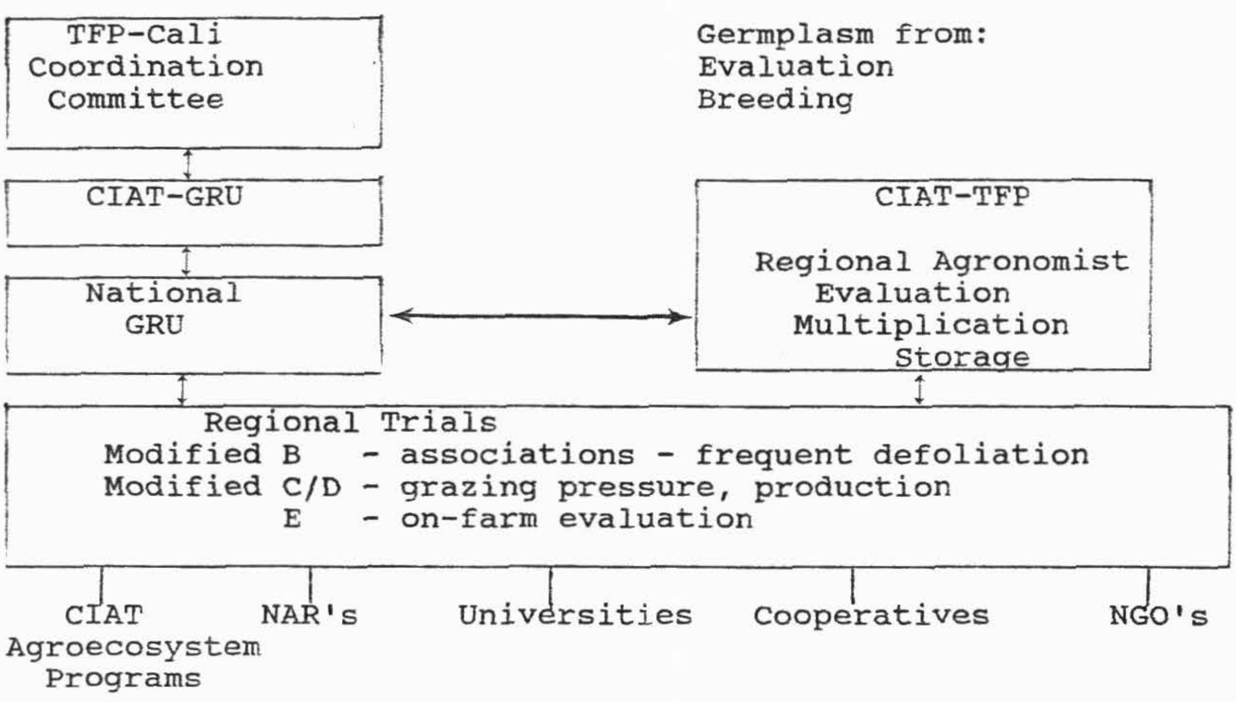
Our scientists will also participate in research programs initiated by other CIAT Programs and national institutions. 'Nutrient cycling and pasture productivity' is one such collaborative project with the Savannas Program.

Regional evaluation/agronomy

CIAT has a world mandate for evaluation and distribution of germplasm adapted to acid soils and with a high tolerance to disease in the humid and subhumid tropics. At present we have regional agronomists based in Costa Rica in Central America, Brazil in South America and the Phillipines in Southeast Asia. There is a collaborative arrangement with ILCA and IMEVT for evaluation of germplasm in west and central Africa.

Seed from primary evaluation of new germplasm or from plant improvement programs will be distributed to CIAT regional agronomists. They will have responsibility for multiplication of seed for further regional trials within the CIAT Agroecosystem Programs, for distribution to national networks or to other organizations who have an active interface with the farmers and knowledge of their needs:

REGIONAL EVALUATION



There will be a need for national organizations to multiply seed of promising material from these regional trials for use in large scale evaluation and for release to farmers. This is in part because the present quarantine regulations of several countries prevent seed of any accession being introduced more than once and in part because the TFP no longer has the resource to produce large quantities of seed for distribution. However, the TFP will continue to research and provide information on seed supply systems.

The regional agronomists will also perform an important role in providing feedback to other scientists within the TFP and in collaborating directly or arranging for collaborative research with TFP scientists based in Palmira.

Partners in Research

Regional evaluation of germplasm identified by CIAT has depended on strong collaboration with national scientists through the RIEPT network for tropical America and more recently by more informal networking arrangements in Southeast Asia and West Africa. The national programs have largely borne the cost of such evaluation while external funding agencies have provided funds for regional meetings and training. Sources of funds for networking activities are now very scarce. Hence together with our national partners we need to devise means of maintaining strong interaction.

The total resource available to CIAT for forage activities has also diminished. However, there is now a much stronger foundation in terms of available germplasm, the knowledge of this germplasm and in numbers of well qualified national scientists. We in the Tropical Forages Program have a strong conviction that together we can capitalise on these postive aspects and can continue to develop strong interactive programs with our partners.

The Interface for Forage Germplasm

Successful identification and development of new forage cultivars cannot take place without

(i) a knowledge of the needs of farmers within particular farming systems, and

(ii) some evaluation of whether the new forage or forage mixture is an appropriate and acceptable technology for them.

Thus it is essential that the Tropical Forages Program have an involvement in forage evaluation up to the on-farm evaluation stage, regardless of who executes the on-farm evaluation or by which method it is carried out. Some technology, e.g. the use of legumes in pastures will be quite a new concept to many farmers. Farmers will need to be informed about the technology and will need to be convinced of the worth of it to them.

The TFP will endeavour to maintain this contact with on-farm evaluation through the regional agronomists, the CIAT Agroecosystem Programs and direct contact with all organisations working with farmers.

The Lost Agenda

Development and management of pasture mixtures is complex:

(i) the presence of components which compete with each other (e.g. the grass and legume),

(ii) the grazing animal which can be both selective (with reasonable management practices) and destructive (with mismanagement), and

(iii) the inability to provide inputs to overcome nutrient deficiencies and protect against diseases and insects,

presents a greater challenge in the development of adapted forage germplasm than with domesticated arable crops.

These are not issues of production but of persistence and need to be addressed in any forage improvement program. Thus it is essential that studies on adaptation to soil, climatic and biotic conditions are also accompanied by studies on compatibility between plants and on reaction to defoliation by animals. The TFP will be working towards filling the gap in this area of research by seeking complementary funds to fill an *ecophysiology position*.

Close linkages will need to be maintained with other CIAT Programs to:

(i) characterize more closely the soils on which germplasm is evaluated so that results can be readily extrapolated
(ii) evaluate the effect of forages on soil fertility and
(iii) evaluate the productive potential of the forage germplasm that is developed.

There is also scope for collaboration with national scientists in these areas.

SUMMARY OF ACTIVITIES 1992

In general, the research activities this year have been a continuation of those presented last year. However, as indicated above some staff have moved from the Program and others have taken up vacant positions. Dr Segenet Kelemu took up duties as Senior Scientist, Pathology, in August, Dr Peter Kerridge became Leader of the Program in September and Dr Brigitte Maass began the transition from her position as Curator of the Genetic Resources Unit to Senior Scientist, Germplasm Specialist, in September. An internal review of the Program was conducted in November.

Acquisition and evaluation

A review of the activites in the genetic resources area of the GRU was made by Brigitte Maass. Regional evaluation activities were curtailed in Peru and Gerhard Keller-Grein was transferred to Palmira from where he took over responsibility for evaluation trials in the Llanos at Carimagua and commenced new trials in the humid forest margin area in Caqueta, Colombia. Evaluation activities were continued in Costa Rica by Pedro Argel at a very acid soil site in San Isidro, a very humid moderately fertile site at Guápiles and a fertile subhumid site at Athena. Evaluation studies in Brazil on the Cerrados site at EMBRAPA-CPAC, Planaltina, were extended by Esteban Pizarro to areas outside CPAC. A new regional project commenced in Southeast Asia in cooperation with the CSIRO Division of Tropical Crops and Pastures with CIAT involvement being concentrated in the Phillipines under the direction of Bert Grof. There has also been continuing delivery of germplasm for evaluation in West and Central Africa in cooperation with CIRAD-IEMVT and ILCA.

The cooperation of national organizations in regional evaluation of advanced germplasm in tropical America has continued under the RIEPT network. The results of five years of evaluation in the Savannas - the Llanos of Colombia and Venezuela and the Cerrados of Brazil was presented in a RIEPT-Savannas workshop in Brasilia in November. CIAT has also continued to provide support to national organisations through training activites. A regional workshop on 'On-farm evaluation and seed multiplication' was held in Honduras for scientists from Mexico and Central America and a workshop on 'Developing seed systems for forage species' in Colombia, for persons from both the public and private sectors in Latin America.

Plant Improvement

A major thrust on plant improvement has continued with *Brachiaria* of which there are some 40 million hectares in South America. But the productivity of the main species, *B. decumbens* - an apomict, is severely limited by susceptibility to the spittle bug insect. The ability to combine resistance found in some accessions of other species of *Brachiaria* through the sexual *B. ruziziensis* and to use the new techniques of screening for resistance, developed by Steve

Lapointe, and assessment of sexuality through embryo sac analysis, developed by Dr Cacilda do Valle of EMBRAPA-CNPGC, has allowed John Miles to make rapid advances in developing a spittle bug resistant *Brachiaria* with the same wide adaptation as *B. decumbens*. He is also investigating the inheritance of apomixis and has successfully hybridised *B. ruziziensis* and *B. jubata*, some accessions of the latter having a unique form of resistance to spittlebug. The chemical nature of the resistance to spittle bug is being investigated in a collaborative program with Cornell University. Improvement of *Brachiaria* is also continuing through the screening of a major introduction of *Brachiaria* accessions collected in Africa. Other attributes being selected for are tolerance to waterlogging and improved nutritive quality.

Accessions of *Panicum maximum* adapted to the very acid and infertile conditions of Llanos Orientales have been confirmed in Category III animal evaluation trials in Carimagua.

The main thrust in legume improvement continues to be focussed on the forage *Arachis* species, in particular on *A. pintoi*. This legume has shown very wide adaptation to soil and climatic conditions, has not been severely affected by disease or insect damage, is compatable with the very competitive *Brachiaria* species and its value as a quality animal food and contributor to soil nitrogen has been confirmed in many experimental and on-farm situations. Further, it has been demonstrated in Costa Rica that a vigorous *A. pintoi-Brachiaria* pasture can suppress weed invasion, a major problem in pastures of the humid tropics. This characteristic has led to it being demostrated as a useful ground cover for tree crops. However, widespread adoption by livestock farmers will depend on educating and convincing them of the value of grass-legume pasture over the traditional nitrogen fertilized grass pasture and devising a reliable seed production and storage system.

On-farm evaluation of *A. pintoi* based pastures has commenced in

Costa Rica in collaboration with CATIE and MAG but further seed funds are needed to extend this activity to other countries in the region. High seed production has been achieved by the regional agronomists in small plot trials and John Ferguson, the seed biologist, who also has demonstrated that this can be achieved in farming situations. However, further work is needed to ensure that high seed quality is obtained and maintained during storage. The TFP is also collaborating with EMBRAPA-CENARGEN to acquire and evaluate a much wider range of genetic variability that is known to exist in forage *Arachis*. Some 45 accessions of *A. pintoi* are currently undergoing primary evaluation in Brazil. Idupulapati Rao, the plant nutritionist, has suggested that one reason for the compatibility of *A. pintoi* with *Brachiaria* species is its superior ability to acquire alumimun-bound and organic phosphorus from the soil. Foliar symptoms of nutrient deficiencies have been described and photographed.

Research on improvement of *Stylosanthes* has focused on breeding for resistance to anthracnose and increasing seed production. There are now several advanced lines available for regional evaluation. It was demonstrated at Planaltina, Brazil that commercial seed production of *S. guianensis* could be increased considerably by use of irrigation. It is planned to increase research activity in improvement of *Stylosanthes* as this genus has the potential to become a major legume for forage and soil improvement throughout the tropical world. This is illustrated by the widespread adoption of the cultivar 'Pulcallpa' (CIAT 184), selected as a forage for the humid tropics of South America, but now being used extensively as a cover crop in orchards in southern China.

Non-chemical control of diseases and insects

The TFP is pursuing a policy of Integrated Management for control of pests and diseases. It was mentioned above that the entomologist, Steve Lapointe, is collaborating on research to elucidate the nature of the resistance to spittle bug. It has also been demonstrated that spittlebug infestation can be reduced by management practices of heavy grazing and introduction of fungal insect-pathogens. Damage by leafcutter ants can be managed by use of tolerant cultivars and cultivation prior to establishment. An exciting new development is the possibility of isolating the chemical agent that inhibits the growth of the ant fungus.

In the area of disease control our pathologist, Segenet Kelemu, has commenced work with a *Bacillus* sp. that produces a broad anti-fungal activity. A crude antibiotic extract inhibited the growth of *Colletotrichum* and *Rhizoctonia* species isolated from different pasture and crop plants. There are plans to identify the gene or genes involved with a view to transferring them to plants.

Forage quality

Research has concentrated on the difference in feed quality among legumes, in particular new shrub legumes, and the reasons for these differences. Carlos Lascano, animal nutritionist, has shown that the higher digestibility of shrub legumes such as *Cratylia argentea, Desmodium velutinum* and *Uraria* species is associated with low tannin levels. Considerable variation has also been found in the tannin levels of species such as *Flemingia macrophylla*, thus offering opportunity for selection of low tannin cultivars.

Different methods for tannin analysis were investigated with the finding that the Butanol-H_2SO_4 method gives good estimates of soluble and condensed tannins. Contrary to suggestions that only soluble condensed tannins are responsible for the depression of fibre and protein degradation, research has shown that soluble condensed tannins depress ammonia production and insoluble condensed tannins depress fibre digestion.

Tannin extracts from fresh and dried legume samples showed that drying resulted in varying reactivity of tannins with protein for different species. This work will be followed up with feeding trials.

Nutrient cycling and pasture productivity

In a joint project with the Savannas Program, the processes controlling pasture productivity and animal production in a humid well-drained savanna system are being studied. Emphasis is being placed on utilization and cycling of plant nutrients and available nutrients for animal production. Legume-grass and pure grass systems are being compared on two soils of contrasting texture, and measurements are being made of nutrient cycling, soil organic matter, soil physical characteristics, plant-soil and plant-plant relationships, and animal intake and liveweight gain. The ultimate objective is to obtain sufficient mechanistic understanding of the processes involved to model the system so that the effect of various management options can be predicted.

BIOTECHNOLOGY RESEARCH UNIT
1988-1992

EXECUTIVE SUMMARY

1. BIOTECHNOLOGY RESEARCH AT CIAT

The involvement of CIAT in biotechnology research should be viewed against the ever-increasing gap between the progress being made in developed countries and that which is evident in most of the tropical developing countries. As an international public research institution, CIAT shares responsibility for ensuring that the benefits of biotechnology will not fail to be achieved for long-term public goals including growth, equity and good environmental stewardship.

CIAT has constantly been on the alert to identify innovations in science and technology that can result in quick pay-offs in terms of technology development. In its long-term plan for the 1980s CIAT anticipated its involvement in monitoring and applying biotechnology. In fact work on tissue culture for conserving cassava germplasm and accelerated rice germplasm improvement were tackled in 1980-84. In 1985 CIAT established the Biotechnology Research Unit (BRU) in response to a recommendation by the 1984 External Panel Review (EPR). From 1988-92, the period included in this report, a significant evolution in biotechnology research at CIAT took place. The BRU's research and collaboration focused further on critical challenges in CIAT crop germplasm and expanded to include the study of selected microorganisms; modern biochemical and molecular techniques were incorporated, developed and used to address those constraints. Priorization of production and utilization constraints led to the strengthening of international collaborative research, which in the case of cassava and beans, took the form of advanced research networks. Practical biotechnology methods and techniques have been integrated into the activities of other CIAT Units and Programs for further implementation and use. A considerable portion of the activities in the BRU have been carried out with special project funding.

2. THE BIOTECHNOLOGY RESEARCH UNIT

2.1 Role and Objectives

The role of biotechnology research at CIAT is to develop applications of modern biological methodologies for increasing the efficiency of CIAT strategic research in germplasm development. The BRU's work addresses three broad objectives: (i) characterization of genetic diversity, (ii) characterization of plant biotic and abiotic stress mechanisms, and (iii) broadening the genetic base of crops and germplasm conservation. CIAT biotechnology research focuses on important constraints in cassava, *Phaseolus* beans, rice for Latin America, some tropical forages, and will also pay attention to other selected components of the biodiversity occurring in CIAT agroecological regions.

2.2 Strategies

To perform its role as a scientific bridge for developing and using modern cellular, molecular and biochemical methods and techniques, the BRU employs three strategies:

- Biotechnology methods and tools are integrated into ongoing CIAT Program and Unit research activities: constraints that are amenable to biotechnological solutions are identified; the BRU monitors basic research developments worldwide and brings to CIAT new information, and research is carried out to develop and utilize biotechnology tools. Collaboration with CIAT scientists and advanced labs is essential for implementing this strategy.

- The BRU cooperates with CIAT programs and units to bring prioritized research constraints to the attention of the world scientific community and donors, encouraging and establishing international cooperative efforts and effective research linkages between research organizations in developed and developing countries and the strategic research conducted at CIAT.

- To accomplish its bridging role with the national agricultural research systems (NARS) of developing countries, the BRU cooperates with CIAT programs to offer training to developing country scientists and to organize workshops and visits to the NARS. Awareness on issues such as biosafety and intellectual property protection are also addressed.

2.3 Organization of the BRU's Activities

In the last three years, the BRU has implemented three interrelated research activities, which interphase in research at the cellular, biochemical and molecular/genetic levels with CIAT scientists and with responsibilities across CIAT germplasm: (i) characterization of genetic structure; (ii) characterization of mechanisms involved in resistance and tolerance to biotic and abiotic stresses in plants, and (iii) broadening of the genetic base of crops and germplasm conservation.

3. ACTIVITIES DURING 1988-92

3.1 Advanced Research Networks

The Cassava Biotechnology Network (CBN) was founded as a result of a workshop held at CIAT in 1988; and in a 1990 workshop, the Beans Advanced Research Network (BARN) was formed. Since its inception the CBN has made steady progress in encouraging research projects addressing critical cassava topics; from 5 projects in 1988 to 25 in 1992. The network was consolidated in 1992 with the appointment of a Coordinator and the organization of the network's first scientific meeting. Plans are under way for the first BARN scientific meeting in 1993. In addition, CIAT participates actively in the Rice Biotechnology Program under the auspices of the Rockefeller Foundation (RF).

3.2 Special Project Research at CIAT

In cooperation with CIAT programs and units, the BRU developed and carried out the following complementary research through special project funding:

- A pilot project on a cassava in vitro active genebank: 1988-90 (IBPGR)
- A pilot project on cassava cryopreservation: 1989-91 (IBPGR)
- Anther culture-derived haploids for rice germplasm improvement: 1989-91 (RF)[1]
- Gene tagging and mapping of rice hoja blanca virus (RHBV) and rice blast resistance genes: 1991-ongoing (RF)[1]
- Construction of a cassava molecular map: 1992-94 (RF)
- Gene tagging and mapping of common bean useful genes: 1991-94 (Belgian AGCD)[2]
- Construction of a molecular map of tepary beans: 1991-94 (Belgian AGCD)[2]
- Characterization of mechanisms involved in resistance to the bean weevil: 1991-94 (Belgian AGCD)[2]
- Operations and coordination of the Cassava Biotechnology Network (CBN): 1992-97 (Dutch DGIS)[3]

In addition, four PhD theses fellowships have been supported by the GTZ, CIDA and IDRC for the period 1990-93.

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[1] Two projects under a grant.
[2] Three projects under a grant.
[3] Cassava Program and BRU cooperation.

3.3 Collaborative Research Projects in Developed Countries

During the last five years, the BRU has collaborated in the following formalized research relationships with U.S. and European institutions:

- Cassava genomic studies. U. of Georgia, Athens, and Washington U., St. Louis: 1992-94 (RF)
- Rice Biotechnology: Cornell U., Ithaca; Purdue U., West Lafayette: 1990-onward (RF)
- Cassava cyanogenesis. Ohio State U., Columbus: 1990-92 (USAID)
- Cassava virus resistance. ILTAB, The Scripp Research Institute, La Jolla: 1990-93 (USAID, Rockefeller)
- Construction of a molecular map of common bean. U. of Florida, Gainesville: 1990-92 (USAID)
- Common bean molecular markers for evolutionary studies. U. of California, Davis: 1989-91 (USAID)
- Cloning of bean mexican weevil resistance gene and transformation of common beans. U. of Ghent, Belgium: 1991-94 (Belgium AGCD)
- Regeneration of common beans. U. of Bonn: 1990-92 (GTZ)
- Cassava cyanogenesis. U. of Newcastle Upon Tyne, UK: 1990-93 (RF, ODA, EC)
- Cassava somatic embryogenesis. U. of Bath, UK: 1988-90 (ODA)

In addition, nonformalized research relationships have been developed with a dozen US and European institutions.

3.4 Research Achievements and Future Plans

3.4.1 **Characterization of genetic structure**. In the past five years, the Unit has implemented various techniques to carry out detailed studies on the genetic structure of CIAT crops. Starting in 1988, seed protein and isozyme techniques were implemented and used to characterize the variability of the germplasm deposited in the Genetic Resources Unit (GRU). The questions to be addressed were different for each crop.

- In the case of **beans**, the molecular data available from research conducted at the U. of Wisconsin, Michigan State U. and Cornell U. provided a starting base for the research at CIAT. These studies were aimed at increasing our understanding of the variability of wild and cultivated *P. vulgaris*, the implications of domestication on the existing variability in cultivated beans, and the genetic structure of bean gene pools. Additional molecular markers such as RFLPs and RAPDs are currently being used either to complement the available data with a better resolution or address the same issues with more adequate tools. The use of mtDNA probes and minisatellites is being initiated. Additional emphasis will be placed on implementing or developing molecular markers to characterize the genetic diversity in order to manipulate said diversity through introgression from non-*P. vulgaris* species. The identification of species-specific probes and the use of markers from the common bean molecular map (constructed at the U. of Florida in cooperation with CIAT) to tag important bean genes will be areas of research in the coming years.

- The initial questions to be addressed in **cassava** were related to germplasm conservation. The collection contains an estimated 20% duplicates, resulting in increased costs of maintaining large field and *in vitro* collections. In order to detect possible duplicates, the collection was fingerprinted with isozymes. The survey initiated by the BRU was later implemented by the GRU in collaboration with the Cassava Program. More recently, DNA fingerprinting using both M13 and RAPD is being carried out to obtain better coverage of the genome. These markers will not only allow better identification of duplicates but will also provide information related to the stability of the *in vitro* collection and the characterization of the cassava gene pools and wild *Manihot*. The construction of a cassava molecular map using RFLPs and RAPDs has been initiated and will continue on the next few years, followed by the use of the map in gene tagging.

- Due to CIAT's regional mandate for **rice**, the focus of genetic characterization has been more toward understanding the genetic base. Isozyme analysis has already been conducted on elite and selected cultivars. To complement this study, an extensive survey is currently been carried out using RAPDs to understand the genetic base of elite cultivars of Latin American breeding programs and to link the molecular data with agronomic data. Using RFLPs and RAPDs on anther culture-derived doubled haploid populations, a resistance gene to RHBV has been tagged and located on chromosome 12; and the resistance gene to blast lineage SRL-1 was tagged and located on chromosome 4.

The direction of new research will focus on implementing and developing molecular markers that will provide ample information at a minimum cost. A Molecular Markers Applications Lab will be implemented for use by all CIAT programs and units. An additional research area will be the fingerprinting of microorganisms and its use for germplasm characterization. The use of PCR-based markers will undoubtly be expanded. Oligonucleotide DNA fingerprinting using repetitive sequences or species specific sequences will be tested for evolutionary and taxonomic and biodiversity studies. One of the primary uses of these markers will be the already established core collections in beans and cassava. Sequence-characterized amplified regions (SCARs) will be developed to facilitate future screening. Implementation of non-radioactive labelling will be further emphasized in the immediate future.

3.4.2 **Characterization of mechanisms involved in resistance and tolerance to biotic and abiotic stress in plants**. Research being done in this area can be subdivided into three categories:

- characterization of resistance mechanisms to pests and pathogens
- characterization of physiological and biochemical processes in plants and bacteria
- development of methodologies

In the first category we are investigating resistance to bruchids, a major pest of beans, and antibiosis to the spittlebug in *Brachiaria*. The molecular bases of co-evolution of the bean common bacterial blight (CBB) pathogen and *Colletotrichum lindemuthianum*, the fungal agent that causes anthracnose in beans, are also being researched. In the second category, studies are being conducted on the stress tolerance of cassava to drought and the related $C0_2$ assimilation mechanisms. We are also quantifying organic acids and sugars of forage roots under aluminum stress as part of a project to develop glasshouse screening techniques for acid soil tolerance. The study of the bacterial amylolytic activities during cassava starch fermentation also falls into this category. In the methodology development category, we are searching for more convenient alternatives for DNA extraction and the development of a quick, reliable methodology for quantifying linamarin in cassava.

i. Characterization of resistance mechanisms to pests and pathogens:

- **Resistance to bruchids**. Breeding programs have not been successful in introgressing the complex resistance trait to the bean weevil *Acanthoscelides obtectus* from wild to cultivated beans. Identification of a resistance-conferring factor has been elusive. We have identified a proteinaceous fraction in the resistant accessions that induces death of first instar larvae feeding on artificial seed suplemented with the fraction at lowest doses. The experiment is being repeated with *Zabrotes subfasciatus*, the Mexican bean weevil, to assess the specificity of the particular fractions toward the bean weevil.

Inhibitors of α-amylases with specific-action spectra that may play a synergistic role together with other resistance factors (e.g., arcelin) have been identified in certain wild bean accessions. Specific proteinase inhibitors are being sought.

As an alternative to natural resistance, we have initiated work to clone the specific inhibitor of the insect's gut cysteine-type protease, cystatine, from egg white into beans. This transgenic approach could be the basis for multigenic resistance, which would be harder to break. We have shown in artificial seed that this could be a very effective way to control the insect.

- **Antibiosis to spittlebug in *Brachiaria*.** The spittlebug causes severe damage in *Brachiaria decumbens* fields. Resistance has been found in *B. jubata*, and there are indications that the factor involved could be a phytoecdysone. We are working on this hypothesis by developing an immunologic assay for ecdysone. The antibody would not only be used to identify the substance, but could also be used to assay for ecdysone in germplasm improvement programs. Ecdysone has been successfully bound to a carrier protein in order to produce antibodies, and antisera to the conjugate has been produced. We are in the process of isolating polyclonal monospecific antibodies for the assay.

- **Molecular bases of co-evolution in bean pests.** In collaboration with the Bean Pathology Section, genetic diversity in the CBB pathogen was demonstrated by DNA fingerprinting, using two probes isolated from the genome and the plasmid, respectively, of a *Xanthomonas campestris* pv *phaseoli* (XCP) isolate. After optimizing the conditions for generating the fingerprint patterns, most of the collection comprising over 300 isolates, has been characterized. The pigment-producing XCP var *fuscans* (XCPF) was clearly identified by the probes. Furthermore, the isolates were grouped into families by their fingerprints, which relate to their geographic origins. An attempt will be made to establish the relationship between fingerprints and pathogenicity. This may not be an easy task as resistance to CBB is of quantitative nature and thus no races exist for XCP or XCPF.

DNA fingerprint analysis of *C. lindemuthianum*, the fungal agent that causes anthracnose in beans, has been initiated. For that purpose we have conducted hybridizations of total genomic DNA from different races with a ribosomal DNA probe and with the M13 bacteriophage. Some degree of polymorphism was detected but not enough to provide a fingerprint pattern. Polymorphisms in the ribosomal intergenic regions will be analyzed using PCR. Our goal is to understand the molecular basis of co-evolution of the fungus and beans. Our present model is based only on pathogenicity tests on differential bean lines.

ii. Characterization of physiological and biochemical processes in plants and bacteria:

- **Drought and heat tolerance in cassava.** The objective of this project is to understand the molecular mechanisms involved in photosynthesis that enable cassava to grow under drought and high temperature stress. The goal is to develop selection criteria for this trait in germplasm development programs. We are in the process of cloning genes involved in CO_2 assimilation and have also purified PEP carboxylase from cassava in order to carry out *in situ* hybridization studies and immunohistochemistry on thin sections of embedded leaf tissue. These techniques are being used to establish the cellular compartmentalization of the enzymes in the leaf and thus facilitate the elucidatiion of the underlying mechanisms.

- **Aluminum tolerance.** HPLC is being used to measure carboxylic acid and sugar levels in roots of plants treated differently with respect to aluminum and phosphorus concentrations. This is part of a project being carried out by the Tropical Forages Program (TFP) Nutrition Section, aimed at understanding the molecular mechanisms involved in tolerance to acid soils.

- **Cassava starch fermentation.** Solid-state fermented cassava is a natural product that is traditionally produced and consumed in Colombia and in Brazil. It can replace a certain percent of wheat flour in many products and is used as a unique starch source in several others. We are characterizing the amylolytic bacteria involved, at the enzymatic and molecular levels, in order to identify the strains best suited for the process and help define the fermentation parameters that will lead to reproducible high-quality fermented starch. Defined inocula would be a useful step toward upscaling of the process. This is part of a larger project, headed by SAR/CIRAD, to analyze the problem from the technological, microbiological, biochemical and market standpoints.

3.4.3 **Broadening the genetic base of crops and germplasm conservation.** In this area research has been conducted to develop and use methods and techniques for gene transfer by sexual and nonsexual means for expanding our access to a wider range of genetic variability from related and more distant sources. Development of methodologies for conserving genetic resources is another BRU activity, contributing toward broadening the genetic base of CIAT crop germplasm.

i. Building upon the Unit's early work on *in vitro* conservation of cassava, a collaborative project was established to develop and implement the technical and logistical aspects of this approach for running a large (i.e., over 4500 accessions) *in vitro* collection. The cassava *in vitro* active gene bank was transferred under the responsibility of the Genetic Resources Unit in 1989.

ii. Following the development of the *in vitro* active gene bank for cassava germplasm, a breakthrough was achieved in cassava cryopreservation. Complete plants have been recovered consistently from cassava shoot tips conserved in liquid nitrogen. Future work will emphasize expanding the protocol to a wider range of cassava genotypes and developing the logistics for a base gene bank of cassava in liquid nitrogen.

iii. With the objective of transfering important traits--i.e., resistance to bacterial blight and to *Empoasca*, and tolerance to drought--from tepary beans (in the tertiary gene pool) to common beans (primary gene pool of *Phaseolus*), an interspecific crossing system was implemented using recurrent and congruity backcrosses aided by embryo rescue and culture. Large numbers of recurrent and congruity mature, fertile hybrid plants have been obtained for field evaluation. Work continues to increase fertility of the hybrids further in order to develop a tepary x common bean gene pool and eventually expand this to other *Phaseolus* species so as to access traits not expressed, or inadequately expressed, in the common bean.

iv. We have developed a model system for transforming and expressing foreign genes using the forage legume *Stylosanthes guianensis*. Regeneration of *Agrobacterium*-mediated transformed stylo plants, expressing marker genes, was achieved. The presence of the introduced gene and its Mendelian inheritance have been demonstrated. In the case of cassava, regenerated somatic embryos are growing in a selection medium, following transformation with *A. tumefaciens*. In addition, expression of a reporter gene was obtained in cassava somatic embryos 60 days after particle bombardment.

   Plant regeneration of five *Brachiaria* spp. through somatic embryogenesis and organogenesis and of *Arachis pintoi* through organogenesis was obtained. Likewise, regeneration of plants from isolated protoplasts of an *indica* rice variety was achieved. These results are critical for developing methodologies for future implementation of novel strategies of germplasm enhancement.

3.4.4 **Technologies transferred to programs and units**. As a means of enhancing the integration of biotechnology tools into CIAT program and unit activities, responsibility for the following activities was shifted from the BRU to the respective Program/Unit during the period 1988-90:

- Rice anther culture to the Rice Program: 1988-89
- Cassava *in vitro* genebank to the GRU: 1989
- Cassava germplasm exchange *in vitro* to the GRU: 1989
- Isozyme fingerprinting of cassava germplasm to the GRU/Cassava Program: 1988
- Bean germplasm characterization using phaseolin markers to the GRU: 1988
- The implementation of a Molecular Markers Applications Lab, will be carried out shortly as a means of increasing the application of molecular genetic markers at CIAT.

3.4.5 **Training**. Nearly 90 people from NARS of 20 countries in Latin America, Asia and Africa have participated in various training activities on tissue culture, biochemical and molecular characterization of genetic resources at CIAT. Future training will emphasize advanced degree theses and in-service research, linked as much as possible to research projects in the NARS.

3.4.6 **Biosafety**. Biosafety Guidelines and an Institutional Biosafety Committee (IBC) have been organized at CIAT to oversee and advise the Director General and Management on Center research using R-DNA organisms and their eventual release into the environment (small-scale testing). The Colombian Institute of Agriculture (ICA) has appointed a representative to the IBC. The guidelines have been prepared to adapt to the latest developments in the field and abide to the oncoming Colombian legislation.

3.4.7 **Complementary future initiatives**:

- The BRU's activities in the characterization of genomic structure and resistance/tolerance mechanisms for implementing genetic manipulation approaches and broadening the genetic base of crops will be complemented with activities for characterizing natural plant-microbial systems as a means to develop safe biocontrol methods.

- The Unit will develop molecular markers to analyze the genetic diversity in CIAT agroecosystems, and draw relationships between plant populations and gene pools, and describe gene flow from ancestral to cultivated species. The goal is to optimize strategies for the *in situ* and *ex-situ* conservation and utilization of critical components of the biodiversity. The biodiversity in CIAT agroecosystems.

- In the oncoming years the BRU will enhance its contribution to the Center's activities designed to enhance public awareness on issues related to biotechnology, such as environmental impact, equity, intellectual property protection and access to, and use of, genetic resources.

EXECUTIVE SUMMARY: 1992 HIGHLIGHTS

This year, the GRU focused its efforts on solving specific issues and/or constraints identified by last year's in depth program review. Modifications were also made to the GRU's personnel structure in response to the layoff that took place in December, 1991.

TROPICAL FORAGES GERMPLASM

CIAT's collection of tropical forage germplasm is managed by the Genetic Resources Unit (GRU), since 1990. The collection consists of about 150 genera with more than 700 wild and undomesticated species of possible forage potential. These species belong predominantly to the legume family, about 10% are grasses. At present, 23,265 accessions are registered, of which 20,193 accessions are conserved in the collection. Of the conserved accessions 70% (14,136 accessions) have enough seed for distribution.

Highlights during 1992 are the following:

(1) Major acquisitions to CIAT's collection of tropical forage germplasm were a donation of *Panicum maximum* germplasm, originating from the French ORSTOM collection and new legume germplasm from a collection trip to Vietnam and Thailand.

(2) A survey of seed health status of *Stylosanthes* spp. stored under short-term conditions over varios years, with special emphasis on anthracnose, revealed the need for further studies.

(3) Monitoring of seed germination of those accessions stored in the base collection for five and more years was initiated, indicating that high quality seed may be stored over a long period of time.

(4) In two collaborative projects, taxonomy and genetic variability of *Brachiaria* are being studied, utilizing morphological characters and isozymes.

Phaseolus BEANS GERMPLASM

Six aspects of managing *Phaseolus* germplasm were emphasized during 1992:

(1) Follow-up on the release of the first draft of accessions, selected for the "core" collection of *P. vulgaris*, from both primary and secondary centers of diversity.

(2) Implementation of ORACLE the new relational database system used for handling data produced and needed during the management of the *Phaseolus* germplasm collection.

(3) Initiation of a thorough revision of the inventory of germplasm stored under short and long-term conditions to program multiplication in different field locations (Tenerife, Popayán).

(4) Edition and release of a catalog of the available *P. vulgaris* germplasm (23,767 accessions).

(5) Completion of a research project to estimate the percentage of allogamy in the field location used for seed increase-multiplication purposes (Tenerife, 2000 m.a.s.l.) of *P. vulgaris* in cultivated and wild forms: The allogamy average found for cultivated forms was less than 1%, whereas the average for wild forms was about 1.5%.

(6) Completion of a research project to compare the genetic diversity of the "core" collection with that of the original reserve collection by using nine isozyme systems. The results indicated that 95.7% of alleles were preserved in the 100 accessions selected for the "core" from a population of 382 accessions.

Cassava (*Manihot*) Germplasm

The most important developments in the management of in vitro cassava germplasm in 1992 are:

(1) The number of cassava clones maintained in the in vitro gene bank increased this year to 5051, which is 95.9% of CIAT's entire field collection.

(2) A total of 775 clones were indexed for CCMV, CsXV, and CCspV, and 507 clones were processed for FSD (225 are part of the collection).

(3) Including 16 wild species, 293 clones were distributed to 13 countries, through 18 requests. CIAT received 93 clones from Brazil and Thailand.

In addition to the above, two highly significant events for institutional relationships took place this year: in August, 1992, CIAT hosted the First International Workshop on Cassava Genetic Resources, in collaboration with IITA and IBPGR. The workshop identified problems and issues for cassava genetic resources and successfully formulated global action plans to develop an effective international network of cassava genetic resources. The second event CIAT organized was the Latin American Course on in vitro Germplasm Management in October. This helped national program partners to acquire updated knowledge and technology in this area.

Electrophoresis Laboratory

Characterization of both the cultivated cassava collection and the in vitro collection of wild *Manihot* was the major goal during 1992. In fact, 4623 accessions, i.e. about 88% of the total conserved, have been characterized by using the αß-esterase isozyme. The 2146 different isozyme patterns found together with morphological descriptors, are being used for detecting duplicates. So far, 2059 identical groups have been detected and their constitution ranges from one accession (unique genotypes) to 25 accessions. Although the isozyme patterns are useful for discriminating between individuals, they do not reveal geographical groups, whether by country or region. In cooperation with the BRU, a study is under way to use molecular markers, i.e., DNA fingerprinting, to confirm those duplicates detected by morphology and isozyme patterns. Progress is being made in establishing DNA fingerprinting in cassava, and several probes are being monitored to find at least one with a high polymorphism.

Of the 393 genotypes of wild *Manihot* species, 138 (35%) were characterized by isozymes; this percentage includes 29 species of the 33 included in the in vitro collection. High intraspecific polymorphism was found in four species.

Seed Health Laboratory

The Seed Health Laboratory (SHL) is responsible for testing the seed health status of germplasm destined for international exchange. Between October 1991 and September 1992, 2592 samples (3491 accessions) were analyzed: 98.6% corresponded to bean germplasm and 2% to tropical forages legumes and grasses. Of the samples analyzed, 65% showed no pathogens of quarantine importance, although pathogen presence varied between samples according to CIAT's research program sections. On the average, of the samples 19.9 % carried the fungi *M. phaseoli* and *R. solani*. Bacteria were detected on bean seeds in low percentages: *X. campestris* pv. *phaseoli* was the most common. An average of 18.7% of the samples registered positive to BCMV ranging from 6.3% to 55.6%. BSMV was detected in an average of 3.3% of ranging from 0.7 to 7.4%. Research on the effect of seed treatments and storage on the survival of pathogens was initiated.

BIOMETRY UNIT
ANNUAL REPORT 1992

- EXECUTIVE SUMMARY -

1. BIOMETRY UNIT: Role, functions and resources

The Biometry Unit provides advise and support to CIAT research Programs/Units in two main areas:

a) Biometry/data analysis methods.

b) Conceptualization and implementation of databases of experimental results.

During this transition period to a distributed processing environment at CIAT and the possible creation of a new Unit responsible for providing CIAT-wide computer services, the Biometry Unit (previously called Data Services Unit) is still responsible for the provision and maintenance of appropriate computer hardware and software to serve the scientific program's needs through the CIAT mainframe computer, IBM 4361, with its network of 37 terminals and 41 connected microcomputers.

Biometry support: Role definition:

Biometry collaboration to CIAT research Programs/Units includes the following functions:

a) Statistical/mathematical advice to researchers in project design, data analysis methodology, interpretation of results, their generalization capacity, and final presentation.

b) Involvement in collaborative methodological studies and specific data analysis projects with researchers.

c) Training in statistical/mathematical methods and data analysis to colleagues in other disciplines (both internal and external).

d) The biometrician participates as member of database teams --databases containing CIAT experimental results on crops and forages-- by providing selected input to the databases: appropriate statistical summaries with which to characterize a given research process.

An important activity of the biometrician is his/her involvement in **collaborative data analysis projects** with researchers, aimed at responding relevant questions of research. These projects utilize data generated by a given research project through the years, combine experimental results of a given research discipline, or combine data generated by various disciplines within a Program. The results of some of these projects have appeared as chapters of CIAT Programs publications, some as contributions to International Networks reports, some have been published as joint papers with the scientists, and some others are in progress. A brief summary of selected case studies are included in this report.

Another important activity is the biometrician involvement in collaborative **methodological studies** with researchers. The biometrician contribution in this context is to identify sources of variation relevant for research planning; evaluate and recommend appropriate experimental designs for a given research; evaluate and recommended appropriate statistical analysis methodologies: their efficiency, accuracy and applicability for a given research problem.

Basic **training** in statistical methods and data analysis is provided to CIAT research associates/assistants and to National Institutions researchers from Latinamerican and African institutions, CIAT collaborators. The Microcomputer Training Laboratory is used for this purpose. During the five years of existence of the Laboratory, Biometry has offered a total of 35 one to two-week training courses, with a total number of 344 National Institutions researchers trained from Latinamerica (260), Asia (24) and Africa (50). An approximate number of 105 participations from CIAT research associates/assistants have benefit from this effort, during a 5-year period.

In the light of the new CIAT, new areas of biometrical expertise in which invited Biometrician Consultants can add useful contributions are foreseen. For example: a) Design and analysis of intercropping experimentation, combining multiple short-cycle crops or combining perennial and short-cycle crops. b) Design and analysis of agro-silvo-pastoral systems. c) Quantitative genetics/population dynamics. d) Econometric techniques in response to a new expected demand from the economists/social scientists.

Statistical/data analysis software for the mainframe computer include: SAS/BASICS, SAS/STATS, SAS/GRAPH, SAS/FSP, SAS/ETS, SAS/IML and SAS/OR from SAS Institute Inc. Raleigh, North Carolina, USA; GENSTAT, from the NAG Algorithm Group, London, England. Microcomputer statistical/data analysis software include MSTAT, from Michigan State University; GLMM, from Louisiana State University; SYSTAT, from SYSTAT Inc. Chicago, Illinois, AGROBASE/4, from Agronomix Software, Manitoba, Canada; MATMODEL from Soil, Crop and Atmospheric Sciences, Cornell University, Ithaca, New York; Lotus 1-2-3 and Dbase III.

Databases of experimental results:

The conceptualization, design and implementation of databases to store crops and pasture research results, require from the "database teams" a clear understanding of the biological nature of the crop and its multiple components. Members of our "database teams" include: a) the System's Analyst, who is the software expert, the designer of the how to efficiently store the datafiles with minimum redundance, and how to provide interactive access to the data in the most effective manner; b) the Researcher(s), who have a clear understanding of the problem and the purpose of the database; and c) the Biometrician, who has a clear understanding of the data and of the most suitable statistical summaries with which to characterize a given research process.

In terms of database management software technology an important decision was reached in September 1991: that of moving from the 'network' database technology, represented by our previous database management software IDMS/R from Computer Associates Inc., to the 'relational' database technology, represented by ORACLE, from Oracle Corporation. Starting October 1, 1991, ORACLE was acquired as the standard database management software for CIAT's mainframe and microcomputer environment, as a replacement of IDMS/R. Previous problems in design, implementation and utilization of research databases developed on IDMS/R during the past 10 years, such as lack of flexibility for modifying a database design, extremely long data loading times, lack of a user-friendly query tool, lack of a flexible and powerful development tool and lack of micro-mainframe interface, have been greatly solved. Between October 1991 and December 1992, four important ORACLE database applications have been designed, implemented and released to the end-user:

a) The **Genetic Resources Database**, including passport and characterization data on all CIAT's germplasm collections: beans (40,000 accessions approx.), cassava (4,700 varieties approx.), tropical forages-legumes and grasses (25,000 accessions approx.).
b) The **Cassava Breeding Database**, including information on parents and crosses, F_1 evaluations, statistical summaries of preliminary yield trials, advanced yield trials and regional trials. This database contains at present research results between 1974 and 1992.
c) The **Bean Breeding Database**, linked with the Bean Genetic Resources database, includes information on crosses genealogy, advanced lines genealogy, advanced lines evaluations, VEF - EP trials from 1977 - 1991 and, IBYAN trials from 1976 - 1990. Results and statistical summaries from other international nurseries conducted by Bean Scientists are planned to be added in 1993.
d) The **Tropical Forages Evaluation Database**, linked with the Tropical Forages genetic resources database, contains results from the characterization and early evaluation of grasses and legumes carried-out by Program Scientists since 1978 up to present. Most of this application was implemented in IDMS/R. Its re-design and implementation in ORACLE of a large part of its components, was carried-out in 1992 in a very close collaboration with the Program Leader and Scientists. This effort will continue during 1993.

Details on these four major ORACLE databases are described in this report.

Training courses for end-users in the use of ORACLE databases: The Unit has provided 4-day training courses to users from the following programs: Bean Program breeding sections and Cassava breeding Section (February 92), Genetic Resources Unit (Dec/91 and November/92) and Tropical Forages support personnel (November/92). These short courses were intended to explain content of the databases to the direct users and teach them how to do easy queries to each database.

PERSONNEL RESOURCES. Composition of Biometry Unit teams to support CIAT research Programs/Units

The list of our 1992 personnel is presented at the beginning of this report. In order to provide a multi-skilled support to each CIAT research Program/Unit in the two areas of the Unit responsibility --Biometry and Databases of experimental results-- teams of biometrician/analyst/programmer are assigned to serve the needs of **projects** within each Program/Unit.

Through this approach, each Program/Unit scientist has access to the range of technical skills represented by personnel within the Biometry Unit. The attached table shows the composition of these teams.

VIROLOGY RESEARCH UNIT

EXECUTIVE SUMMARY
1988 - 1992

December 1992

DESCRIPTION OF ACTIVITIES

CORE ACTIVITIES IN THE AREA OF PLANT PROTECTION

IDENTIFICATION OF VIRUSES AFFECTING CIAT-MANDATED COMMODITIES

Specific course of Action

The VRU will concentrate research efforts on the unknown viral pathogens of cassava, particularly the virus-complexes found in Colombia, and of tropical forage legumes, with emphasis on those species currently being exchanged with collaborating national agricultural research institutions.

Outputs

Identification of Bean Viruses

The major viral pathogens of *Phaseolus vulgaris* have been already identified worldwide. A major effort to conduct a survey of the most limiting viral diseases of *P. vulgaris* in Latin America, East Africa, West Asia, and China has produced data indicating that Bean Common Mosaic Virus (BCMV) is still the most ubiquitous viral pathogen of beans worldwide. The mosaic-inducing strains of BCMV predominate in most continents with the exception of East Africa where the necrosis-inducing strains of BCMV, mainly BCMV NL3, are commonly found. Another virus closely related to BCMV but of limited distribution in the above-mentioned continents, is bean yellow mosaic virus. This virus and its numerous strains occur mostly in temperate zones of the world. Some beetle-transmitted viruses of beans, such as bean southern mosaic and bean mild mosaic viruses, are also widely distributed in the world and in the American Continent, respectively, due to their seed-transmissibility and/or high rate of seed contamination. Another important group of beetle-transmitted bean viruses is the bean severe mosaic virus complex. Last, the whitefly-transmitted viruses, bean dwarf mosaic and bean golden mosaic viruses have caused the loss of thousands of hectares traditionally planted to beans in Central and South America, and the Caribbean.

The VRU has been carefully monitoring the spread of several viruses of the cucumber mosaic virus group (cucumoviruses). These viruses are now found worldwide wherever beans are grown, and are a threat to bean production in Latin America, North America, Africa, and West Asia. The main mode of transmission of these cucumoviruses, is through seed and by several aphid species.

The last exotic virus identified in Latin America, is *alfalfa mosaic* virus, also a seed-borne virus efficiently transmitted by aphids. Currently the virus is restricted to the southern cone of South America.

Identification of Cassava Viruses

Caribbean mosaic and frogskin disease are distinct manifestations of the same disease and the distribution of the disease has been extended. Frogskin (FSD) and Caribbean mosaic diseases (CMD) have long been considered as distinct diseases. Studies on the expression of symptoms in different environments and genotypes, as well as progress on the identification causal agents confirm that FSD and CMD are different manifestations of the same disease. For this and future reports the isolates of CMD will be considered as isolates of FSD.

Although FSD was first described in the mountain valleys of Colombia, it is present throughout Colombia, is common in the Amazonian region of Brazil, and is in Central America.

A reoviruslike virus is associated with FSD. Viruslike particles 80 nm in diameter have been consistently found in plants infected with FSD. Inclusionlike bodies have been found in affected plants. Consistently nine ds-RNA segments are found in the affected plants. Based on the morphology of the viruslike particles and ds-RNAs, the virus associated with FSD should be classified in a new genus of the reoviruses. The research on FSD is continuing and the investigations are centered on confirming the association of the reovirus-like agents and the entire complex of disease symptoms.

Identification of the distribution of cassava vein mosaic virus. Surveys to the determine the distribution of cassava vein mosaic virus (CVMV) were made, and it was found to be a widespread pathogen throughout the semi arid area in the northeast of Brazil. It is not unusual to find more than 50% of the plants infected with CVMV. CVMV is also found in Venezuela. The expression of symptoms are unusual, because they are more severe at high temperatures, and the infection can latent during cooler seasons.

Identification of Tropical Forage Viruses

So far, the main forage legumes investigated by the VRU, according to past research priorities of the TPP, were *Arachis pintoi, Centrosema* spp., and *Stylosanthes* spp. To date the VRU has identified six potyviruses infecting these species, some of which are well known viruses of other legumes. Recently, an isometric virus has been detected for the first time in *Calopogonium mucunoides*.

The first virus identified in a forage grass, was recently detected in several locations of Colombia and Brazil, affecting different species of *Brachiaria*.

CHARACTERIZATION OF VIRUSES AFFECTING CIAT-MANDATED COMMODITIES (BIOLOGY)

After viruses, which infect CIAT-mandated plant species, have been identified and shown to be important (not opportunistic), they have to be characterized to gain information on their pathogenicity, variability, mode of transmission, and to physically isolate them to produce reliable detection methods, such as antisera, probes, etc.

Specific Course of Action

There are still a number a bean viruses, such as bean severe and cucumber mosaic viruses which must be fully characterized within the 1992-1996 period. This is also true of cassava, where, most viruses occurring in Latin America, have only been partially characterized. The characterization of the CCMV and CVMV are significant pathogens are being characterized by the VRU.

The identification and characterization of unknown viruses of forage legumes investigated by the Tropical Pastures Program.

The characterization of the rice hoja blanca virus at the molecular level is being undertaken to better understand the virus.

Outputs

Characterization of Bean Viruses

The Bean Severe Virus Complex predominantly belongs in the cowpea Severe Mosaic Virus Serogroup. There are several comoviruses which attack bean cultivars in tropical America, particularly in Mexico, Central America, the Caribbean, and South America, (mainly in Venezuela and Brazil). A recent investigation of Central American, Venezuelan, and Brazilian comoviruses, demonstrated that they most likely belong to the cowpea severe mosaic virus serogroup and they all have the capacity to induce necrosis in many improved bean cultivars.

The cucumoviruses that infect common beans worldwide possess considerable pathogenic variability and different origins. Cucumoviruses are undoubtedly the most epidemic group of viruses attacking beans around the world. The various cucumoviruses isolated from beans in South America, West Asia, and China, are pathogenically different not only in *P. vulgaris* but in other plant species, including cucurbits. The classification of cucumoviruses adapted to legumes, has not been discussed yet by legume virologists and therefore we can not assign them yet to any known subgroup of plant viruses. The characterization of these bean cucumoviruses at the molecular level, however, suggests that their virulence is related to the presence of a conspicuous band of satellite RNA or CARNA 5 (CMV-associated RNA 5).

The molecular characterization of the main bean golden mosaic virus (BGMV) isolates which affect beans in tropical America has demonstrated the existence of different viruses (strains) inducing bean golden mosaic in South America, Central America, and Mexico. The current proposal is to maintain the name bean golden mosaic virus and denominate the various strains as Type I, II, etc.

Characterization of Cassava viruses

Characterization of the reovirus associated with FSD. The viruslike particles in plants affected with FSD have been partially purified. During the purification process, the particles quickly degrade and after one cycle of centrifugation a 50 nm particle, typical of the inner core of reoviruses, is the predominate particle.

A cDNA probe has been developed to identify rapidly the ds-RNAs associated with the disease. In hybridization analysis both the FSD and CMD isolates cross hybridized giving further evidence that the causal agents are very similar.

The vector of FSD is Bemisia tuberculata. The whitefly Bemisia tuberculata is the vector of the reovirus-like virus. Plants infected by whitefly transmission were grown in a screenhouse and expressed symptoms typical of FSD.

The primary molecular characterization of cassava common mosaic virus has been completed. Although cassava common mosaic virus is found throughout south and central America, it is most prevalent in southern Brazil, Paraguay, and northern Argentina. The symptoms are most severe during the periods of cooler temperatures in the subtropical areas. Serological tests are available for the detection of CCMV and the screening of germplasm. The complete sequence of CCMV is 6387 bases in length, and encodes for six proteins. 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.

The distribution of CVMV has been determined and the virus has been partially characterized. Cassava vein mosaic virus (CVMV) is found in Brazil and Venezuela. Since the virus is not present in Colombia, all work with infectious virus has to be done in Brazil. We are able to work and have obtained a full length (approximately 8500 bases) non-infectious cDNA clone to CVMV. Nearly 3000 bases have been sequenced and we non-infectious cDNA clone to CVMV. Nearly 3000 bases have been sequenced and we are preparing a fusion protein to the coat protein and PCR primers in order to develop rapid diagnostic tests.

Characterization of Rice Viruses

Genomic characterization of rice hoja blanca virus. The genome of RHBV was determine to contain four species of ss-RNA. Also three species of ds-RNA were detected in purified viral preparations. Two proteins were translated *in vitro* from purified RNA. A 20K protein was translated from the RNA 4, and it is the major nonstructural (MNS) protein that is expressed in plants but not in the insect vector. A 17K protein was translated from the RHBV RNA 3.

Complementary DNA cloning and primary molecular characterization of RHBV. Complementary DNA (cDNA) libraries to RHBV have been prepared. The library contains cDNA clones that represent the complete RNA 3 and RNA 4. There are cDNA clones that represent parts of the RNA 1 and RNA 2.

The entire RNA 4 has been sequenced, and it is an ambisense RNA species. The viral RNA 4 (vRNA 4) and the viral complementary RNA 4 (vcRNA 4), each encodes one protein. The protein encoded by the vRNA 4 strand is the MNS protein, and there is enough similarity with other proteins to suggest that this MNS protein may play a role in the transmission of RHBV.

The entire RNA 3 has been sequenced and it is also an ambisense RNA specie. The viral coat protein is encoded by the vcRNA 3 strand. The coat protein gene will be transformed into rice as part of experiment to generate rice plants resistant to RHBV using the coat protein mediated cross protection technique.

Characterization of Tropical Forages Viruses

The majority of viruses identified to date in the tropical forage legumes: *Arachis pintoi, Centrosema* spp., and *Stylosanthes* spp. are members of the potyvirus group. These flexuous, filamentous viruses, are typically transmitted by mechanical means, aphids in a non-persistent manner (within a minute), and some through seed. The main potyviruses of *Centrosema, Arachis* and *Stylosanthes* have been characterized as strains of soybean mosaic virus, in the case of *Centrosema*, and as peanut mottle virus strains, for the potyviruses found in *Arachis* and *Stylosanthes*.

The potyvirus found in *Brachiaria* is closely related to guinea grass mosaic virus, originally described in Africa.

SEARCH FOR SOURCES OF VIRUS-RESISTANCE (PLANT PROTECTION COMPONENTS)

This is an activity which plays a major role in support of general germplasm development activities at CIAT in the same period.

Specific Course of Action

The viruses for which suitable sources of genetic resistance need to be identified are: cassava viruses in general, bean severe, bean yellow and cucumber mosaic viruses in *P. vulgaris*; potyviruses in general in tropical forage *Centrosema* and *Stylosanthes* species, and, in the case of rice, it would be advisable to broaden the genetic base of rice hoja blanca virus resistance. These activities will certainly be developed in 1992-1996.

Outputs

Sources of Resistance to Bean Viruses

Identification of recessive genes conferring protection to bean severe mosaic. Some bean genotypes, such as Great Northern 31 and 123, Red Mexican 34 and 35, Pinto UI 114, and the experimental line IVT 7214, devoid of the dominant I gene (effective against bean common mosaic virus), are tolerant to bean severe mosaic viruses. A preliminary genetic analysis of the nature of resistance in Great Northern 123, indicated that this bean genotype possesses a recessive gene which greatly restricts the virus. This recessive gene also protects dominant I-gene bean genotypes against the development of necrosis, attenuating symptom expression.

In simultaneous studies with other bean genotypes, such as Arbolito Retinto, which react to bean severe mosaic viruses with top necrosis, despite the absence of the dominant I gene, it was found out that these genotypes possess a dominant 'top necrosis' gene, independent of the dominant I gene. The detection and avoidance of this gene in future crosses is essential to the stability of improved bean germplasm.

Selecting for resistance to bean golden mosaic in interracial populations of common beans. Significant differences among 83 recombinant inbred lines, selected from a population obtained from the cross Pinto 114 and ICA Pijao, were found for virus incidence, mosaic, and yield. The heritability values for all yield components was higher than 0.49. It is thus apparent that considerable progress in increasing the level of BGMV resistance can be achieved in *P. vulgaris* by exploiting interracial crosses.

Multiple resistance to bean yellow and cucumber mosaic virus in *P. vulgaris*. Although there is considerable pathogenic variability in bean yellow (BYMV) and cucumber (CMV) mosaic viruses, some common sources of resistance have been identified against both viruses in medium-seeded genotypes of Central (Meso-) American origin, such as Pinto, Red Mexican and Great Northern genotypes. However, it is evident that there are strains of both viruses, capable of attacking all *P. vulgaris* genotypes tested so far. Fortunately, BYMV is of restricted distribution and, in the case of CMV, the VRU is closely following the incorporation of resistance to CMV in other horticultural crops through genetic engineering techniques. Potential collaborators have already been identified.

Sources of Resistance to Rice Viruses

Strain diversity of RHBV and the breakdown of resistance. The resistance in most of the varieties is thought to be controlled by a single dominate gene. There is already some evidence that the resistance may be less effective than originally thought, and resistant varieties such as llanos 5 are being infected in the field by RHBV. While it is still not known if this breakdown of resistance is from inadequate screening methodology or a result of aggressive strains of RHBV. The strain used to screen these varieties at CIAT appears to be closely related to the strains in the Tolima valley where the breakdown of resistance is occurring. The similarity of the strains was determined both serologically and by nucleic acid hybridization analysis. This indicates that there may be a need to improve the screening methodology for resistance to RHBV.

Sources of Resistance to Tropical Forage Viruses

Considering the relatively early stages of germplasm development activities in the Tropical Forage Program, no major virus screening work is currently being conducted, other than the evaluation of germplasm accessions. In the case of *Centrosema*, for instance, several accessions, representing four species: *C. acutifolium, C. brasilianum, C. macrocarpum*, and *C. pubescens*, proved susceptible to the various potyviruses tested (six), with the exception of *C. macrocarpum*, which was resistant to two potyvirus isolates (CP-1, and CP-2), originally isolated at CIAT-Palmira. In the case of *Arachis pintoi* we only have one susceptible plant species. For *Stylosanthes*, the potyvirus described was originally found in *S. capitata*, and later shown to be infectious to *S. macrocephala* but not to *S. guianensis* (CIAT 184). Furthermore, some accessions of *S. macrocephala* and *S. capitata* could not be artificially infected.

The following *Brachiaria* species have been shown to be susceptible to the Latin American isolate of guineagrass mosaic virus: *B. brizantha, B. decumbens, B. dictyoneura, B. humidicola, B. jubata, B. platynota* and *B. ruziziensis*.

DEVELOPMENT OF RELIABLE VIRUS DETECTION METHODS FOR EPIDEMIOLOGICAL AND QUARANTINE PURPOSES (ECOLOGY)

This is probably the most consistent and resource-demanding activity of the VRU, since regardless of their economic importance, all viruses infecting CIAT-mandated commodities must be identified for quarantine purposes, to demonstrate that plant germplasm being introduced or exported by CIAT, does not contain plant viruses.

Specific course of action

The VRU will replenish and produce polyclonal and monoclonal antisera to some of the viruses characterized at CIAT. The basic antisera collection will increase our capacity to detect the viruses that naturally infect CIAT commodities.

The VRU has been expanding its capacity to generate radioactive and non-radioactive specific probes for viruses. The main thrust of this effort is to develop and utilize nucleic acid hybridization techniques and are primarily directed towards the detection of whitefly-transmitted geminiviruses in legumes, and cassava viruses in general, and RHBV.

Outputs

Detection Methods for Bean Viruses

To date, the VRU has developed the necessary diagnostic capacity to detect the major bean viruses that occur in the world using serological or nucleic acid hybridization (for bean gemiviruses) techniques, which are rapid and accurate. These tests can be readily supplemented by electron microscopy and electrophoretic techniques designed to detect viral nucleic acids in infected-plant extracts. Among the various serological techniques available, the VRU has already contemplated the installation of a monoclonal antibody facility at CIAT headquarters.

Detection Methods for Cassava Viruses

Diagnostic tests have been implemented for 3 symptomless viruses found in tropical America. Diagnostic methods have been developed not only to the four viruses that are known to cause diseases, but also to three symptomless viruses found in Latin America. These diagnostic methods help assure the safe movement of cassava germplasm.

Radioactive and nonradioactive hybridization techniques for the detection of plant viruses. Dot blot hybridization techniques were developed using cDNA probes to BGMV and to RHBV. The first set of probes utilized the incorporation of radioisotopes for the detection of these viruses. The technique is very useful because dot blots can be prepared with minimal facilities and then taken to a central laboratory for the hybridization analysis. The major drawbacks are that isotopes have a short half-life, are expensive, and few national program laboratories are set up for handling isotopes.

Non-radioisotope methods utilizing chemoluminesce detection systems were adapted to both BGMV and RHBV detection. The probes if stored properly remain functional for years and a specialized lab is not needed. The cost of this methodology is comparable to using isotopes and remains one of the limitations in the devolution of this technology. These chemoluminensce or enzyme base detection systems are continually being refined, and it is expected that in the future the costs will decline. The technology is extremely promising when serological detection methods are not available.

Detection Methods for Viruses of Tropical Forages

The VRU has produced diagnostic materials, mainly antisera, to all the different viruses that have been detected so far in forage legumes and grasses. For unknown viruses, the VRU is relying heavily on its electron microscopy capacity to detect cytopathic effects and inclusions induced by viruses in infected plant cells.

COMPLEMENTARY ACTIVITIES

IMPLEMENTATION OF MOLECULAR VIROLOGY AND GENETIC ENGINEERING TECHNIQUES FOR THE PRODUCTION OF TRANSGENIC PLANTS POSSESSING RESISTANCE TO PLANT VIRUSES

The recent introduction of useful foreign genes into plants by ballistic methods have allowed scientists to circumvent the failure to regenerate many species, such as beans, by tissue culture techniques.

Specific course of action

The incorporation in plants of foreign genes shown to confer virus-resistance has been demonstrated for various virus-plant systems. The VRU will be working on the genetic transformation of bean and cassava plants in 1992-1196, using ballistic methods to test different virus-induced plant resistance schemes, such as coat protein, satellite, and lethal mutant-mediated plant resistance. Other vectors of genetic material, such as *Agrobacterium* spp., can also be tested with tobacco systems amenable to plant transformation, in anticipation of future breakthroughs in the area of plant regeneration.

Outputs

Molecular characterization of bean golden mosaic virus (BGMV) and genetic engineering of bean plants. A USAID-funded collaborative research project between the VRU, the University of Wisconsin (Dept. of Plant Pathology and Institute of Molecular Biology), and a private Biotechnology Company, AGRACETUS, led to the molecular characterization of the main isolates of BGMV in Latin America and, for the first time, to the production transgenic bean plants. These transformed bean plants contain three major foreign genes, the GUS, BAR, and BGMV coat protein genes, and are now being used as parental genotypes to obtain resistance to BGMV. At the same time, other molecular approaches are being followed to achieve the same objective.

These transgenic bean plants are now being tested in Puerto Rico under containment for their reaction to BGMV inoculated by whiteflies.

Genetic engineering for coat protein mediated cross protection of cassava mosaic virus. In cooperation with a project with ITAB located at the Salk Institute the molecular characterization and the development of resistant cultivars using coat protein mediated cross protection was initiated. The coat protein mediated cross protection has been achieved using *N. Benthamiana*, and the bottleneck for the completion of this project is the transformation and regeneration of cassava.