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Annual Report 1985

Bean Program

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CIAT Centro Internacional de Agricultura Tropical

CIAT is a nonprofit agricultural research organization devoted to the goal of increasing sustainable food production in tropical developing regions. CIAT is one of 13 international agricultural research centers under the auspices of the Consultative Group on International Agricultural Research (CGIAR). The government of Colombia provides support as a host country for CIAT and furnishes a 522-hectare site near Cali for CIAT's headquarters. In addition, the Colombian Foundation for Higher Education (FES) makes available to CIAT a 184-hectare substation in Quilichao and a 73-hectare substation near Popayán; the Colombian Rice Federacion (FEDEARROZ) also makes available to CIAT a 30-hectare farm—Santa Rosa sub-station—near Villavicencio. CIAT comanages with the Colombian Agricultural Institute (ICA) the 22,000-hectare Carimagua Research Center on the Colombian eastern plains and carries out collaborative work on several other ICA experimental stations in Colombia; similar work is done with national agricultural agencies in Latin American, African and Asian countries.

CIAT is financed by a number of donors, most of which are represented in CGIAR. During 1986 these CIAT donors include the governments of Australia, Belgium, Canada, France, the Federal Republic of Germany, Italy, Japan, Mexico, the Netherlands, Norway, the People's Republic of China, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America. Organizations that are CIAT donors in 1986 include the European Economic Community (EEC), the Ford Foundation, the Inter-American Development Bank (IDB), the International Bank for Reconstruction and Development (IBRD), the International Development Research Centre (IDRC), the International Fund for Agricultural Development (IFAD), the Rockefeller Foundation, the United Nations Development Programme (UNDP), and the W. K. Kellogg Foundation.

Information and conclusions reported herein do not necessarily reflect the position of any of the aforementioned entities.

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HIGHLIGHTS 1985

We are well familiar with the predominant small farmer nature of beans, and that beans are an important protein crop, produced in many ecological zones and cropping systems, each of which differ greatly in their production constraints. Bean production in the tropics is centered in Latin America and East Africa, with some production in West Asia.

The Bean Program strategy is to seek improved production without necessarily increasing inputs. This must be achieved:

(1) Primarily through stress tolerance breeding to gradually reduce the effect of production constraints;

(2) Improve the yield potential and nutritional quality of the above-mentioned multiple resistant varieties.

To achieve the objective of increasing bean production and to execute its strategy, the Bean Program at CIAT-Palmira embodies three research themes. These themes and support personnel are listed as follows:

Germplasm Development (6 senior staff)

Germplasm Promotion and Use in On-Farm Testing (3 senior staff)

Yield Potential (2 senior staff)

These three groups form the CIAT-based headquarters staff one of whose functions is to provide support to the outposted staff which function as regional research groups. There is great interaction among these research groups within national programs. They form the CIAT part of the bean network, the other two components are the national programs and the basic research centres. CIAT interacts with national programs mostly through the decentralization of genetic improvement and strengthening of national programs through training.

Personnel Changes

The Bean program underwent several staff changes during the year. Steven Temple, the most senior bean breeder, left after 10 years of service to CIAT to further develop his career in his home country. Steven Beebe, the Central American breeder succeeded him. Cesar Cardona returned to CIAT as senior staff entomologist. Julia Kornegay joined the program as postdoctoral bean breeder to support the African outreach activity from homebase and to replace Jeremy Davis who is on sabbatical leave. Joachim Voss became senior staff. Barry Smithson was contracted as a breeder for East Africa Project, and Willi Graf strengthened the Great Lakes Project as agronomist. Leif Youngdahl joined CIAT for 1 1/2 years as IFDC staff to study the mechanism of low P tolerance and improve screening methods for this. Specific expertise was

brought to the Bean Program by Porfirio Masaya and George Abawi who joined CIAT for sabbatical periods of different lengths. Jairo Castaño left the Bean Program for a position in the Pan American School in Honduras.

Highlights

Of germplasm base

- Due to four germplasm collection trips (to Mexico, Argentina Colombia and Peru) carried out by the CIAT-IBPGR project on germplasm collection, 876 new accessions were added to the Genetic Resources Unit (GRU). Seven more expeditions are planned for 1986.

- A second evaluation of the entire, available germplasm collection was carried out for resistance to viruses, angular leaf spot, rust, anthracnose, common bacterial blight, maturity, adaptation for vigor and reproduction, and growth habit. Most of the team participated in the evaluation and the data are stored in the IDMS-R database system which is now partially operational. As a result of the evaluation many new parents were added to the breeding programs of CIAT and the national programs. Also, exciting new variability was found, e. g. small pods combined with medium seed size.

Of disease and pest resistance

- Excellent grain types have been selected in BCMV resistant lines for Africa carrying the bc-3, bc_2 or other recessive genes alone or combined with the I gene.

- BGMV screening of advanced breeding lines, not specifically bred for golden mosaic resistance detected non-black seeded lines A 429 and DOR 303 with high levels of tolerance. Resistance was also expressed in crosses involving those lines as parents.

- A previously unknown BGMV resistance mechanism- local lesions- was found in a red-seeded bean genotype, Red Mexican 35. This mechanism effectively restrains the systemic invasion of bean plants following their mechanical inoculation with BGMV, and will be tested in the presence of the white-fly vector.

- Two new races of halo blight were found (for a total of four existing races) and many new parents were identified for the African program.

- The presence of five pathogenicity groups of angular leaf spot has been indicated and valuable resistance sources for the Latin American and African programs have been identified.

- New screening techniques for charcoal root rot have facilitated the evaluation of germplasm apart from the drought nurseries.

- New parents for resistance to Apion such as Guate 59, Guate 209, Puebla 21, Puebla 36-1 and G 13614 now show good progress in maintaining resistance in better adapted materials.

- Resistance to bruchids in the small seeded types has been successfully transmitted to larger seed types. It appears (from collaborative studies with the Bean/Cowpea CRSP) that resistance is based on substitution of the phaseolin protein for a new arcelin type glycoprotein.

  The question remains why this protein is only found in wild beans, and why it was lost during domestication. Scientists at the University of Wisconsin believe that it contributes to their evidence that the domesticated bean germplasm is based on a small part of the variability found in the wild types.

  Of N-fixation

- The N fixation research strategy was revised to: (1) improve ability of bean lines to better fix N with good strains; and (2) improve the competitiveness of good strains with often ineffective native strains. In controlled studies, using the N 15 isotope, selected bean lines fixed about 30 kg N/ha, which was about 40% of the total N in the plants. Given the different mechanisms for fixing N, genetic improvement should be possible by combining these.

Future Challenges

The ERP recommended and endorsed the efforts of the Bean Program to increase research on yield potential. This does not mean that the program is shifting away from stress tolerance breeding. It rather follows from increasing decentralization and progress in research. After many years of training of national program scientists in the area of resistance breeding, principally for diseases, and the increasing decentralization that followed, more selection for disease resistance is taking place at the national program level. This frees time to develop a basic strategy to breed for increased yield.

With respect to network expansion, the Bean Program increasingly concentrates its activities in those countries where the probability of impact is greatest. The expansion of the network to include additional countries will continue according to the following criteria:

(1) The candidate country must have a serious and dedicated research group. It may be a small program but it must show all signs that it can utilize effectively the collaboration with CIAT and improve local bean production.

(2) The grain types and production problems of candidate countries must be under improvement at CIAT.

Network expansion in Africa continued. The Great Lakes Project (Rwanda, Burundi and Zaire) is fully operational and collaborative projects with eastern African countries are being developed.

Adoption Studies

Adoption studies teach us much about the reasons why farmers adopt, or fail to adopt new technology. A total of 21 countries have released network varieties. Significant adoption occurs so far in 11 countries and we conduct adoption studies in three countries and expect to expand this next year to six. Many new varieties were released or named. It becomes increasingly unclear if a variety is released in a decentralized network.

In Colombia, we follow the adoption of E 605 after its release and farmers' positive or negative comments.

Costa Rica

In the most important bean regions, over 50% of the farmers now use Talamanca, and Brunca is coming up strongly. In selected areas over 80% of the farmers grow Talamanca. Farmers like its yield and erectness, the latter being a problem of Brunca.

Guatemala

The country is self-sufficient in beans, and is testing new grain types for export markets in non-traditional bean growing areas. Adoption rates were not as high as we expected, but yield advantage was much higher. We are growing out samples of the farmer's plots to measure if adoption data are correct, or if farmers are using new varieties under landrace names.

Argentina

This country greatly increased bean yields, and provides beans for areas which are deficient, mostly Brazil and Mexico. Net benefit of research in 1985 was US $2.4 million. Over 80% of the farmers now use the new black varieties.

Some Brazilian states show strong adoption of new varieties. We hope to be able to do collaborative impact studies in Espirito Santo, Goias and Rio de Janeiro in 1986.

In summary, we feel that much progress can be reported and many exciting stories can be told. But the place of beans in the future, as a world crop, will in our view be determined by the success we have in raising its yield potential and improving the nutritional quality. These are two challenges requiring several years of dedicated, collaborative and imaginative research.

I. BEAN GERMPLASM ACTIVITIES

A. Germplasm Collection, Multiplication and Distribution

Acquisition

The acquisition of *Phaseolus* germplasm continues as an important objective in the assembling of the collection. Besides the donations of national institutions, a co-sponsored IBPGR-CIAT collector started expeditions to Peru, Argentina, Colombia, Mexico and Guatemala this year (this activity is explained in detail later on). A total of 1,845 accessions were added to the collection, including samples of the four cultivated species and several wild species; these materials came from 29 countries (Table 1).

Status of the Phaseolus collection

The *Phaseolus* collection has increased to 36,154 accessions (Table 2). The common bean *P. vulgaris*, and its wild relatives are 88% of the collection; with respect to the lima bean, *P. lunatus* germplasm is about 7% of the total, of which the *P. coccineus* complex represents half (3.5%). The *P. acutifolius* germplasm adds up to 0.5%, and the wild non-cultivated species only 0.2%. A total of 55% of the collection has been increased and is available for distribution.

Germplasm characterization

Two sets of germplasm were evaluated in CIAT-Palmira during 1985 (one per semester). The objectives of this work were twofold: first to evaluate the usefulness and practicality of the minimum descriptors proposed by CIAT for characterization of *P. vulgaris* germplasm, and second to continue with the clustering of similar germplasm. The first group selected for applying the minimum descriptors corresponded to the large-seeded, types I and II.

In preliminary observations of the large-seeded growth habit I, and using the variability factor concept, those characters that are environment-dependent appeared to be more variable (Table 3), however, they cannot be used as separators. Nevertheless, those characters not influenced by the environment were considered, such as nodes to first raceme on stem, and appeared as a potential separators. They showed almost three times more variability than days to flowering. The rest of the variability factors coincided with previous results for all growth habits (CIAT Bean Program Annual Report, 1982).

Storage

An agreement has been signed between CIAT and EMBRAPA/CENARGEN to duplicate the *Phaseolus* bean germplasm collection in Brazil. This duplicate will be stored in the CENARGEN facilities for long term storage. The samples will have the same characteristics as the ones in long term storage in the CIAT bank regarding viability, seed moisture content and packing. The collection will be sent in batches increased exclusively for this purpose.

Table 1. *Phaseolus* introduction: List of bean germplasm introduced by the Genetic Resources unit (GRU) during 1985.

Region/country	*P. vulg.*	*P. lun.*	*P. coc.*	*P. acut.*	Wild species	Others
North America						
USA	395	-	-	-	-	-
Central America						
Mexico	22	-	-	-	-	-
Guatemala	60	-	-	-	-	-
El Salvador	7	-	-	-	-	-
Honduras	2	-	-	-	-	-
Nicaragua	18	-	-	-	-	-
Costa Rica	2	-	-	-	-	-
Panama	4	-	-	-	-	-
Caribbean						
Guadaloupe	5	-	-	-	-	-
Dominican Republic	9	-	-	-	-	-
Puerto Rico	18	-	-	-	-	-
Cuba	10	-	-	-	-	1
Andean South America						
Colombia	18	7	2	-	-	2
Ecuador	11	-	-	-	-	-
Peru(a)	771	27	17	-	11	-
Chile	99	-	-	-	-	-
Non-Andean S. America						
Brazil	24	-	-	-	-	-
Argentina[a]	-	-	-	-	17	-
Europe						
Netherlands	6	-	3	-	-	-
Belgium	1	-	6	-	5	-
England	1	-	-	-	-	-
Africa						
Kenya[b]	79	-	-	-	-	-
Zimbabwe[b]	5	2	-	2	-	-
Zambia[b]	87	-	-	-	-	-
Malawi	4	-	-	-	-	-
Tanzania	32	-	-	-	-	-
Burundi	11	-	-	-	-	-
Rwanda	29	-	-	-	-	-
Asia						
N. Guinea[b]	13	-	-	-	-	-
	1,743	36	28	2	33	3
			Grand total =			1,845

[a] Cosponsored IBPGR-CIAT [b] IBPGR collecting expeditions

Table 2. Status of the bean collection held at the CIAT Genetic Resources Unit as of December, 1985.

Species	Introduced	Increased
P. vulgaris	31,619	18,208
P. vulgaris wild ancestors	364	344
P. lunatus	2,563	655
P. lunatus wild ancestors	63	40
P. coccineus subsp. *coccineus*	792	347
P. coccineus subsp. *polyanthus*	415	199
P. coccineus wild ancestors	67	19
P. acutifolius	134	116
P. acutifolius wild ancestors	50	50
Wild non-cultivated		
P. anisotrichus, *P. filiformis*, *P. galactoides*, *P. microcarpus*, *P. metcalfei*, *P. pedicellatus*, *P. polystachius*, *P. parvulus*, *P. ritensis*, *P. wrightii*, *P. pachyrrhizoides*	87	34
Total	36,154	20,012

Table 3. Example of an analysis of *Phaseolus* quantitative data[a] (First semester 1985).

Descriptor	C.V.	V.F.[b]
Days to flowering	11.4	1.00
Days to harvest	11.7	1.02
Nodes to flowering	11.6	1.01
Pod length	13.9	1.21
Locules per pod	17.8	1.55
Seeds per pod	19.8	1.72
Duration of flowering	29.1	2.54
Nodes to first raceme	31.9	2.78
Pods per plant	46.5	4.06
Yield per plant	53.6	4.68

a. 1,216 accessions, large-seeded, growth habit I

b. V. F. = Variability Factor = $\frac{\text{C.V. \% of any character}}{\text{C.V. \% of least variable character}}$

Data management

The introduction file (which is the largest file containing all the materials received together with the corresponding passport data) has been incorporated into the data base of the Bean Program. Also, emphasis has been placed on the search for information on the materials that lack data, to facilitate the identification and establishment of origin of the germplasm which in turn will help in the task of grouping similar germplasm. Finally, a catalogue of *P. vulgaris* germplasm was produced and distributed to bean researchers around the world.

Seed distribution service

There were many demands for seed, both from outside and within CIAT. A total of 6,595 accessions of *Phaseolus* germplasm were sent to 27 countries; in addition, 128 accessions of other genera of beans (i.e., *Vigna*, *Psophocarpus*, etc.) were also distributed, for a total of 6,723 samples (Table 4). The requests for germplasm by the Bean Program add up to 30,690 samples (Table 5), indicating a prime interest in the germplasm available.

Table 4. Bean sample distribution outside CIAT (1985).

Region	No. of countries	No. of requests	No. of accessions
North America	2	11	134
Central America	4	10	4,829
Caribbean	1	2	106
Andean South America	3	5	47
Non-Andean South America	2	3	35
Europe	9	12	632
Africa	2	4	135
Asia-Oceania	3	6	245
Middle East	1	1	560
Total	27	54	6,723

Table 5. Distribution of Phaseolus within CIAT (1985).

Program	No. of requests	No. of samples
Breeding 1	12	1,292
Breeding 2	16	16,483
Breeding 3	17	1,821
Agronomy	2	314
Physiology	9	29
Microbiology	1	7
Phytopathology/virology	41	3,499[a]
Entomology	24	7,213[b]
Biotechnology	10	32
Total	132	30,690

[a] Includes 5 species in addition to P. vulgaris
[b] Includes 1 other species in addition to P. vulgaris

Collaborative project between IBPGR and CIAT for Phaseolus germplasm collection.

Purposes of the project

Large collections of Phaseolus germplasm have already been assembled throughout the world (CIAT, Pullman, Chapingo, Cambridge, etc.). Facing the current problems of duplicates and genetic erosion, pertinent questions are:

-- Does the germplasm bank have a good representation of the primitive varieties of the three American centers of genetic diversification for the five cultivated species of this genus?

-- Is the total genetic variability satisfactorily represented in the germplasm bank? For instance: germplasm of P. vulgaris from the coolest areas of the Andes, of P. acutifolius from the wet mesoamerican tropics. The GRU is also concerned with the whole genetic diversity from "strategic" areas (such as the western highlands of Guatemala for rust resistance sources in the common bean, etc.). This is the problem of the representativity for the characters which are known to be poorly expressed.

-- Does the germplasm bank have good representation of the wild ancestors and the true wild species?

A survey made in the largest bean gene banks resulted in a negative response to the aforementioned questions. This is due to the lack of basic information about the materials already collected and the

poor representation of any Phaseolus taxon outside cultivated vulgaris. It was, therefore, necessary to resume selective germplasm collection activities in the three American centers: Mesoamerica, north Andean center and south Andean center.

Initially, the project was to put the major emphasis on the cultivated Phaseolus species other than vulgaris (lunatus, coccineus, polyanthus, acutifolius) to complete the present collections of CIAT (by far the most complete in the world) and secondarily to a systematic collection of the wild ancestors and the true wild species. However, as a result of variability studies in the fields in selected parts of the three american centers, the above scheme was soon revised and a common priority given to the five cultivated species to fill gaps in the existing collection. Indeed, from a check of the types encountered in the fields with the ones in the different gene banks, it appeared that for P. vulgaris the wealth of the three American centers was still under-represented. Collections were thus planned each time involving national staff responsable for genetic resources, with whom accessions and information were shared to secure the germplasm.

Highlights

During 1985, four germplasm explorations were made and another one is planned in western Guatemala for December. The results in terms of species and number of samples are summarized in Table 6.

Since separation of some genetic mixtures is still under way especially for the Peruvian material during the first seed increase, the total number of accessions will be higher. The total number of species collected was 13 of which five were collected for the first time for germplasm purposes.

Concluding remarks

(1) To make better use of each field expedition, a more aggregate approach to study the variability of the crop in situ has been developed, including the sampling of Rhizobium and pests (mainly bruchids). This has been done in close collaboration with the microbiology and entomology sections. Samples have also been distributed worldwide to interested specialists.

(2) Information is a key issue in germplasm management and utilization. A special form has been used, Figure 1, therefore, at the collection site for each material and copies of which were shared with the national GRU involved.

(3) The accessions listed in Table 6 represent new genetic variability, i.e. not already available in germplasm banks, since a careful comparison was made with the existing material for each region before collecting the germplasm.

Table 6. Results of germplasm explorations, 1985.

Country (region) Species	No. of samples
ARGENTINA (Tucuman, Jujuy, Salta, Catamarca)	
P. vulgaris var. *aborigineus* (wild ancestor)	26
P. augusti	3
PERU (Cajamarca, Amazonas)	
P. vulgaris var. *vulgaris*	
landraces	more than 511
weedy types	8
P. lunatus var. *lunatus* (landraces)	25
P. polyanthus	13
P. pachyrrhizoides	2
COLOMBIA (Nariño, Putumayo)	
P. vulgaris var. *vulgaris* (landraces)	54
P. lunatus var. *lunatus* (landraces)	68
P. polyanthus	15
P. coccineus	1
P. natural hybrids *polyanthus* x *coccineus*	16
MEXICO (Nuevo Leon)	
P. vulgaris var. *vulgaris*	more than 71
P. coccineus	1
P. anisotrichus	8
P. glaucocarpus	1
P. neglectus	5
P. scabrellus	3
P. xanthotrichus	4
P. sp. (new taxon)	2
Total number of samples	more than 837

It is obvious that there is a problem of representativity of previous collections. As an example, for Cajamarca, Peru, the previous collection contained 220 entries of *P. vulgaris* to which more than 511 new accessions were added; for Nuevo Leon, 42 accessions existed in the Mexican GRUs and more than 71 new materials have been found in the southern part of this state. A list of the varieties grown at present and some of the ones grown in the past was also drawn up.

(4) The materials will be made available soon to the different GRU's throughout the world, to breeders and agronomists for further evaluation, but also to extension services, since the field studies have revealed an increasing interest by farmers to plant vanished bean types as well as to diversify their products. New characters will also be examined at the first seed increase to better characterize the entries as well as to calculate diversity indexes. The latter will help to orient further collection activities.

CIAT

Unidad de Recursos Geneticos / IBPGR

FORMATO PARA RECOLECCION — FRIJOL

1. NU STOCK: 2. NOMBRE Y NUMERO DEL COLECTOR: 3. INSTITUCION RESPONSABLE: 4. LUGAR DEL PRIMER DEPOSITO: 5. ESPECIE: 6. NOMBRE LOCAL: 7.

LUGAR DE RECOLECCION:

NU STOCK 8. PAIS 9. ESTADO: 10. DISTRITO: 11. SITIO: 12. PROXIMO PUEBLO:

NU STOCK 13. DISTANCIA AL PUEBLO: KM 14. LADO DE CARRETERA: 1 = SI 2 = NO ORIENTACION N S O E DE LA CARRETERA 15. FECHA (DIA/MES/AÑO) 16. ALTITUD: M 17. LONGITUD: GRADOS MIN O/E 18. LATITUD: GRAD MIN N/S 19. TOPOGRAFIA: 20. EXPOSICION: 21. TEXTURA DEL SUELO: 22. DRENAJE: 23. SALINIDAD 24. NUMERO HERBARIO: 25. TRANSPARENCIA: 26. RHIZOBIUM: 27. MUESTRA INSECTOS: 28. OTRA MUESTRA: (1 = SI 2 = NO) 29. PROCEDENCIA INMEDIATA: 30. CANTIDAD:

DATOS AGRONOMICOS:

NU STOCK 31. MUESTREO: 32. PRODUCTIVIDAD: 33. DENSIDAD: 34. FENOLOGIA AL ENCONTRAR: 35. SISTEMAS DE PRODUCCION: 36. RIEGO: 37. FERTILIZANTE: 38. INSECTICIDA: 39. FUNGICIDA: (1 = SI 2 = NO) 40. DESHIERBA: 41. HABITO DE CRECIMIENTO: 42. ENFERMEDADES: 43. PLAGAS:

45. CUIDADO ESPECIAL:

NU STOCK 44. USO: 46. RAZONES POR COLECTAR: 47. NOTAS ADICIONALES:

Codigos para ENFERMEDADES y PLAGAS:

42. ENFERMEDADES:

Fungi: ALS, ALT, ASC, ANT, BOT, BRR, CER, DAP, ERY, RAC, PHY, R, RR, WBB, WHR.

Bacteria: BB, BBS, BU, HBL.

Virus: BCMV, BCLMV, BGMV, BRMV, BSMV, BSDV, BYMV, CMV, CTV.

43. PLAGAS:

APH, APN, BRU, CRI, EMP, HEL, HYL, MAR, MBB, MIT, NEM, THR, WFL.

47. NOTAS ADICIONALES:

41. HABITO DE CRECIMIENTO:

1 = Determinado arbustivo
2 = Indeterminado arbustivo
3 = Indeterminado postrado
4 = Indeterminado trepador
5 = Otro

7. TIPO DE MATERIAL:

1 = cultivado criollo
2 = cultivado mejorado
3 = escapado
4 = silvestre

19. TOPOGRAFIA:

1 = Pantanoso
2 = Orilla
3 = Plano
4 = Ondulado
5 = Colinas
6 = Montanoso

20. EXPOSICION:

1 = en el sol
2 = en la sombra
3 = intermedio

21. TEXTURA DEL SUELO:

1 = Arenoso
2 = Franco
3 = Arcilloso
4 = Organico
5 = Pedregoso
6 = Diferente

22. DRENAJE:

1 = Normal 2 = Malo
3 = Excesivo

23. SALINIDAD EN EL SUELO:

1 = Ausencia 2 = Presencia
3 = Desconocido

29. PROCEDENCIA INM.:

1 = Campo abierto
2 = Campo cultivado
3 = Casa del agricultor
4 = Tienda 5 = Mercado local

32. PRODUCTIVIDAD:

1 = cultivado, < 400 KG/HA
2 = cultivado, 400-800 KG/HA
3 = cultivado, 800-1200 KG/HA
4 = cultivado, > 1200 KG/HA
5 = silvestre, baja
6 = silvestre, mediana
7 = silvestre, alta

33. DENSIDAD:

1 = cultivado, < 1 pl/m^2
2 = cultivado, 1-4 pl/m^2
3 = cultivado, 4-8 pl/m^2
4 = cultivado, 8-12 pl/m^2
5 = cultivado, 12 pl/m^2
6 = silvestre, aislado
7 = silvestre, en grupo

34. FENOLOGIA AL ENCONTRAR:

1 = vegetativo
2 = en floracion
3 = en madurez

35. SISTEMAS DE PRODUCCION:

1 = monocultivo
2 = asociado con maiz
3 = asociado con otro
4 = multicultivo

40. DESHIERBA:

1 = Manual
2 = Mecanica
3 = Quimica
4 = Ninguna

Future plans

Collection activities will continue during 1986:

-- In the south Andean center to look for wild ancestors of *P. vulgaris* and *P. lunatus* as well as landraces of both species.

-- In the north Andean center, for the same materials as well as *P. polyanthus* and *coccineus*. Special attention will be paid to the transition area between these centers in Peru, to understand their relationships.

-- In the Mesoamerican center where two long expeditions are planned, since the majority of the known species have their distribution to this center (see Table 7).

Table 7. List of *Phaseolus sensu stricto* species (including the three sections *Phaseolus*, *Alepidocalyx* and *Minkelersia*)*

*P. acutifolius***	*P. ovatifolius*
P. amabilis	*P. pachyrrhizoides*
P. amblyosepalus	*P. parvulus*
P. angustissimus	*P. pauciflorus*
*P. anisotrichus***	*P. pauper*
P. augusti	*P. pedicellatus***
P. brevicalyx	*P. plagiocylix*
*P. chiapasanus***	*P. pluriflorus***
P. coccineus	*P. polyanthus***
*P. esperanzae***	*P. polymorphus*
P. falciformis	*P. polystachyus*
P. filiformis	*P. purpurascens***
P. floribundus	*P. ritensis*
*P. galactoides***	*P. salicifolius*
*P. glabellus***	*P. scabrellus*
P. grayanus	*P. schaffneri*
*P. griseus***	*P. sempervirens*
*P. jaliscanus***	*P. sinuatus*
*P. leiosepalus***	*P. smilacifolius*
*P. lunatus***	*P. sonorensis*
*P. macrolepis***	*P. striatus***
*P. metcalfei***	*P. tuerckheimii***
*P. micranthus***	*P. venosus*
*P. microcarpus***	*P. vulcanicus***
P. neglectus	*P. vulgaris***
*P. nelsonii***	*P. wrightii*
*P. oaxacanus***	*P. xanthotrichus***
*P. oligospermus***	*P. zongolicensis***

* Tentative list as of November, 1985. Some taxa will be ranked as subspecies in the definitive (!) revision of the genus.

** Species distributed in the central part of the Mesoamerican center (central and southern Mexico, Guatemala).

B. Biotechnology Research Unit

As stated in the document "CIAT in the 1980s Revisited", the Biotechnology Research Unit (BRU) will deal primarily with those new technologies that can significantly increase the efficiency of plant improvement methods or help resolve problems that escape solutions through traditional procedures. While emphasis is on applied research, the Unit also assumes responsibility for selected research with high potential pay-off in terms of technology development. In the development of these activities, close interaction with CIAT commodity programs, especially with the breeders, will be established. On the other hand, the Unit will seek complementarity with advanced institutes and national program scientists through special research projects.

In 1985, the major activity in the Unit involved research in cell and tissue culture for clonal propagation and for the generation of useful variability. This activity included work carried out at CIAT and at collaborating institutions abroad. Work at CIAT concentrated on research to develop tissue culture applications with CIAT crops. Research was initiated abroad to tackle potentially useful areas that require higher specialization at this stage.

Beans

Plant Regeneration in Tissue Culture. The development of a tissue culture cycle in *Phaseolus vulgaris* is the first essential step for applying most biotechnological tools in the species. A tissue culture cycle involves the establishment of a more or less dedifferentiated cell or tissue culture under defined culture conditions, proliferation for a number of cell generations and the subsequent regeneration of plants. In other words, a period of essentially dedifferentiated cell proliferation is imposed between an explant (initial plant part) and the next plant generation. While induction of dedifferentiation can be done readily, beans have resisted the regeneration phase. Since regeneration seems to depend primarily on the genotype, the kind of tissue used as explant, and the response being modulated by the culture environment, a systematic approach to this problem in beans, is appropriate.

Results of work initiated this year at CIAT are now reported. Using embryo axes from mature seeds of four genotypes, sterile plantlet cultures were established in a medium routinely used for cassava meristem culture. Shoot tips and nodes (0.5 cm in size) were excised from actively growing plantlets and used as explants in four culture media (Table 1), under low illumination (1000 lux) for four weeks. Both types of explants reacted in a similar fashion; a mass of nodular callus grew around and underneath the explant (Figure 1 Aa), leafy tissue developed at some points of the nodular mass where differentiation of buds occurred (Fig. 1Ab). The amount of budding in media 3 and 4 was twice as much as in 1 and 2, while the amounts of leafy tissue and nodular mass were about the same in all media, and all genotypes responded in a similar way, C 07060 being somewhat better (Table 1). The nodules could be isolated and sub-cultured in

Table 1. Responses of shoot-tip and node explants from bean *in vitro* plantlets to four media of different composition.

Additives to basal* medium (mg/l)				Cultures with responses (%)**		
BAP	NAA	IAA	L-cysteine	Callus	Leafy tissue	Budding
1. 0.02	0.18	-	-	78	27	12
2. 0.02	0.18	-	100	80	27	10
3. -	-	0.18	-	94	24	30
4. -	-	0.18	100	82	31	38

* Basal medium for 1 and 2: MS + 3% sucrose; for 3 and 4: 1/2 MS + 3% sucrose.

** Average of 8-10 cultures per treatment per genotype (G 07060, G 00012, G 15637).

the same media. In medium 1, and to some extent in 2, these nodules would become phenolic and die; however in media 3 and 4, many buds would differentiate on each nodule (Figure 1B). Upon transfer of these nodular cultures to a low salt medium, with higher cytokinin and low auxin, a single plantlet would grow from each culture (Figure 1C) due to dominance of the oldest bud. Since it was possible to go from a somewhat undifferentiated structure (nodular callus mass) to plantlets via a "budding" process, these results should set the beginning of more work in bean tissue culture regeneration. The origin of buds, whether adventitious or axillary, and the use of liquid, shake, cultures for increasing the proliferation of such nodular structures should be investigated.

Tissue culture for recovering germplasm accessions. In the handling of bean germplasm, two frequent constraints to the flow of materials are: (a) slow multiplication of materials proceeding from the so-called high risk countries; and (b) very few and/or deteriorated seeds available in many accessions.

In collaboration with the GRU, work was carried out to find out: (a) if healthy plants can be recovered by embryo culture of virus infected seed; and (b) if viable plants can be recovered by embryo culture of rare and unique *Phaseolus* spp which are represented in the GRU bank by 1-3 seeds only.

Seeds of three accessions with BMMV were used for embryo culture. Embryos accompanied by the cotyledons and embryonic axes only (without cotyledons) were explanted individually in test tubes containing the medium routinely used for cassava meristem culture; immediately one set of tubes was maintained continuously at 25°C, with a photoperiod of 12 hrs and another set was exposed first to a continuous cycle of day/night, 12 hr each, 35°C for 25 days and then to alternating, 40°C day and 35° night, temperatures for seven days. At the end of these treatments, the embryo-derived shoots were sub-cultured in a single medium, at 25°C day/night, where rooting occurred in 1-2 weeks. The plantlets were potted and then used for serological, (ELISA) evaluation. Table 2 shows clearly that healthy clones could be recovered only if embryonic axes were cultured at high temperature; neither thermotherapy or culture of embryos without cotyledons was sufficient to produce healthy plants. Seed was collected from these plants for virus re-testing.

One seed from each of the following seven accessions of rare *Phaseolus* spp were received from the GRU: DGD 1510 *P. neglectus*, DGD 1516 *P. scabrellus*, DGD 1513 *P. xanthotrichus*, DGD 1523 *P. pedicellatus*, DGD 1522 *P. neglectus*, DGD 1520 *P. neglectus*, DGD 1509 *P. glaucocarpus*. Following surface sterilization with 70% ethyl alcohol for 0.5 min, and a rinse in sterilized distilled water, 10 min. immersion in 5% sodium hypochlorite, and throughly washing (4-5 times) with sterilized distilled water, the seeds were slightly scarified and explanted in the medium routinely used for cassava meristem culture. After about three weeks of culture under low light intensity, 25°C, 12 hr. photoperiod, embryo-derived shoots were transferred to a simpler medium for rooting.

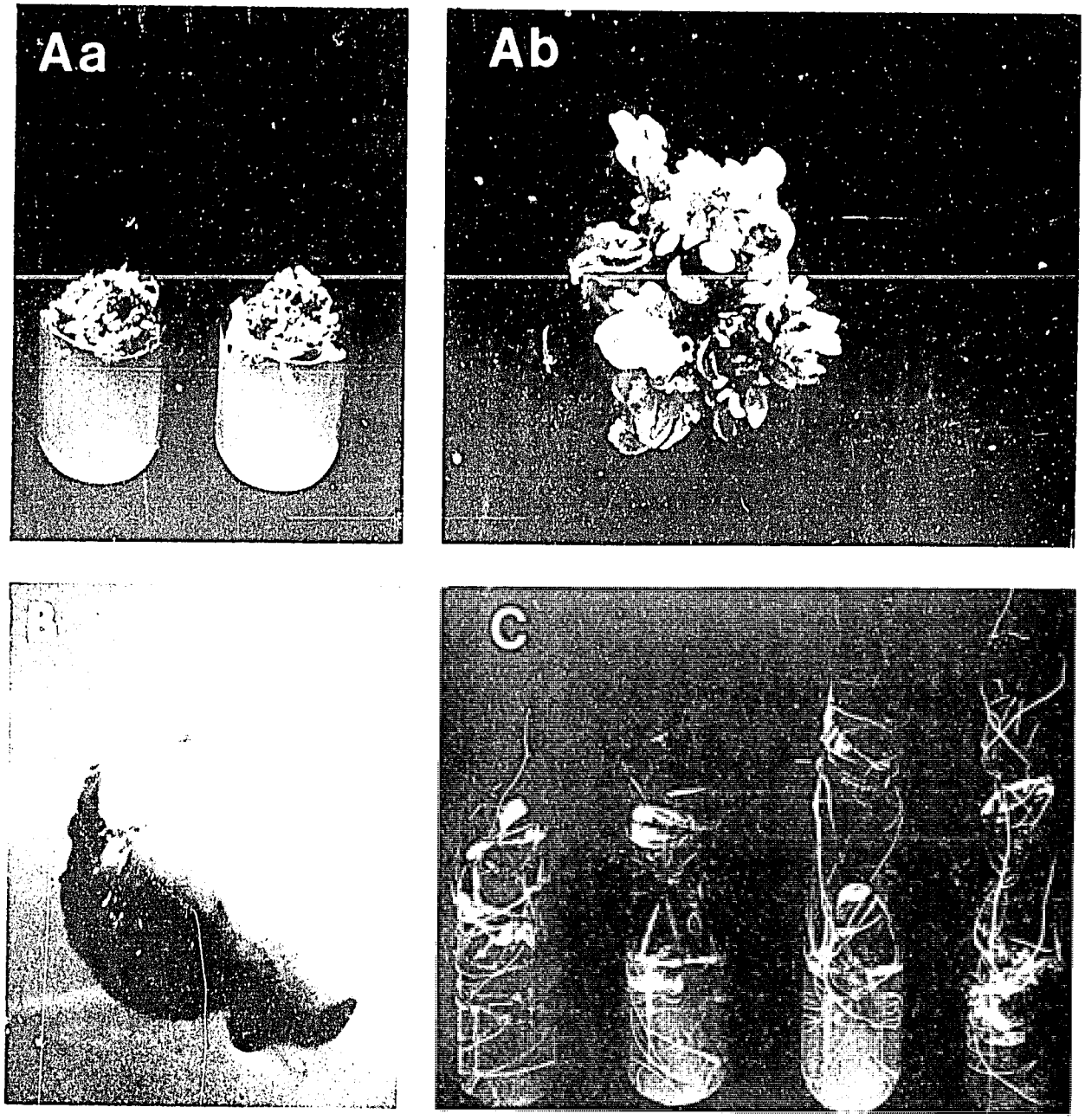

Figure 1. Regeneration of bean plants in tissue culture.

Aa. Nodular "callus" mass formed from shoot-tip and node explants.

Ab. Development of multiple budding from a nodular mass as at Aa.

B. Buds differentiating on an isolated nodular structure.

C. Plant regeneration from the buds as at B.

Table 2. Recovery of healthy bean plants by means of thermotherapy of cultured embryos.

	Thermoperiod*					ELISA test for BMMV**	
	I		II				
	Day	Night	Day	Night		Embryo with cotyledons	Embryo without cotyledons
1.	25°C	25°C	25°C	25°C			
					G 07060	+	+
					G 12491	+	+
					G 00012	+	+
2.	35°C	35°C	40°C	35°C			
					G 07060	+	–
					G 12491	–	–
					G 00012	+	–

These results demonstrate that valuable, rare, bean germplasm as well as completely infected materials can be saved, making them available for use.

Genotype identification by electrophoresis. The IDRC supported collaborative project also includes the development of genotype finger-printing for *Phaseolus* bean germplasm.

Research with beans at the University of Manitoba began a few months ago using germplasm accessions provided by the CRU. Initial trials with seed isozymes did not show good discrimination between varieties. However, seed proteins separated in poly-acrylamide acid gels did show different patterns for different varieties with white, black and yellow color seeds (Figure 2A), and even accessions with very similar patterns could be identified within white-seeded accessions (Figure 2B). The resolution of the banding pattern was further improved by a sequential extraction procedure of residual proteins (Figure 2C).

These results, though promising, are still preliminary. Work now underway should provide a workable procedure, quick, and consistent for handling large accession numbers. The research team will move to CIAT early in 1986 to adapt the techniques to CIAT conditions.

Inoculation of beans with *Agrobacterium*. As research in techniques for genetic engineering of important crop plants progresses in advanced laboratories, the tissue culture component of these new approaches can be developed at CIAT. The large germplasm collection and tissue culture capabilities available at CIAT provide a comparative advantage in this area.

In order to develop the basic methodologies of gene transfer techniques with beans, a collaborative effort has been initiated with scientists at Louisiana State University. At LSU, a synthetic DNA sequence (sp DNA) has been constructed and put under the control of the nopaline synthase promoter, and introduced into *Agrobacterium rhizogenes* plasmid vectors. The sp DNA was shown to code for a polypeptide rich in essential amino acids, especially the sulfur-containing ones: up to 23% lysine, 12% tryptophan, 11% methionine.

Three *A. rhizogenes* strains, 10-3-2, 10-3-3 and 10-3-4, containing the plasmid with the sp DNA, plus a wild type R 1000, were obtained from LSU for use in the inoculation trials. Using the wild type, R 1000, several bean varieties were inoculated, with the result that ICA Viboral (G 12722) and Calima gave the best response.

During the infection process, *A. rhizogenes* transfers to the host cell genome a portion of its plasmid DNA which elicits root growth at the point of inoculation. Thus, root formation is a signal for successful inoculation with *A. rhizogenes*. In this trial, control plants only developed a small callus, but no roots at the point of inoculation. Next, various inoculation techniques were tried, being the immersion of excised embryos in a bacterial suspension for 24 hrs,

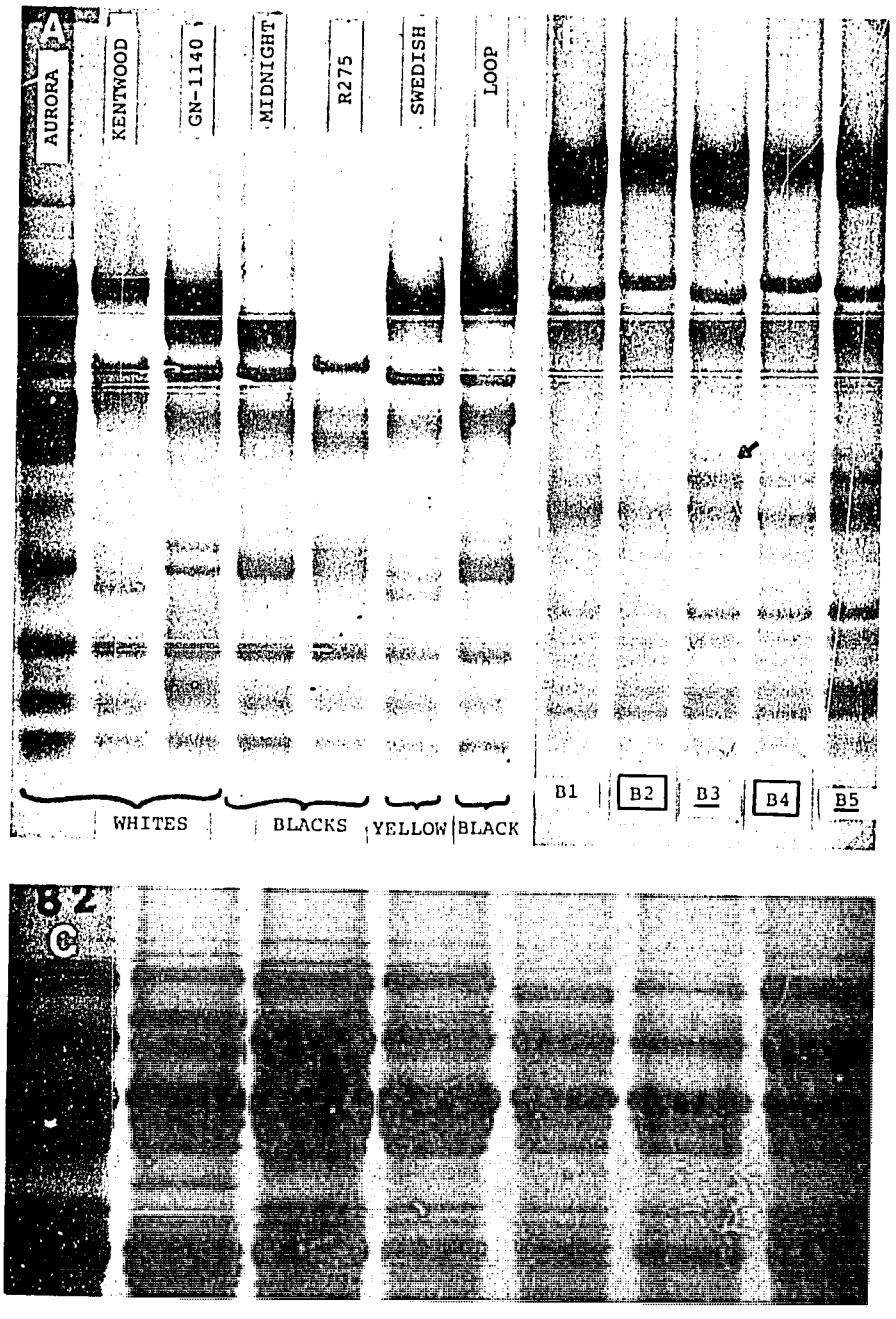

Figure 2. Electrophoretic characterization of bean germplasm.

A. Seed proteins of seven bean varieties separated in polyacrylamide acid gel. Note striking differences between lanes; each lane represent one variety.

B. Same as at A for five white seeded varieties. Note similarities between lanes B_2 and B_4 and between lanes B_3 and B_5. Each lane represents one variety.

C. The same seven varieties as at A, but using sequentially extracted residual proteins in polyacrylamide gel. Note the much higher band resolution obtained with this procedure.

and the inoculation of *in vitro* plantlets by a cut on the stem, which were the ones that yielded highest root development (Figure 3A). It was also found that the *A. rhizogenes* strain 10-3-3 induced root formation in up to 50% of the embryos and 70% of the *in vitro* plantlets in contrast to 10-3-2 and 10-3-4 which could only induce 20-30% rooting. In addition, embryos treated with the strain 10-3-3 gave rise to plantlets with twice as many roots as shoots, compared to strain 10-3-2 and the wild type which yielded almost an equal number of root and shoot mass, and the control (non-treated) which had about half root mass (Table 3). There is probably a high *A. rhizogenes* strain/bean genotype specificity for transformation.

Fifteen days after inoculation, the roots were excised from the plant and cultured in a medium with 250 mg/l cefatoxine to eliminate the bacteria. Upon sub-culturing root tips, transformed roots branched and grew more than the control (Figure 3B); close examination of laterals revealed the typical "hairy root" syndrome caused by *A. rhizogenes* (Figure 3C). LSU scientists have extracted DNA from the putatively transformed roots, and using a DNA probe specific for the root genome, have shown the presence of the synthetic gene in the bean root genome. Although this result is promising, the level of transcription and traslation of the gene must still be determined.

While this research is conducted at LSU, work at CIAT will concentrate on tissue culture regeneration (see above) as a fundamental prerequisite for further progress.

Table 3. Root mass production by bean plantlets (ICA Viboral) grown from embryos after inoculation with *A. rhizogenes* strains*.

A. rhizogenes strain	X F. W. (gr) **		Root/shoot F. W. ratio
	Root	Shoot	
Control ***	0.15	0.24	0.64
R 1000 (wild type)	0.36	0.33	1.09
10-3-2	1.51	1.55	0.97
10-3-3	2.84	1.49	1.91

* Following 24 hr. immersion in bacterial broth, antibiotic treatment was used to rid the bacteria from embryos and then cultured in a simple medium for plant growth.

** Average of 4-6 plantlets per treatment.

*** Embryos placed on Luria Broth without bacteria.

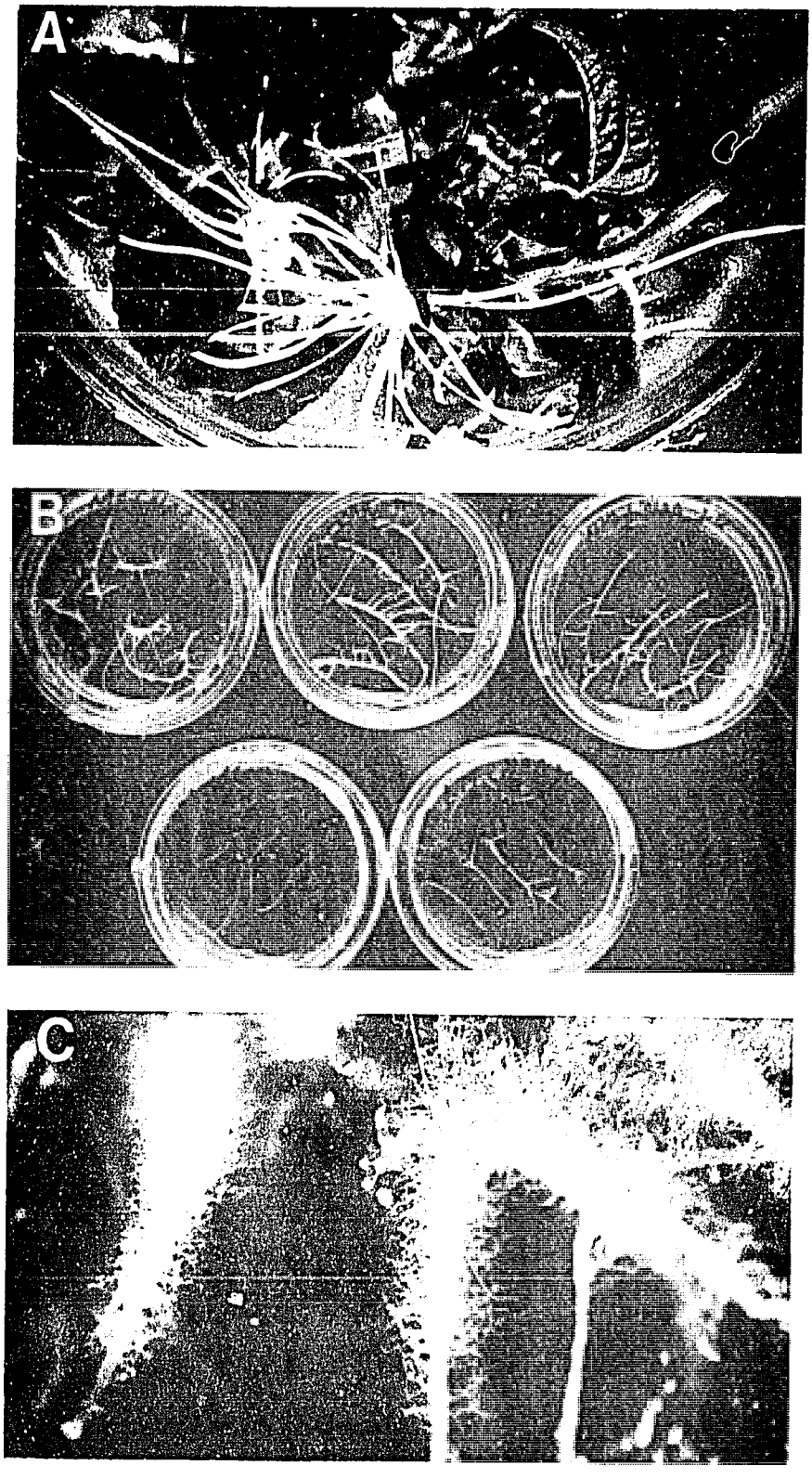

Figure 3. Response of beans inoculated with Agrobacterium rhizogenes.

A. Root formation at the point of inoculation on the stem.

B. Proliferation of induced roots (top row) as compared to control (non-treated) roots (lower row).

C. Close up of B to show typical "hairy root" syndrome caused by A. rhizogenes cell transformation.

C. Germplasm Data Management-The IDMS/R Database for Beans

The bean database is now operational, through incomplete. It was designed to deal with two principle groups of data: the identification and origins of bean accessions and their characteristics. The first category is nearly complete, in terms of both storing data previously held in other files and of providing an on-line data management system. The second category is incomplete, with no on-line data management yet available. The contents of the database in December are shown in Table 1. The database contains all the advanced lines of the breeders, all the accessions in the germplasm bank, and the majority of the crosses made by the breeders. All staff are able to interrogate the contents of the database, but in its present state only the breeders and Genetic Resources Unit are able to change the contents. Breeders may modify data concerning crosses and advanced lines, and the GRU, basic data for germplasm accesions.

Immediate Future of the Database

With the arrival of the latest version of IDMS/R in December, progress in developing a data management system for beans has become much more rapid. We are now able to write one new dialogue a day, which, according to Cullinet is the "normal" rate of progress for IDMS.

Completion of the system for the identification and origin of accessions - requires only a few corrections to data in "pre-IDMS" files: these erroneous data cannot be stored on the database until they have been corrected.

More effort is now being put into developing the system for the second category of data - the characterization of accessions. The on-line system should be complete by the end of February, as should the translation of the correct parts of existing files into IDMS/R. Once this is complete, it will be possible for all members of the Bean Program to keep all their trial data on the database.

Longer Term Future of the Database

A list of future developments is given in Table 2. The integration of data on IBM-PCs of outposted staff with the database on the mainframe - is already possible. The link between Goldengate and IDMS/R has been tested successfully. However, so far it has not been put into practice.

Summaries of trip reports can also easily be incorporated within the existing framework of the database. It needs only a small series of dialogues to implement it, and would be on excellent way of collating and cross-referencing the numerous comments that appear in trip reports on the behaviour of specific accessions.

Integration of the bean database with the agroecological database is not imminent. Conversion of the agroecological database to IDMS/R

is expected to begin in 1986: once that is complete, integration of the two can be completed.

Large amounts of data on Phaseolus are held at both Pullman and Gembloux. Merging these into one system under IDMS/R would result in a crop database and data management system of breadth and scope unrivalled in any institute inside or outside the CGIAR system.

Finally, the integration of CIAT's IDMS/R with the systems of other CGIAR institutes is a more speculative possibility. It depends to a large extent on the success of Cullinet's announced collaboration with DEC to allow VAX computers - the make used by most CGIAR institutes - to communicate with IDMS/R. Since IDMS/R is more powerful than any data management system available on VAX, this would be a useful development.

Table 1. The principle contents of the bean database as of December 1985.

Type of data	Number of occurrences in the database
CIAT staff with access to the database	8
Species of Phaseolus	48
Subspecies of Phaseolus	66
Codes used for identifying accessions	94
Identifiers assigned at CIAT to advanced lines and GRU accessions	63138
Common names of accessions	31677
Codes used for identifying crosses	563
Crosses	15242
Connections between crosses and their parent accessions (comprising the pedigree of crosses)	41212
Connections between advanced lines and the crosses from which they were selected.	4308
Genealogies of advanced lines	6726
Corrections between accessions and other accessions from which they were derived	22007

Table 2. Possible development of the bean database.

1. Integration of data on IBM-PCs of outposted staff with the database on the mainframe.

2. Inclusion of summaries of trip reports in database.

3. Integration of bean database with agroecological database.

4. Integration of CIAT's bean database with those of Pullman and Gembloux.

5. Integration of CIAT's IDMS/R with the systems of other CGIAR institutes.

II. GENETIC IMPROVEMENT

II. 1. Character Improvement

A. Pathology

Introduction to Fungal and Bacterial Diseases

Even though many bean diseases were researched over the years much of the work in bean pathology was concentrated on rust, anthracnose and common bacterial blight- three economically important and widespread diseases in many of the bean growing regions of the world. During 1985, the main emphasis was on angular leaf spot, root rot pathogens and halo blight of beans. The principal activities related to these three diseases, as with the other diseases, were the identification of new and better sources of disease resistance, that are broad and stable in time and space, studies on pathogenic variation and on the disease reaction mechanisms present in the bean germplasm to these pathogens.

During 1985, work was also conducted with rust, Ascochyta, web blight and common bacterial blight diseases. As in previous years, the principal activities were related to evaluation of bean germplasm for their reaction to the disease causing agents. Both, segregating and advanced uniform bean nurseries as well as international bean disease nurseries were evaluated principally under field conditions in several locations but also some nurseries were evaluated under greenhouse conditions. Much of the work of evaluation of bean germplasm was conducted in close collaboration with the breeding sections of the program.

Resistance to Fungal Diseases

Angular leaf spot (ALS)

During 1985, ALS was widespread and severe in several bean production regions of Latin America and Africa and many of the local commercial varieties were severely attacked. Since the severity of this disease has increased considerably in many bean growing areas, one of the main objectives of the program has been to identify sources of resistance.

Initially, most accessions were evaluated for their ALS reaction in Popayan. Many that had an ALS intermediate or resistant reaction in Popayan, were susceptible elsewhere as reported in previous years. However, since 1984, field evaluations have been conducted in Santander de Quilichao, where the disease often occurs naturally and where the pathogenic variation appears to be broader than in Popayan. In addition, since 1984, the Bean Angular Leaf Spot International Nursery (BALSIT) has also been distributed to several bean growing areas of Africa in addition to Latin America. The results of the BALSIT evaluations in Africa are informative and encouraging. For instance, the evaluation of the BALSIT during 1985 in Mulungu, Zaire, where ALS was severe on local commercial cultivars, shows clearly that many of the

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bean lines that are resistant in Colombia and Brazil, are also resistant in Zaire and other countries of the Great Lakes community of Central Africa (Table 1).

Lines A 163, A 345, BAT 76 and Caraota 260 were very resistant to ALS both in Zaire and Rwanda. Similarly, lines A 140, A 216, BAT 1458 (Grade 1 in Zaire); A 217, A 240, A 295, A 339, A 345, A 384, BAT 76 (Grade 2) and A 154, BAT 67 (Grade 3) which had an excellent resistance in Zaire were previously reported as resistant in more than one location of Brazil and Colombia (CIAT Bean Program Annual Report, 1982, 1983, 1984).

However, some lines, such as Jalo EEP 558, A 385, and BAT 1407, considered in Brazil and Colombia as having an intermediate or resistant ALS reaction, were susceptible in Zaire or Rwanda. The line BAT 332 had a resistant reaction in Zaire and Rwanda and during 1984 and 1985 respectively, but is severely attacked by the ALS pathogen in Brazil. Since the evaluation of the same germplasm under field conditions in Africa and Latin America has been done under uniform severe pressure, the information generated is most useful. It has aided in the identification of several bean lines with broad ALS resistance under field conditions, some of which are well adapted such as BAT 76, a line generally characterized by having small ALS foliar lesions, an intermediate or resistant reaction in most locations where it has been evaluated. It has excellent adaptation in Rubona, Rwanda. This line is also well adapted in many locations of Latin America in addition to having a resistant rust reaction in most locations where it has been tested. These field evaluations also strongly suggest that the Isariopsis griseola populations in Africa are different in their pathogenicity from those from in Latin America. The evaluation of newly identified ALS resistant germplasm from Latin America will continue in Africa. Likewise, resistant lines from Africa will be evaluated in Latin America.

During 1985, ALS was also widespread and severe in the northern states of Brazil : Pernambuco, Alagoas, Sergipe and Bahia. The BALSIT has not yet been evaluated in these regions; several lines from the Preliminary Regional Trial of the Mulatinho grain color also present in the BALSIT (EPR-M) were identified as having either an intermediate or resistant reaction in all locations of the four states where the EPR was evaluated (Table 2). It is worth noting that line A 295 was among the most ALS resistant in all the northeastern states of Brazil. This line has been evaluated extensively in other ALS endemic areas of central Brazil where it is also resistant. A 295 also has an ALS resistant reaction in Colombia as well as in Zaire (See Table 1). On the other hand, Jalo EEP 558 has an excellent ALS reaction in all northeastern and central Brazilian states and in Colombia but was susceptible in Zaire. All lines with a resistant or intermediate reaction in northeast Brazil and Africa are presently planted in Santander de Quilichao, where there is an adequate ALS attack. Results are still preliminary, however.

Because of the apparent extensive pathogenic variation existing the populations of I. griseola, a study was started (in collaboration with Michigan State University) to learn more about the pathogenic variation

Table 1. Bean lines from the Bean Angular Leaf Spot International Nursery (BALSIT) with a resistant reaction in Mulungu, Zaire during 1985.

ALS Reaction[a]		
GRADE 1	GRADE 2	GRADE 3
A 74, A 140	A 82, A 163[b], A 212, A 217, A 221 A 240	A152, A 154, A285
A 216, BAT 1410	A 295, A 339, A 345[b], A 352, A 384, A 387	BAT 67, BAT 285, BAT 332
BAT 1458, G 1458	BAT 76[b], BAT 93, BAT 1435, APN 18, XAN 37, XAN 68	BAT 963, BAT 1354 BAT 1432, BAT 1647,
G 2676, G 5173	G 1647, G 4459, G 5207, G 5473, G 11526, Caraota 260[b]	G 731, G 2959, G 3366, G 5272, G 94621

[a] ALS reaction on 1-9 scale where: 1 = free from disease, 5 = intermediate, 9 = severely diseased.

[b] Present in the regional nursery and also evaluated as resistant in Rwanda.

Table 2. Bean lines with a resistant or intermediate reaction to the angular leaf spot pathogen (Isariopsis griseola) in the northern states of Brazil during 1985.

	REACTION AT							
	PER[a]		ALA		BAH		SER	
	1[b]	2	1	2	1	2	1	2
82 PVBZ 1824	1[c]	2	5	3	1	2	2	4
JALO EEP 558	2	3	3	3	3	4	3	3
A 154	2	4	7	3	2	2	3	3
A 251	3	4	5	3	2	2	3	2
A 295	2	4	4	3	2	2	2	5
ESAL 504	2	7	3	3	1	3	3	2
82 PVMX 1637	2	4	5	4	2	3	5	4
82 PVMX 1638	2	4	4	3	2	2	5	4
LM 21303-0	2	6	6	6	2	5	3	5
82 PVBZ 1718	3	6	7	4	2	3	5	3
A 156	2	6	4	4	2	3	5	5
A 275 (S)	8	9	7	9	6	8	8	9

[a] Location: Per = Pernambuco; 1 = Belem do Sao Francisco 2 = Sao Bents do Una; ALA = Alagos; 1 = Santana do Ipanema 2 = Uniao dos Palmares; BAH = Bahia; 1 = Riberao do Pombal 2 = Nova Soure; SER = Pozo verde; Sergipe.

[b] 1 = monoculture, 2 = associated with maize.

[c] Reaction of the bean lines to the ALS Pathogen on a 1-9 scale where: 1 = free from disease; 5 = intermediate; 9 = severely diseased.

in Latin America and Africa and about the disease resistant mechanisms available in the bean plant. Seventeen isolates from different areas of Argentina, Brazil, Colombia, Costa Rica, Nicaragua and Mexico were inoculated singly on a series of 21 bean cultivars under greenhouse conditions. After incubation and symptom development, evaluations were made using the following criteria: (1) reaction or lack of it of the host cultivars to the pathogen; (2) latent period or days after inoculation when plants exhibited ALS symptoms on 20% or more of the leaf area inoculated; (3) lesion size, in mm; (4) number of lesions per leaf; and (5) spore production per mm. of leaf area.

Based on the results obtained, the 17 isolates studied were categorized into what appear to be five distinct pathogenicity groups, races or pathotypes (Table 3). Quantitative differences were also observed both on the host and pathogen. On the host, bean genotypes showed differences in incubation period, lesion size, number of lesions per leaf and number of spores produced by each lesion (Table 4). It is also apparent that the ALS pathogen is highly variable from one location to another and even within a given location (Table 5). This information is needed in formulating a general strategy to manage this important bean disease. Efforts will continue to identify a wide range of resistant genotypes to study the effect of each of these disease resistance mechanisms on ALS management and the effect of the pathogen in reducing yield on varieties representative of each of these resistance mechanisms.

Root rots

Root rot diseases caused by a complex of soilborne fungi, are widespread throughout Latin America. The economic importance of these diseases vary considerably from one location to another often depending on the pathogen complex present in a given region. In coastal Peru, root rots are important and generally are caused by a complex of *Fusarium solani* f.s. *phaseoli* with *Rhizoctonia solani* and are often accompanied by plant parasitic nematodes. In northeast Brazil, *Fusarium oxysporium* f. sp. *phaseoli* is important in some locations, whereas *Macrophomina phaseolina* is damaging in others.

During 1985, considerable efforts were dedicated to root diseases with the collaboration of Dr. George S. Abawi (Dept. of Plant Pathology Cornell University, Geneva, New York).

Charcoal rot (=Ashy stem blight) caused by *Macrophomina phaseolina*

Inoculum preparation and screening procedures. Sclerotia and colonized whole rice seeds were found to be the most appropriate and effective source of inocula for evaluating bean germplasm under greenhouse and field conditions, respectively. Infective sclerotia were produced most abundantly in synthetic liquid medium (10 gm peptone, 15 gm dextrose, 0.25 gm $MgSO_4.7H_2O$, and 0.5 gm $KHPO_4$ in 1 l water) as compared to other media such as potato dextrose broth and soybean seed extract. Autoclaved moistened whole rice seeds (1:1/W:V rice seeds to water) colonized by *M. phaseolina* was the most efficient and most easily prepared inoculum for field testing as compared to other preparations.

Table 3. Classification of 17 *Isariopsis griseola* (the angular leaf spot pathogen) isolates from Latin America into five pathogenicity groups based on their reaction on eight bean cultivars.

Pathogenicity group	Isolate	Area of origin	Cornell 49242	Pompadour Checa	BAT 332	G 5686	A 339	Montcalm	Seafearer	BAT 1647
1	Guatemala 1	Jutiapa	S[a]	S	S	S	S	S	S	S
	Colombia 501	Sant. Quilichao	I	S	S	S	S	S	I	S
	Mexico	Tepame	I	S	S	S	I	S	S	I
	Guatemala 2	Monjas	S	S	S	S	I	I	S	I
2	Argentina Dor 41	La Cocha	R	R	S	S	I	S	S	S
	Brazil F	Caruaru, PE	R	R	S	S	R	S	S	S
	Brazil A	Sao Bento, PE	R	R	S	S	I	S	S	I
	Brazil CNF No.22	Goiania	R	R	S	R	R	S	S	I
	Brazil C	Sao Bento, EP	R	R	S	I	R	I	S	I
3	Colombia Pcp.10	Popayan	S	S	R	I	I	S	S	I
	Costa Rica No. 2	Esparza	S	S	R	I	R	S	S	R
4	Colombia	Pasto	R	R	R	S	R	S	R	R
	Colombia	La Selva	R	R	R	S	R	S	R	R
5	Nicaragua	Corazo	R	R	R	I	R	S	R	R
	Argentina, Exp.17	Rapelli	R	R	R	R	R	S	R	R
	Argentina, Pan 35	Ceibalito	R	R	R	R	R	S	R	R
	Argentina A 493	Las Cañas	R	R	R	R	R	S	R	R

[a] S = Susceptible, 5% leaf area covered by *I. griseola* lesions.
I = Intermediate, 1-4% leaf area covered by lesions.
R = Resistant, no symptoms of disease.

Table 4. Reaction of 21 bean cultivars to 17 isolates from Latin America of the angular leaf spot pathogen of beans (*Isariopsis griseola*).

Cultivar	Severity (% disease)	Lesion size (mm^2)	No. lesions	Incubation period (Days to 20% disease)	No. spore (per mm^2)
A 339	7 (10)[a]	3.9	36	13	85
A 212	8 (10)	6.4	46	12	88
BAT 76	12 (9)	6.7	44	12	78
A 235	13 (9)	6.9	46	17	101
BAT 1647	13 (10)	4.4	73	17	97
Caraota 260	14 (8)	8.6	62	17	103
Amendoin	18 (17)	4.6	84	18	172
A 21	19 (10)	7.4	61	12	146
G 5686	20 (14)	6.6	76	19	176
G 1805	22 (11)	11.7	70	16	211
Cornell 49242	22 (5)	17.4	40	18	141
A 62	26 (11)	11.2	79	16	198
Calima	26 (17)	7.9	98	17	284
G 2858	27 (11)	20.4	42	17	384
Jalo EEP 558	28 (7)	6.7	162	14	167
Seafarer	30 (11)	21.3	59	16	148
Alabama No. 1	31 (11)	9.5	84	16	240
BAT 332	34 (11)	13.9	106	13	171
Montcalm	34 (17)	8.8	139	15	271
A 301	39 (9)	16.2	90	14	182
Pompadour Checa	37 (6)	13.3	163	15	200

[a] Number of isolates infecting that cultivar.

Table 5. Quantitative differences among 17 *Isariopsis griseola* (the angular leaf spot pathogen) isolates from Latin America based on their reactions on 21 bean cultivars.

Pathogenicity group	Isolate	Origin area	Infected cultivars (out of 21)	% disease	No. lesions	Lesion size (mm^2)	Days to cause 20% disease / No. cultivars exhibiting 20% or more disease
1 - A	Guatemala 1	Jutiapa	21	26	65	15.4	18/15
B	Colombia SQ 1	Sant. Quilichao	21	36	105	10.9	14/17
C	Mexico	Tepame	21	27	159	9.8	13/13
D	Guatemala 2	Monjas	21	16	30	16.9	19/8
2 - A	Argentina Dor 41	La Cocha	19	22	89	5.4	15/10
B	Brazil F	Caruaru, PE	18	22	82	4.4	16/10
C	Brazil A	Sao Bento, PE	18	24	89	5.3	14/9
D	Brazil CNF No. 22	Goiania	18	13	65	5.7	16/6
E	Brazil C	Sao Bento, PE	19	10	19	11.9	20/4
3 - A	Colombia Pop 10	Popayan	17	11	24	11.1	19/5
B	Costa Rica No. 2	Esparza	16	21	92	7.5	18/9
4 -	Colombia	Pasto	5	40	172	9.0	14/5
	Colombia	La Selva	5	45	181	6.0	15/5
5 - A	Nicaragua	Corazo	4	28	212	4.8	15/4
B	Argentina Exp. 17	Rapelli	4	25	60	20.8	17/3
	Argentina Pan 35	Ceibalito	4	32	124	5.8	13/3
	Argentina A 493	Las Cañas	4	41	149	6.0	14/4

All data are based on the number of cultivars susceptible to each isolate.

The following is a brief description of the inoculation methodology employed :

(i) Greenhouse tests : Dried sclerotia are added to pasturized soil and mixed thoroughly at a rate of 2 gm sclerotia/kg soil. A layer of infested soil of about 2 to 3cm deep is then added on top of bean seeds to be evaluated. Containers are maintained in the greenhouse and watered and fertilized as needed. Seedlings of susceptible bean germplasm will either fail to emerge or exhibit essentially 100% infection symptoms by *M. phaseolina* (Figure 1). Generally, symptoms appear first on the cotyledons and then expand rapidly to the stem tissues (Figure 2). Seedlings of highly susceptible germplasm may die within two weeks.

(ii) Field tests : Four grams of colonized whole rice seeds are added to bean seeds as an in-furrow treatment (about 2-3 colonized rice seeds/bean seed). The latter level of infestation with this inoculum has resulted in almost 100% infection of susceptible germplasm.

Variability among isolates of M. phaseolina and their virulence to beans. Results obtained have shown that isolates of *M. phaseolina* differ significantly in their pathogenicity to beans (Table 6). The most aggressive isolate (Mp/Ch-84) identified to date was originally obtained from the bean cultivar 'Chileno' grown near Palmira. Other isolates from different bean growing regions are now being evaluated in comparison to the MP/Ch 84 isolate.

Germplasm evaluation. The reaction of over 60 breeding lines and cultivars against *M. phaseolina* were evaluated in replicated split plots (inoculated and non-inoculated) at Quilichao where severe incidence of charcoal rot occurred the previous season. Selections that looked good included San Cristobal 83, BAT 477, A 55, G 5059 and many others. The promising materials from the nursery along with the appropriate checks (total of 43 materials) have been replanted for a second cycle of evaluation at Quilichao. Preliminary greenhouse tests have demonstrated the effectiveness and consistency of the procedure in differentiating the reaction of tolerant lines such as BAT 477 and G 5059 from those with a susceptible reaction such as A 464 and VRB 81030 (Table 7). All lines evaluated in the field will also be screened by the greenhouse procedure.

Rhizoctonia-rot and Fusarium-rot

An initial root rot nursery was established in Popayan with about 136 materials replicated three times. Each line was evaluated in non-inoculated, *Fusarium solani*-inoculated, and *Rhizoctonia solani* inoculated plots. Considerable variability was evident in the reaction of the tested materials. Some of the promising materials included A 54, A 107, RIZ 21, RIZ 30, BAT 1753, ICA Tui, G 02006, G 03153 and several selections obtained from Cornell University. About 60 materials selected from the above nursery were replanted at Popayan for a second cycle of evaluation. A fourth treatment was added that consisted of

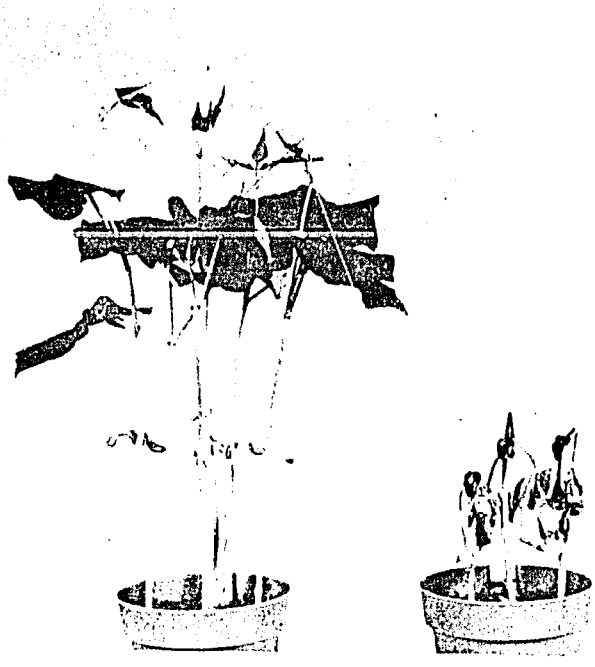

Figure 1. Symptoms of charcoal rot of 100% infection by Macrophomina phaseolina on plantlets of susceptible germplasm.

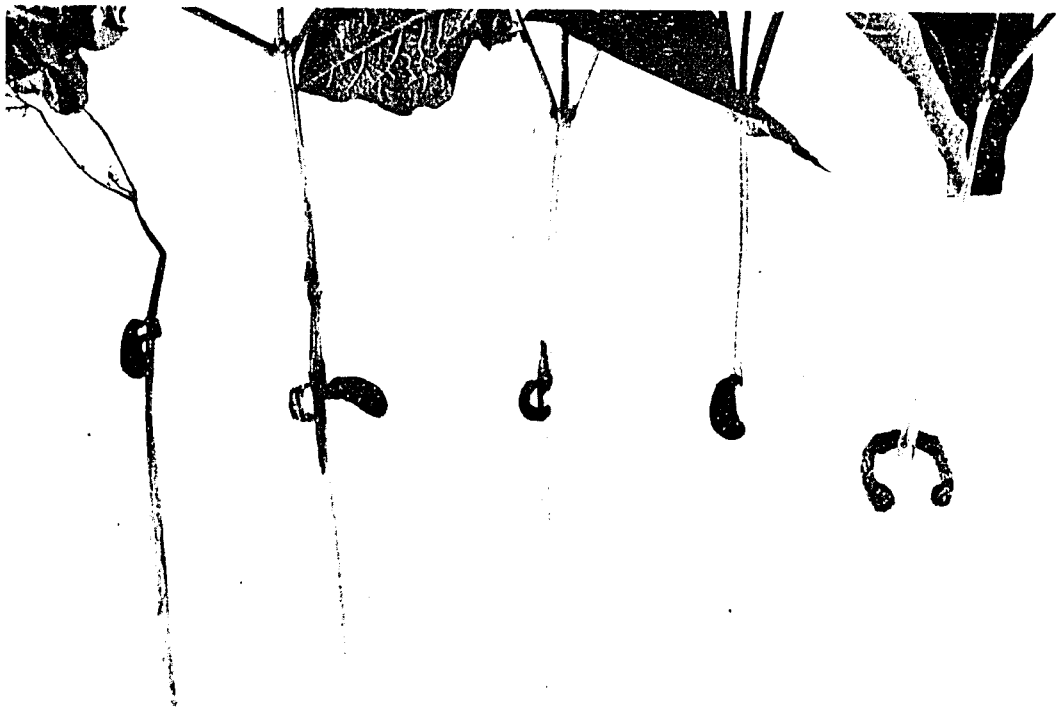

Figure 2. Appearance of symptoms of charcoal rot first on the cotyledons extending rapidly to the stem tissues.

Table 6. Virulence of four isolates of Macrophomina phaseolina to California Light Red Kidney bean under greenhouse conditions.

Isolate/code	Dry weight (gm) of bean plants/replicate[a]
Mp-2	2.58 a
Mp-1	1.91 b
Mp-St./85	1.11 c
Mp-Ch./84	0.88 c

[a] Weight of non-inoculated check plants was 2.90 gm.

Table 7. Evaluation of the reaction of BAT 477 and A 464 to Macrophomina phaseolina under greenhouse screening conditions.

Inoculum source	Disease severity rating[a]	
	A 464	BAT 477
None	1.0	1.0
Sclerotia[b]	7.2	1.0
Sclerotia[b]	9.0	2.6
Colonized seeds[c]	4.7	1.0

[a] Emerged seedlings were rated on a 1 (no visible symptoms) to 9 (most severe symptoms- dead plants) at four weeks after planting.

[b] Sclerotia were produced on the soybean extract broth and the M-medium, respectively, and were incorporated into soil at 2 gm/kg soil.

[c] Whole rice seeds were inoculated with the fungus two weeks prior to use. Two colonized rice seeds were placed in direct contact with each bean seed.

non-inoculated plots with an in-furrow spray application of Brasicol and Difolatan. The promising materials will be evaluated further under greenhouse conditions.

Web blight

F_2 populations were evaluated in the web blight nursery in Costa Rica within the Central American project, as in previous years. These represented the first large group of segregating populations combining the best parents identified in the International Web Blight Nursery (VIM). These crosses were planned specifically to search for those combinations that could offer transgressive segregation. Selection was thus practiced first among populations to identify those offering more promise of transgressive segregation, and then within the most promising populations. Individual plant selections will be increased and progeny tested in 1986. Porrillo 70 and Talamanca, both well adapted and moderately resistant, did not prove to be good parents, while combinations of parents giving promising populations were specific.

Some of the most promising combinations were:
Acacias 4 x MUS 6
BAT 450 x Turrialba 1
BAT 1636 x S 630-B
MUS 6 x A 40
DOR 60 x PAI 113
PAI 113 x A 40
MUS 13 x Talamanca
MUS 14 x BAT 304

Sources of resistance to common bacterial blight continue to produce promising progeny with resistance to web blight. *Xanthomonas* resistant lines developed in CIAT as part of a Ph.D. thesis of a Cuban national program scientist were therefore planted in Costa Rica. Several of these lines resulted from backcrosses to moderately resistant cultivars, such as ICTA Quetzal, ICTA Tamazulapa, etc. Several progenies selected for *Xanthomonas* resistance in CIAT were rated 2 to 3 points better than the resistant check, Porrillo 70, on a 9 point scale.

Growth chamber screening for resistance to web blight. Inherent variability in web blight field evaluations led CIAT investigators to study a methodology for growth chamber screening of resistance under controlled conditions. Two successive factorial experiments were realized which combined: four plant ages at inoculation (1, 2, 3 and 4 weeks after planting); 3 and 5 genotypes, respectively (MUS 6, PVA 1380 and Chileno in the first study; these three plus PAI 113 and Uribe Rosado in the second); and four inoculum concentrations, constituted by macerating a petri plate of *Rhizoctonia solani* on PDA in 200. 400, 600 and 80 ml distilled water, respectively. MUS 6, PAI 113 and PVA 1380 were chosen as resistant genotypes, Chileno and Uribe Rosado as susceptible. Seed was sown initially in pots in a screenhouse and transferred to the growth chamber for incubation after inoculation by spraying foliage with the micelial suspension. The growth chamber was maintained at 28° C and 95% RH, with 12 hours continuous light per day. Plants were maintained there for eight days; evaluation of symptoms

began on the 2nd day after inoculation and was carried out several times. Data were taken as percentage foliage infected.

Results of the two experiments were essentially the same, and only those of the second experiment are discussed. Analysis of variance revealed a high CV (47%), thus a transformation of data was performed (% +.1) which reduced the CV to 19%.

Field results were essentially repeated in the growth chamber experiment, in so much as the genotypes maintained their relative resistance rankings: MUS 6 and PAI 113 had fewer symptoms, Chileno and Uribe Rosado were highly susceptible. Only PVA 1380 tended to be somewhat erratic in its response in the growth chamber.

With respect to age at inoculation, it seems undesirable to inoculate at one week of age (unifoliate stage) since reaction of unifoliates was not consistent and genetic differences were not clear. Older plants tended to present more symptoms, and widest genetic differences were observed with the two week-old plants.

Either the 400 or 600 ml inoculum dilution served well, the 200 ml dilution being too concentrated and the 800 ml too dilute.

In summary, it was possible to repeat field results with the inoculation technique described, and it would be possible to screen germplasm or non-segregating families with this technique. However, examination of plant-by-plant data revealed that escapes do still occur, and thus screening of segregating populations is not advised.

It should be noted that these findings are valid only for a highly virulent isolate, such as the one used in this study, which was obtained in Monteria, Colombia. Another isolate from Armenia, Colombia, proved to have much lower virulence, and the concentration recommended here would be inadequate for that isolate.

Resistance to bacterial diseases

Halo blight

Continuing the collaborative project between the CIAT and the National Vegetable Research Station (NVRS) initiated in 1984, studies were made: (1) to determine the occurence and distribution of pathogenic variants of the causal organism *Pseudomonas syringae* pv *phaseolicola* in Africa and Latin America; and (2) to identify sources of resistance to the pathogen in *Phaseolus vulgaris* appropriate to the two continents.

a. *Pathogenic variation*. Isolates from infected bean material collected in Africa, Latin America and to a limited extent in Europe were screened for their pathogenic response on a range of potentially-differential cultivars of *P. vulgaris*. On the basis of these tests, four differential cultivars were selected (Table 8) and 312 isolates were designated as either races 1, 2, 3 or 4 (Table 9).

Table 8. Race identification in *Pseudomonas syringae* pv *phaseolicola*, the pathogen of halo blight of beans.

Differential cultivars	Reaction to race			
	1	2	3	4
Canadian Wonder	+[a]	+	+	+
Red Mexican	-	+	+	-
Tendergreen	+	+	-	-
Edmund	-	-	-	-

[a] +, susceptible; - resistant

Table 9. Occurrence and distribution of races of *Pseudomonas syringae* pv *phaseolicola*.

Source of	Number of isolates of race				All races
	1	2	3	4	
Africa	34	89	144	7	274
Latin America	8	14	-	-	22
Europe	12	4	-	-	16
Total	54	107	144	7	312

Race 1 was present on P. vulgaris in Africa and Latin America and although not the predominant race, it had a wider natural host range than the other races. In Africa particularly, it was found infecting a number of leguminous species including P. coccineus (runner bean), P. acutifolius (tepary bean), Cajanus cajan (pigeon pea), Lablab purpureus (hyacinth bean) and an unidentified leguminous weed.

Race 2 was widely distributed in Latin America (e.g. Colombia, Mexico, Peru) and in certain African countries especially Kenya, Tanzania and Zambia. Some African isolates of race 2 from northern Tanzania and Kenya produced a brown diffusible pigment in agar culture. These isolates were measurably more aggressive than race 2 isolates previously encountered in Europe, North and South America. Race 2 is probably the predominant race on a world scale and is well adapted to P. vulgaris. It was not isolated from other Phaseolus species although in Africa, isolates were obtained from Cajanus cajan and Lablab purpureus.

Race 3, first identified in 1984, was the most widely distributed race in Africa. It was present on P. vulgaris in Ethiopia, Uganda, Rwanda, Burundi, Zaire and Tanzania. It was also isolated from P. coccineus and Desmodium sp.
Race 3 was not found outside Africa.

Race 4, identified for the first time in 1985, was present on Glycine max (soybean) in Rwanda and Zaire. It was isolated on only one occasion from P. vulgaris growing alongside infected soyabeans. The importance of this race to soybeans and its potential significance to P. vulgaris is not known.

To summarize, the races in order of importance were: in Africa, races 3, 2 and 1; in Latin America, races 2 and 1. There was insufficient data on race 4. Further collections will be necessary to complete the picture of race distribution especially for Latin America and southern Africa.

b. Sources of resistance. Preliminary tests for resistance were made on a collection of 454 accessions of P. vulgaris from the CIAT germplasm collection. Inoculations were made with a selection of eight isolates representative of races 1, 2 and 3 from various geographical areas, mainly from Africa and Latin America but also from North America and Europe.

Plant reactions were recorded on a 1-9 scale with grade 1 highly resistant and grade 9 highly susceptible. This enabled the detection of both qualitative (race specific) and quantitative (race non-specific) responses to infection. Race specific reactions (grade 1) were fairly common with 82 accessions showing resistance to either race 1 or race 3 or races 1 and 3 (Table 10).

No specific resistance has yet been found to race 2. However, 11 accessions showed evidence of a high level of race non-specific resistance with mean grades of less than 5 against isolates of all races, including race 2. Many other accessions showed varying degrees of susceptibility/resistance (quantitative resistance) (Table 11).

Table 10. Sources of halo blight resistance in 454 CIAT bean accessions

Number of accessions	(%)	Resistance type
361	(80)	Susceptible (to varying degrees)
54	(12)	Race 3 specific
23	(5)	Race 1 specific
11	(2)	Race non-specific
5	(1)	Race 1 and 3 specific

Table 11. Bean lines with race non specific resistance to the halo blight pathogen.

G No.	Identification	Origen	Reaction to race[a]		
			1	2	3
-	Mix of 6 Lines	Burundi	1.0	3.6	1.6
G2829	Gloriabamba	Mexico	3.0	4.0	3.0
G3954	WIS HBR 72	USA	1.0	1.0	1.0
G5476	Jules	USA	1.0	1.0	1.0
G5477	GNN # 1 Sel 27	USA	1.0	2.0	5.0
G11766	Pajuro	Peru	1.0	3.6	2.4
G12666	Nariño 20	Colombia	1.0	3.6	5.0
G12669	Palomo	Peru	1.0	4.0	5.6
G12592	Poroto	Peru	5.0	3.6	5.0
G13673	Mantequilla	Mexico	3.0	5.0	5.0
G8108[b]	Kabanima	UGANDA	9.0	9.0	8.4
G5772[b]	Diacol Andino	Colombia	7.0	8.0	8.4

[a] Race 1 = isolate from UK, Race 2 = isolates from Colombia, Mexico, USA and Tanzania; Race 3 = 3 isolates from Tanzania, Uganda and Rwanda.

Scores are means on a 1-9 scale, 1 = free from disease, 9 = severely diseased

[b] Check cultivars

The majority (70%) of accessions showed an intermediate level of susceptibility (grade 4 - 6) and only 19% were in the highly-susceptible category (8-9). At the more resistant end of the scale, 48 accessions (11%) had mean grades of less than 6. This included the 11 accessions previously categorized as race non-specific resistant (Table 12) on the basis of a mean grade of less than 3. Previous experience in comparing the results of glasshouse screening for resistance with field performance would suggest that the 48 accessions should have a high level of field resistance.

Future Prospects

With the present knowledge of the distribution of races, especially in East Africa and the range of resistant material available, it should be possible to deploy accessions with resistance characteristics appropriate to a particular area. For example, in East Africa, resistance to race 3 or combinations of resistance to races 1 and 3 and race non-specific resistance. Seed of many accessions, especially those with race 3 resistance, have been multiplied under quarantine conditions at NVRS for dispatch to trial sites in Africa.

Although relatively few sources of high level race non-specific resistance have been identified, over the long-run, the development of such material may provide a more durable solution to the halo-blight problem than the deployment of race specific resistance, particularly with the present lack of specific resistance to race 2.

Screening of specific resistance to race 2 and race non-specific resistance should receive high priority in further tests of CIAT germplasm. Additional studies will be necessary to elucidate the inheritance of resistance in the various sources. Present evidence indicates that race specific resistance is controlled by a single dominant gene. The inheritance of race non-specific resistance is as yet uncertain but may be due to recessive genes or polygenes.

Table 12. Quantitative variation in susceptibility/resistance in 454 CIAT accessions.

Susceptibility resistance grade	Number of accessions in grade to race			
	1*	2	3	Mean**
1 - 2	35	1	60	1
2 - 4	6	6	6	5
4 - 6	64	43	43	42
6 - 8	268	298	254	320
8 - 9	78	106	91	86

, majority in the grade represent race-specific resistance; *, 3 missing values; ** mean 3 races (8 isolates) but excluding race-specific components.

B. Virology

Bean Common Mosaic Virus

Common mosaic resistance

The demand for dominant I-gene screening not only remained stable but registered a slight increase (10%) over last year's figure. Out of the total number of breeding materials evaluated this year (23,968), approximately 81% belonged to the three breeding sections of the Bean Program, and 10% to the national programs of Peru (1,268 lines), Chile (242 lines), and Costa Rica (31 lines). The rest of the materials evaluated were part of internal nurseries and special projects. The BCMV screening capacity was increased to 1,600 plants or 160 lines per work day.

Black root resistance

The main emphasis of the BCMV research conducted at CIAT-Palmira was the characterization of black root resistance mechanisms and identification of new resistance sources. Two resistance mechanisms : the expression of pin-point local lesions and immunity (no symptoms) were previously known to be associated with the recessive genes bc 2 (together with the I gene) and bc-3, respectively. Most of the black root resistant lines screened in the past, however, have exhibited a larger type of local lesion which appears to involve some modifier genes besides the combination Ibc2. The fourth type of reaction, originally observed in the cultivar Red Kloud, consisted of a restricted vein necrosis in mechanically-inoculated primary leaves, without any further manifestation of systemic necrosis. This reaction was recorded for the NL3 strain, the most aggressive necrotic variant of BCMV known to exist in Latin America and Africa. This resistance, however, is overcome by the more pathogenic NL5 necrotic BCMV strain which exists in Europe.

With respect to the search for mosaic/black root resistant genotypes in the Phaseolus vulgaris CIAT collection, none of the 17,723 accessions evaluated so far, has proved to possess bc-3 or any previously unreported black root resistant gene. A thorough investigation of the promising G 13936 accession, previously thought to contain the bc-3 gene, demonstrated the presence of unidentified genes different from bc-3 (absent in this genotype) which slow down virus multiplication and inhibit symptom expression in the first stages of plant development. This phenomenon had been observed in five other bean accessions of the evaluated bank collection.

While Bean Virology will probe deeper into the potential value of these various resistance mechanisms, we are recommending an increase in the number of crosses between I and bc 2 genotypes to facilitate the selection of truly resistant plants and not merely symptomless virus hosts, and to exploit existing tropically-adapted $bc2^2$ genotypes in crosses. The bc3 gene, however, constitutes a stable source of black root resistance, currently exploited through the cooperative IVT-CIAT project. There are over 150 lines being evaluated in Africa

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for their reaction to common mosaic/black root resistance and other desirable agronomic characteristics.

Selection of homozygous BCMV-resistant yellow-seeded genotypes exhibiting linkage problems.

As reported last year, several common mosaic resistant red-seeded lines, previously exhibiting color/BCMV-susceptibility linkage problems, have already been selected. This year, the linkage problem was finally broken for the more refractory yellow-seeded 'Canarios'. The homozygous-resistant lines identified VA 85-875 and 876; CIFAC 1278, and VA 85-819, have both the commercial color and acceptable seed size. As with other 'problem' seed colors, the selection of these homozygous resistant genotypes has been possible following a continuous scheme of intensive individual selection and BCMV evaluation.

Research projects

Characterization of BCMV. Despite the numerous research papers available on BCMV, its main physicochemical properties were unknown. The proper characterization of plant viruses and their strains is critical to the understanding of their pathogenic variability and epidemiology. In this study, for example, the necrotic strains NL3 and NL5 proved to be serologically distinct from the mosaic-inducing Type, Florida, New York 15, and NL4 strains. By orthodox criteria, it would be possible to conclude that the necrosis-inducing strains NL3 and NL5 did not evolve from the same plant host as the original mosaic-inducing BCMV strains and that, furthermore, these two groups of strains represent different viruses.

Seed-transmission of BCMV strains in different bean genotypes

One necrosis- and four mosaic-inducing strains of BCMV were seed-transmitted in 14 mosaic-susceptible bean varieties. However, the seed transmission incidence varied depending on the bean genotype and BCMV strain tested (Table 1). The varieties Dubbele Witte, Redlands Greenleaf B, Michelite, Sanilac and Red Mexican 35, transmitted the Type, Florida, New York 15, NL3 and NL4 strains in 40 to 54% of the seed produced by infected plants. The maximum seed transmission was observed in those test plants inoculated at the primary leaf stage. The necrosis-inducing NL3 strain showed a low seed-transmission incidence in most of the bean varieties tested, with the exception of the navy bean cultivars Sanilac and Michelite. This observation has important epidemiological implications (Table 2). Twelve of the 14 varieties tested did not transmit BCMV in the seed of plants inoculated 30 days after sowing. Three varieties -Imuna, Great Northern 123, and Great Northern 31- transmitted the virus below the 1% seed infection level (Table 3). Pinto 114 did not transmit the New York 15 strain in tests involving over a 1,000 seeds harvested from systemically infected plants (Table 3). These results clearly demonstrate the existence of seed-infection resistance mechanisms in *Phaseolus vulgaris*. This resistance could be useful for production

Table 1. Mean seed transmission incidence of selected bean common mosaic virus strains in differential bean varieties inoculated at three different growth stages.

Differential variety	Bean common mosaic virus strain				
	US 1	US 5	US 2	NL 3	NL 4
Dubbele Witte	14.6[x] abA	19.7 a AB	5.2 b C	19.6 a A	13.2 abA
Stringless Green Refugee	22.2 a A	20.3 a AB	0.0 b D	1.2 b C	12.0 abAB
Redlands Green Leaf C		5.8 a BC	0.0 b D	0.0 b C	0.0 b B
Imuna		0.0 a C	0.0 a D	0.0 a C	0.0 a B
Puregold Wax		29.0 a A	0.5 cCD	0.0 cC	10.0 bAB
Redlands Greenleaf B		15.1 a AB		0.0 b C	6.8 abAB
Great Northern 123		0.0 a C		0.0 a C	0.0 a B
Sanilac			12.7 a B	20.1 aA	
Michelite 62			18.1 aA	15.4 aAB	
Red Mexican 34			2.5 a CD	10.4 a B	
Pinto 114			0.0 a D	0.0 a C	
Monroe					52.2 A
Great Northern 31					0.0 B
Red Mexican 35					51.9 A

x Values represent the means (%) of three replicates and inoculation dates (10, 20, 30 days after sowing). Means followed by the same letter are not significantly different (P=0.05) between strains (small letters) or differential cultivars (capital letters).

Table 2. Maximum seed transmission incidence of five bean common mosaic virus strains in differential bean varieties.

Differential variety	Bean common mosaic virus strain				
	US 1	US 5	US 2	NL 3	NL 4
Dubbele Whitte	43.5[x]	57.5	20.23	43.2	37.1
Stringless Green Refugee	29.7*	29.7	0.0	8.3	26.5
Redlands Greenleaf C		12.3	0.0	0.0	0.0
Imuna		0.0	0.0	0.0	0.0
Puregold Wax		52.9*	1.6	0.0	25.0
Redlands Greenleaf B		28.7*		0.0	12.1
Great Northern 123				0.0	0.0
Sanilac			24.1	39.7	
Michelite 62			54.4	34.7	
Red Mexican 34			4.7	17.0	
Pinto 114			0.0	0.0	
Monroe					42.2
Great Northern 31					0.0
Red Mexican 35					46.6

[x] Values represent mean percentage of three replicates corresponding to the first inoculation date (10 days after sowing), with the exception of values accompanied by an *, which were obtained for the second inoculation date (20 days after sowing).

Table 3. Seed transmission assay of selected bean common mosaic virus strains in differential bean varieties.

Differential variety	BCMV strain	No. of plants infected/evaluated	Seed transmission incidence (%)
Imuna	US 5	1/273	0.36
Great Northern 123	US 5	2/314	0.64
Pinto 114	US 2	0/1126	0.00
Great Northern 31	NL 4	2/326	0.61

areas where BCMV is a pathogen of phytosanitary rather than economic importance.

Bean Yellow Mosaic

The importance of bean yellow mosaic is increasing in most of the subtropical bean production areas of the world. In Latin America, the appearance of the causal virus in Argentina, and a new strain in Chile, has complicated the existing bean improvement projects for these two important bean producers. The main research effort this year was the characterization of the new BYMV-OI (Orfeo-INIA) strain which occurs in Chile. Table 4 shows the pathogenicity range of the previously known 'severe' strain and the new Orfeo-INIA BYMV variant isolated in Chile. As can be appreciated, the sources of BYMV (severe strain) resistance have now proven susceptible to the new Orfeo-INIA strain. As its name suggests, this new strain can infect the newly released variety Orfeo-INIA (Negro Argel x Great Northern 31) previously resistant to the known BCMV and BYMV strains that existed in Chile.

The new BYMV-OI strain has been isolated to look for new sources of resistance and learn more about the epidemiology of BYMV in Chile, particularly its origin. Similar steps are being taken to confirm the presence of BYMV in northern Argentina.

Bean severe mosaic

A severe mosaic accompanied by necrosis in common mosaic-resistant genotypes, had been previously reported in the locality of San Andrés, El Salvador. This year, the problem was also observed in Guatemala and Honduras, where it caused appreciable damage in experimental bean trials. An electron microscopy analysis of infected tissue extracts revealed the presence of isometric comovirus-like particles of ca. 30 nm. A serological assay of these tissue extracts using antisera prepared to the main isometric viruses found in Latin America: bean rugose (a comovirus), bean southern, and bean mild mosaic viruses, gave negative results. The only other comovirus reported eight years ago in Latin America was a bean strain of Quail Pea Mosaic (QPMV) originally described as 'bean curly dwarf mosaic virus', from symptoms induced in plants double infected with bean mild mosaic. A serological assay of infected tissue extracts, using QPMV antiserum, gave a positive serological reaction.

Mechanical inoculation tests demonstrated that the virus systemically infects common mosaic-susceptible and resistant (I gene) bean genotypes, causing necrosis in the latter group. This genetic interaction is being investigated to modify the breeding strategy for the affected bean cultivars. In the meantime, the virus can be controlled by reducing the population of its beetle vectors, mainly chrysomelids.

Table 4 . Reaction of selected bean differentials inoculated with two Chilean strains of bean yellow mosaic virus (INIA-CIAT cooperative BYMV project).

Differential group	Variety	BYMV strain	
		Severe	O.I.
1	Dubbele Witte	+++[a]	++
	Stringless Gree Refuee	+++	+++
2	Redlands Creenleaf C	++	+++
	Puregold Wax	++	++
	Imuna	+	++
3	Redlands Greenleaf B	++	++
	Great Northern 123	-	+
4	Sanilac	++	+
	Michelite 62	++	++
	Red Mexican 34	++	+
5	Pinto 114	-	+
6	Monroe	+	++
	Great Northern 31	-	+
	Red mexican 35	++	+
7	IVT 7214	-	+
8	Widusa	+++	++
	Black Turtle Soup	++	++
9a	Jubila		+++
9b	Top Crop	+	++
	Improved Tendergreen	++	+++
10	Amanda	-	++
11	IVT 7233	-	-

[a]Sympton expression: + = weak; ++ = moderate; +++ = severe; - = no symptoms.

Bean Golden Mosaic

A major revision of research strategies was initiated this year as the coordination of the bean golden mosaic project was centralized at CIAT headquarters. While the incidence of this disease has decreased in the black-seeded bean production areas of Guatemala and the Gulf Coast of Mexico, bean golden mosaic is still a major production constraint in El Salvador, Dominican Republic, Brazil and Argentina, where other seed-colors are preferred. In the latter two countries, the disease became even more widely distributed this year.

A significant observation has been that the tolerance levels incorporated so far vary with the incidence of viruliferous *Bemisia tabaci* vectors. Under high whitefly pressure, most of the tolerant lines developed to date, become susceptible. This observation suggests the possible existence of insect resistance mechanisms in some of the golden mosaic-improved germplasm.

A second objective was to conduct a pedigree analysis of all the golden mosaic-improved lines and other bred materials which have shown good agronomic behaviour under BGMV pressure. This analysis demonstrated that over 95% of the golden mosaic-tolerant lines developed in Latin America, contain 'Porrillo' or 'Turrialba 1' genes. On the other hand, some potentially useful genotypes were identified in the pedigrees of some of the BGMV-tolerant lines found in CIAT breeding nurseries. These genotypes pertain to classes of bean germplasm (specifically Pintos and Kidneys) which have been observed to possess a broad level of tolerance to several bean viruses. Approximately 2,000 accessions of these and other promising germplasm classes have been selected and increased for BGMV screening next year. It is expected that some of these accessions will become new sources of BGMV resistance or tolerance, to broaden the genetic basis of the golden mosaic improvement project.

The year 1985 also saw substantial progress in the efforts to utilize sources of resistance to BGMV. Using resistant lines such as A 429, DOR 302, and DOR 303, identified since the release of the mosaic resistant varieties in Guatemala, progeny were observed which had much higher levels of resistance than those previously attained. All three of the afore-named sources are non-black-seeded. In particular, A 429 was useful as a source for Central American small red-seeded beans, and for the Brazilian Rosinha class, and several lines with commercial grain type were recovered.

While resistant Quetzal checks in the September nursery rated from 6 to 8 in pod load (reflecting very heavy pressure, since 9 is the susceptible extreme of the scale), some of the A 429 progeny rated 2 and 3. In particular, the following crosses were especially promising:

Cross	Grain class recovered
(A 429 x RAO 30)	Rosinha
(A 429 x RAB 56)	Red brilliant

(DOR 201 x Canario 101)	Pompadour
(DOR 316 x A 83)	Carioca
(DOR 303 x A 429)	Carioca
(DOR 303 x A 464)	Carioca

The following step will be to evaluate the yielding ability of these lines with and without BGMV pressure, and to utilize them in a broad range of crosses with high yielding lines identified in the Adaptation Nursery, and with local cultivars.

Originally, the breeding project for Pompadour grain type was hindered by genetic linkage of grain color and susceptibility to bean common mosaic virus. Now a wider range of lines with BCMV resistance and Pompadour grain are available, and these will rapidly be put into crosses with sources for bean golden mosaic resistance.

Several accessions of Phaseolus coccineus, previously identified as resistant to BGMV, were retested under very heavy virus pressure. Of these, G 35171 (NT 15) and G 35172 (NT 16) were practically immune in foliage while G 35149 (M 7708) was intermediate.

C. Entomology

Evaluations of host-plant resistance to Empoasca kraemeri, seed infesting bruchids, and Apion godmani continued in 1985.

Empoasca Kraemeri

Mechanisms of Resistance

Tolerance to leafhopper feeding damage is the predominate defense mechanism in beans to E. kraemeri. Tolerant bean lines are able to support high populations of the insect without showing severe damage symptoms or high yield loss as compared to a susceptible check.

Recent studies, however, have identified low to moderate levels of antixenosis to oviposition - a characteristic of the plant that makes it less attractive or preferred by an insect as a host. No-choice tests, where the insect was confined to a particular genotype, showed that antixenosis resistance reduced the nymphal populations on EMP 89 and EMP 94 under different infestation levels and plant ages in greenhouse experiments (Table 1).

Subsequent field evaluations have identified other bean lines containing antixenosis resistance (Table 2). Of these, EMP 135 had the highest nonprotected yield and the lowest nymphal population, when measured as nymphs/g of plant dry matter. Further studies are needed, however, to determine whether the antixenosis resistance in these lines will be maintained under no choice conditions for the leafhopper.

Evaluation of five cycles of recurrent selection breeding

Leafhopper resistant breeding lines from five cycles of a recurrent selection breeding program were evaluated in a field study to determine whether advances in overall resistance levels had been obtained over cycles of selection. Table 3 shows the resistance measurements (nymphal counts, damage scores and nonprotected yield) of the best lines from five cycles of recurrent selection. No consistent increase of overall resistance levels was obtained in the five cycles (Table 4). The best cycle for mean nonprotected yield was cycle 3, which was significantly better than cycles 1, 2, 4 or 5. Progress was obtained, however, in transferring the resistance to a wider range of bean grain types (Figure 1), though the seed colors having the highest nonprotected yield continued to be the browns, Mulatinos, creams and blacks (Table 5). No differences were found among seed color groups for nymphal populations or damage scores.

Cycles VI/VII

The most promising selections of the combined cycles VI/VII were tested in three yield trials during 1984B, 1985A and 1985B semesters. The analysis of variance showed significant differences among nonprotected yields for semesters, genotypes, and genotype x semester interaction (Table 6). The genotype x semester interaction, however, was not significant for nymphal counts or damage scores. The leafhopper population levels found on tolerant and antixenosis bean lines, and the plants' response to leafhopper feeding damage, appear to remain constant over seasons. Yield under leafhopper attack, however, will vary over seasons, though in general, the highest and lowest yielding lines remain

Table 1. Mean number of emerged nymphs on three bean lines of three age groups infested with different levels of adult *E. kraemeri* in no-choice tests.

Bean line	Plant age (dap)[a]			$\bar{X}$ over plant age	Infestation level[b]			$\bar{X}$ over infest.levels
	10	20	30		5	10	25	
EMP 89	18.0	24.0	53.0	31.7	6.3	54.2	122.0	60.9
EMP 94	8.0	26.2	35.7	23.3	24.3	64.3	98.3	62.3
BAT 41	27.5	42.2	101.2	57.0	75.3	113.0	169.7	119.3
$\bar{X}$ over lines	17.8	30.9	63.3		35.3	77.2	130.0	

[a] Plant age: LSD = 23.4 (P = 0.05) for individual treatment means and LSD= 13.5 for means over plant ages and lines.

[b] Infestation level: LSD= 55.2 (P= 0.05) for individual treatment means and LSD= 31.9 for means over infestation levels and lines.

Table 2. Beans lines showing antixenosis to oviposition under field conditions and natural leafhopper infestations.

Bean line	Nymphs per leaf[a]	Nymphs per g of plant dry wt	Nonprotected yield (kg/ha)
EMP 110	6.1	0.15	660
EMP 124	5.7	0.16	480
EMP 125	4.9	0.15	625
EMP 135	5.7	0.12	1299
G 9527	6.0	0.15	641
EMP 89 (b)	6.7	0.14	1000
EMP 94 (c)	5.5	0.13	635
ICA Pijao (d)	10.6	0.21	1214
LSD (P=.05)	2.09	-	255

a : Mean of 7 evaluations
b - c: antixenosis checks
d: tolerance check

Table 3. Best bean lines from five cycles of recurrent selection for E. kraemeri resistance.

Bean lines	Cycle	Nymphal count[a]	Damage score[b]	Nonprotected yield (kg/ha)
EMP 135[c]	5	2.47	3.30	1915.0
EMP 81[c]	3	2.25	2.85	1604.3
EMP 86	3	2.53	2.95	1586.3
EMP 87	3	2.35	3.20	1501.7
EMP 134	5	2.80	3.35	1420.7
EMP 96	3	2.21	3.25	1403.7
EMP 82	3	2.61	3.20	1401.7
EMP 143	5	2.37	3.20	1396.7
EMP 66[c]	2	2.56	3.30	1381.5
EMP 147	5	2.21	3.70	1300.2
EMP 44[c]	1	2.43	3.80	1254.3
EMP 104[c]	4	2.16	3.60	1246.3
EMP 19	1	2.45	3.50	1209.4
EMP 84	3	2.64	3.45	1191.0
EMP 6	1	2.50	3.55	1180.7
LSD (R 0.05)		0.42	0.22	355.6

a. Values transformed to Log (x+1).
b. Damage score on a scale of 1-5, where 1= no damage and 5= very severe damage.
c. Indicates the highest yielding lines from each cycle.

Table 4. Yield, nymphal count and damage score from cycles 1 to 5 of recurrent selection for resistance to E. kraemeri in beans.

Bean line	Cycle	Yield (kg/ha)	Nymphal count[a]	Damage Score[b]
EMP 44	1	894.5 *	2.36 a	3.60 c
EMP 66	2	768.2 c	2.41 a	3.68 bc
EMP 81	3	1029.1 a	2.28 a	3.59 c
EMP 104	4	725.9 c	2.06 a	3.88 a
EMP 135	5	850.6 b	2.29 a	3.75 ab

[a] Values transformed to Log (x+1).

[b] Damage score on a scale of 1-5, where 1= no damage and 5= very severe damage.

* Means followed by the same letter within a column are not significantly different at P= 0.05 level according to Duncan's Multiple Range Test.

Table 5. Mean characteristics per seed color groups from five cycles of recurrent selection for E. kraemeri resistance.

Seed color groups	Yield (kg/ha)	Damage score	Nymphal count Log (x+1)
Brown	1014.0 a*	2.24 a	3.69 a*
Mulatino	951.7 ab	2.31 a	3.60 a
Cream	950.9 ab	2.22 a	3.72 a
Black	836.2 abc	2.36 a	3.66 a
White	718.4 abc	2.18 a	3.80 a
Red	654.8 c	2.20 a	3.97 a
Pink	595.6 c	2.21 a	4.02 a
Purple	254.6 d	2.12 a	4.15 a

* Means followed by the same letter within a column are not significantly different a P= 0.05 level according to Duncan's Multiple Range Test.

Figure 1: A modified recurrent selection program for *Empoasca* resistance in beans.

Generation	Procedures for population improvement
(Cycle 1) Parental Lines	Intercrosses are made among germplasm accessions and bean lines previously shown to have resistance to *E. kraemeri*.
F1	The hybrids are grown under protected conditions in order to obtain the maximum quantity and quality of seeds. F2 seed from each cross is bulked.
F2	F2 seed (600-1000) from each cross are planted in a block in the field under natural leafhopper infestation. At harvest, the F2 populations that are visually inferior are eliminated. From the remaining populations, 1 pod (app. 3 seeds) is taken from each plant in a cross and the seed is bulked (app. 1500 seed/cross).
F3	Each bulk is yield tested under leafhopper stress. Selection among F3 populations are made on the bases of yield data compared to resistant and susceptible checks. The F4 seed is bulked.
F4	The bulked seed is space planted in the field under leafhopper stress. Individual plant selections with the highest visible yield are made within each F4 population.
F5	Progeny rows of individual selections are planted under leafhopper stress. Selections are made among sister lines at harvest of the highest yielding lines and the seeds from the selected lines are bulked.
F6	A yield trial of the selected lines with nonprotected and protected field treatments is planted. Nonprotected yield and percentage yield reduction are used to select top lines with highest levels of resistance.
(Cycle 2) Parental lines	The second cycle of intermatings are made using resistant selections plus other germplasm.

stable, while the majority of the variation is found in bean lines with intermediate resistance or tolerance levels.

None of the new bean lines were found to be significantly better than ICA Pijao, the tolerant check, for nonprotected yield (Table 7). These results suggest that the overall resistance to E kraemeri was not increased in cycles VI/VII.

Modification of the recurrent selection breeding program

The lack of consistent progress in increasing leafhopper resistance over seven cycles of recurrent selection precipitated a reevaluation and modification of the selection procedures used in the breeding program. Nymphal counts were rejected as a selection criteria because of their poor correlation with nonprotected yield. Simultaneous selection for additional factors such as resistance to rust or common bacterial blight, which was routinely conducted in early cycles was discontinued because the incorporation of other resistance genes was diluting the resistance to E. kraemeri. It was suggested that separate breeding programs be used to incorporate other traits, and that in the Empoasca breeding program, the principal selection criteria would be yield under leafhopper attack.

The first objective of the modified recurrent selection program is the development of a core population of different bean lines with the highest levels of resistance to the leafhoppers from which resistant varieties can be developed. Yield trials are conducted in the F3 and F6 generations under natural leafhopper infestations and the selection criteria are nonprotected yield and percentage yield reduction. The F2 and F3 generations are carried forward as single seed descent with some selections made among populations to eliminate inferior crosses.

The advantages of this breeding scheme are: (1) that selection for additive genetic effects conditioning resistance is enhanced by waiting until the F5 or F6 generation, when genotypes are relatively fixed, to make the majority of selections among sister lines. Some selection, however, is made against inferior crosses in the F2 and F3 generations to avoid advancing populations with low probability of containing useful segregants; (2) single seed descent practices are used to advance as many different potentially favorable genotypes as possible to a homozygous state in the minimum amount of space. This practice increases the chance of finding higher levels of resistant recombinants, especially with quantitatively inherited traits; (3) finally, genotypes x environmental interactions are minimized by the repeated selection and yield testing of populations over time.

Resistance to E. kraemeri in large - seeded bean types.

A separate breeding program was begun in 1984 to develop leafhopper resistant large-seeded bean types (Groups 25, 35). Thirty-six F3 bulk populations were evaluated in 1985, and 381 F4 individual plant selections were made. Progeny rows were evaluated and 96 F5 lines were harvested. These lines will enter yield trials in 1986 and the best materials will be used as parents in the second cycle of recurrent selection following the modified breeding procedures.

Table 6. Analysis of variance of yield trials of the VI/VII recurrent cycle selection for *E. kraemeri* resistance.

Source	df.	Mean squares		
		Nonprotected yield	Nymphs	Damage
Total	107			
Semester	2	3219349.6*	6.58*	0.03
Rep (Sem)	7	433743.9	1.03	0.98
Genotype	10	261119.3	0.24**	0.62**
Genot. x sem	20	118822.5**	0.05	0.10
Error	68	45713.6	0.07	0.09

*, ** indicate significance at P=0.05 and P=0.01 levels, respectively.

Table 7. New bean lines from the VI/VII cycle of recurrent selection for *E. kraemeri* resistance.

Bean line	Nonprotected yield (kg/ha)			
	1984B	1985A	1985B	Mean
EMP 135	1376.1	972.7	553.5	1008.3
EMP 149	922.2	1682.2	585.3	954.7
EMP 150	833.2	1199.6	627.2	881.3
EMP 158	883.3	1061.4	389.7	788.6
EMP 176	1049.2	1002.0	490.6	847.3
EMP 153	682.7	1407.1	528.4	853.7
EMP 157	830.4	1154.7	510.0	831.6
ICA PIJAO[a]	1060.2	1580.5	510.0	1051.2
LSD (P=0.05)	278.6	403.1	200.0	192.7

[a] Tolerant check.

Seed Infesting Bruchids

The identification of wild *P. vulgaris* bean germplasm from Mexico with high levels of resistance to *Acanthoscelides obtectus* and *Zabrotes subfasciatus* formed the bases of a bruchid resistance breeding program which has resulted in the development of seven bean lines (coded BRU 3-10) with intermediate to high levels of resistance to the two bruchid species and larger seed size than the resistant Mexican germplasm (Table 8). Further breeding efforts are needed, however, to obtain bruchid resistance in bean lines of commercially acceptable grain types and growth habits.

In search of new resistance sources, screenings of 80 germplasm accessions of Mexican origen were conducted. From these, five intermediate accessions and two resistant to *A. obtectus*, and one accession resistant to *Z. subfasciatus* were identified (Table 9). These materials will also be used as additonal sources of bruchid resistance in future crosses. Laboratory and field studies were conducted to study the resistance of 20 F4 progeny of crosses between commercial by wild *P. vulgaris* accessions previously evaluated as resistant or susceptible in the F3 generation. Significant (P= 0.01) correlation was found between the reactions of the F3 and F4 generations for number of emerged adults (r= 0.72), life cycle duration (r= 0.65) and dry weight per adult (r= 0.72), and indicated that the reaction of selected progeny to bruchid infestation was consistant over generations and suggested that only a few early generation screenings would be needed to identify resistant offspring.

Significant correlations were also found between resistance measurements taken on infested pods and seeds in the laboratory (Table 10), and between the number of emerged adults from pods infested in the field and seed infested in the laboratory (r= 0.35, P= 0.01). Selection of resistant progeny under laboratory conditions appears to be representative of the reaction of those progeny to *A. obtectus* infestations in the field.

Nine genotypes which were selected for the presence of a new arcelin type glycoprotein, found by F. Bliss, Univ. of Wisconsin only in wild *P. vulgaris*, were evaluated for resistance to *A. obtectus* and *Z. subfasciatus* (Tables 11, 12). WI-85-3 and WI-85-5 were resistant to *Z. subfasciatus*, and WI-85-7 and WI-85-8 were intermediate in their reaction to both bruchid species. These preliminary results suggest that arcelin type glycoproteins alone may not be the only factor conferring resistance to bruchid beetles since the majority of the selections were susceptible to *A. obtectus* and *Z. subfasciatus*.

International Apion Nursery (VIA)

The International Apion Nursery has been distributed within the Central American Project and planted for several years, but the 1984 nursery was particularly interesting because of the diversity of material that it contained. These materials can be grouped into five classes:

Table 8. Evaluation of bean lines bred for resistance to *A. obtectus* and *Z. subfasciatus*.

			A. obtectus[a]			Z. subfasciatus[b]			
Breeding lines	Cross	100 seed wt (g)	No. of emerged adults	Life cycle (days)	Rating	Dry weight per adult (g x 10^{-3})	Life cycle (days)	% emergence	Rating
BRU 4	BAT 1235 x G10019	14.5	18.6	36.4	I	1.2	34.5	70.2	S[c]
BRU 5	V 7920 x G12891	11.2	11.4	40.3	I	1.3	35.7	72.1	S
BRU 6	V 8030 x G10019	20.0	13.2	36.9	I	1.3	36.0	54.7	I
BRU 7	G 12891 x G4011	16.5	8.4	44.5	R	1.1	40.1	50.1	I
BRU 8	BAT 1225 x G12952	10.3	12.8	42.2	I	0.9	47.6	51.8	I
BRU 9	BAT 1235 x G12952	17.0	8.0	42.5	R	0.8	54.4	54.8	I
BRU 10	G 4727 x G12952	15.8	8.4	45.4	R	0.8	57.0	48.1	I
G 12953	Resistant control	6.0	0	0	R	0.8	70.5	10.7	R
Calima	Susceptible control	50.0	54.8	34.9	S	1.5	32.1	78.3	S

[a]Infested 50 seeds of each genotype with 100 eggs in five replications.

[b]Infested 50 seeds of each genotype with seven male/female pairs in five replications.

[c] S = susceptible I = Intermediate R = Resistant

Table 9. Resistant *P. vulgaris* wild type accessions of Mexican origin to *A. obtectus* and *Z. subfasciatus*.

Accession	100 seed wt (g)	No. of emerged adults	Life cycle (days)	Dry wt/ adult ($gx10^{-3}$)	Rating
		A. obtectus			
G 11024	9.4	29	32.4	1.8	I
G 11027	7.8	9	33.2	2.8	I
G 11032	8.5	21	31.4	2.0	I
G 11052	6.5	24	31.5	2.0	I
G 11125	6.0	25	31.1	1.9	I
G 11051	5.8	0	-	-	R
G 12858	9.3	10	32	1.9	R
Calima (Susc.)	50.0	124	29.7	2.6	S
G 12952 (Resist.)	6.0	0	0	0	R
		Z. subfasciatus			
G 11051	5.8	15	37.9	0.8	R
Calima (Susc.)	50.0	244	32.9	1.5	S
G 12952 (Resist.)	6.0	0	-	-	R

Table 10. Correlation coefficients between *A. obtectus* resistance measurements taken on infested seed and pods.

Seeds \ Pods	Emerged adults	Life cycle	Dry wt. per adult
Emerged adults	0.59a	0.56	0.67
Life cycle	-0.49	0.71	-0.65
Dry wt/adult	0.64	-0.58	0.73

[a] All correlation coefficients are significant at P= 0.01 level.

Table 11. Evaluation of nine genotypes from Dr. F. A. Bliss, University of Wisconsin, for resistance to *Z. subfasciatus*.

Genotype	No.of eggs oviposited	No. of emerged adults	% adult emergence	Life cycle (day)	Dry wt adult ($gx10^{-3}$)	Rating
WI-85-1	275.5	247.7	89.5	34.1	1.2	S
WI-85-2	222.5	169.5	76.3	34.7	1.3	S
WI-85-3	242.0	6.0	2.5	53.0	0.9	R
WI-85-4	234.5	49.5	41.8	53.2	1.1	I
WI-85-5	238.0	5.0	2.1	47.8	1.0	R
WI-85-6	220.0	208.5	93.8	34.3	1.3	S
WI-85-7	230.0	89.0	38.7	37.2	1.2	I
WI-85-8	101.0	35.0	34.6	38.1	1.4	I
WI-85-9	235.0	71.0	30.2	35.4	1.3	I
G 12953 (Resist. check)	96.0	7.0	6.6	55.1	0.6	R
G 10011 (Interm.check)	181.5	121.5	66.7	35.5	1.1	I
Calima (Susc. check)	235.5	221.5	92.8	34.0	1.4	S

Table 12. Evaluation of nine genotypes from Dr. F. A. Bliss, University of Wisconsin, for resistance to *A. obtectus*.

Genotype	No. of emerged adults per 100 eggs	Life cycle (days)	Dry wt/ adult ($gx10^{-3}$)	Rating
WI-85-1	56.5	34.9	2.4	S
WI-85-2	46.5	36.2	2.3	S
WI-85-3	32.5	39.3	1.9	S
WI-85-4	46.5	36.8	2.1	S
WI-85-5	30.5	39.9	1.8	S
WI-85-6	52.0	35.7	2.3	S
WI-85-7	24.0	37.6	2.1	I
WI-85-8	18.0	38.5	2.1	I
WI-85-9	32.0	36.9	2.2	S
G 12953 (Resist. check)	0	-	-	R
G 10011 (Interm. check)	13.5	37.7	1.3	R
Calima (Susc. check)	31.5	35.1	2.2	S

1. Materials of known reaction including lines and germplasm that have been used as sources of resistance: Mexico 1290 (G 11506), Tamazulapa, Turrialba 1, Negro 151, Amarillo 54 (G 03982), APN 18, APN 64, APN 68, and Line 17 from El Salvador.
2. New lines selected from the Apion breeding project in Guatemala: APN's 77, 78, 79, 80, 81, 82, 83, 84, 88, 90, 92, 93, 94. These correspond to our strategy 1.
3. Breeding lines which were not developed specifically for Apion resistance, but which demonstrated an intermediate level of resistance at some time: NAG 47, NAG 72, RAB 41, RAO 22, RAB 205, etc. Although not selected for Apion in early generations, some of these lines like NAG 102, were derived from two parents with an intermediate level of resistance, and thus correspond to strategy 2.
4. Mexican germplasm selected in Guatemala for resistance, such as G 03324, G 03307, G 04771, G 03295 and G 03306. These correspond to our strategy 3.
5. Commercial varieties and land races from Central America. These were included to obtain uniform "base-line" data on the levels of resistance in existing varieties.

One nursery each was planted in Guatemala, El Salvador, Honduras, and Mexico, although no data was available form the latter site. Nursery management was the same as employed in previous years, with the exception of including four repetitions instead of three, and using staggered planting dates for early and late flowering materials, to ensure more uniform flowering.

The nurseries developed under very different conditions, as was reflected in the data. The Guatemalan site had a heavy attack, typical of August plantings there. In El Salvador, a drought diminished the attack in mid-flowering, and a few materials might have escaped the Apion due to this condition. In Honduras, the attack was very light, and more damage was caused by Asphondilia, a Diptera which oviposits in the pods. These conditions contributed to a significant genotype x location interaction in the Apion data, but we do not consider this to be typical nor cause for alarm.

In general, those lines selected specifically for Apion resistance were the most resistant. Most of these have black opaque or brilliant red seed, but are not of commercial value. Although these lines represent progress in recombining resistance with tropical adaptation, we still see a tendency for the best resistance to be associated with poor adaptation. The APN lines have entered another cycle of crossing (see Strategy 1), but if we do not recover adequate adaptation in this next cycle, we may abandon these sources of resistance.

At the other extreme, almost all the commercial varieties were highly susceptible, with the exception of ICTA Tamazulapa and Turrialba 1, which we had previously recognized as intermediates (Tamazulapa is a progeny of Turrialba 1). Rojo 70 also showed some resistance, but since it was planted only in El Salvador, this data has yet to be confirmed.

Most of the Mexican germplasm selected in 1983 also performed well. This emphasizes that there should yet be valuable variability for reaction to Apion in the germplasm bank.

As in the past, percentage grain damaged was well correlated with percentage pods with grain damaged, (Table 13) in this case, r = .77.

Breeding Strategy

In previous years we initiated a breeding program for resistance to the bean pod weevil, Apion godmani, based on a triple strategy: (1) utilization of genes of previously recognized sources, principally Mexico 1290 and APN 18; (2) searching for transgressive segregants in progeny of crosses of breeding lines with intermediate levels or resistance; (3) identification of new sources of resistance in germplasm of Mexican origin.

Populations were evaluated in May 1985, representing efforts both to recover transgressive segregants (strategy 2) and a further cycle of crossing using older sources of resistance (strategy 1). Both strategies appeared to be giving promising results, but a virus attack destroyed the progeny test in the fall planting in September, so no conclusions could be drawn.

In 1984, we reported favorable results with G 13614, collected under the name "de celaya". This accession has good resistance, acceptable red grain type, good climbing ability and moderately good adaptation in Central America. In 1985, we observed the first F_2 and F_3 populations derived from G 13614, and these also demonstrated good adaptation, especially in the relay planting system in El Salvador. These have yet to be evaluated for reaction to Apion.

A preliminary Apion (two repetitions) was realized in the May 1985 planting of 198 lines selected from the red and black 1984 adaptation nurseries. A moderately severe attack resulted in approximately 50% of pods damaged in the intermediate check, ICTA Tamazulapa. In Table 14, appear the entries which were as good or better than the check, based on percentage pods damaged.

Our experience with nursery management this year and in years past suggest that two factors in particular favor a heavy Apion attack: (1) a planting date which assures rain in the flowering period and during pod elongation; (2) a planting date (preferably earlier) which is "out of phase" with other bean fields in the region, so that the Apion is attracted by the nursery. Geographical isolation of the nursery has the same effect.

Table 13. Percentage grain damaged of selected entries in the 1984 International *Apion* Nursery. Data represent average of four repetitions at each of three sites.

Group/identity	% grain damaged
Commercial cultivars:	
Rojo de Seda	66
Desarrural	54
Honduras 46	51
ICTA Quetzal	44
Known sources of resistance:	
Amarillo 154 (G 03982)	33
APN 18	28
Mexico 1290 (G11506)	23
Negro 151	19
Lines bred for Apion resistance:	
APN 83	18
APN 84	16
APN 88	20
APN 93	20
Bred lines with intermediate resistance:	
ICTA Tamazulapa	34
NAG 72	32
NAG 47	29
RAO 22	32
Mexican germplasm:	
G 03324	14
G 03307	19
G 04771	22
G 03295	12

Table 14. Percentage pods with grain damaged by *Apion godmani*, of lines selected from the 1984 VA. Jutiapa, Guatemala, August, 1985.

Lines	% pods with grain damaged	Lines	% pods with grain damaged
NAG 107	38	NAG 142	33
NAG 112	30	XAN 182	17
NAG 114	35	DOR 235	28
NAG 121	37	MUS 13	42
NAG 124	23	NAG 149	37
NAG 125	38	NAG 153	35
NAG 126	35	NAG 154	42
NAG 128	30	RAO 40	30
NAG 132	38	RAB 268	33
NAG 133	30		
NAG 134	15		
NAG 135	23		
NAG 139	35		
NAG 140	42		

D. Yield Potential

Studies on yield potential have continued following guidelines discussed in the CIAT Bean Program 1984 Annual Report. An important new component though is a reevaluation of agronomic practices for maximum yield.

Pod Growth Rate

Detailed measurements of individual pod growth were made on 20 lines varying in seed size and maturity to test the following hypotheses:

(1) Large-seeded lines have a lower yield potential because a high pod growth rate results in excessive sink strength.

(2) In order for early maturing lines to attain acceptable yields, they should have relatively high pod growth rates.

(3) If yield is limited by translocation rates during pod filling, highest yielding lines should have the highest pod growth rates. (Note that this hypothesis conflicts with hypothesis 1).

Pod growth rate was measured as the maximum growth rate as estimated from growth curves fitted to dry weight of individual pods from sequential samples. Data for the 20 lines are presented in Table 1, and respective correlations are given in Table 2. The lack of correlation between 100 seed weight and pod growth rate, and the slight, but not significant, positive correlation between yield and pod growth rate, suggests that low yield potential of large seeded materials is not directly related to pod growth rate. There was no correlation between days to maturity and pod growth rate, although it was striking that the earliest maturing line, G 3017, had the highest growth rate of all lines. Thus, the second hypothesis would merit further investigation. If the data for G 3017 are excluded, there are significant correlations between yield and pod growth rate, supporting the hypothesis that translocation rates may limit yield. Of course, there are alternative interpretations of this relation. Perhaps the simplest and most logical one is that more vigorous lines can produce enough assimilate to maintain high pod growth rates, and that this vigor results in higher yields.

Agronomic Management for Maximum Yields

Following various suggestions for an "ideal plant type" for high-yield commercial conditions (e.g. Ideotype B described in the CIAT Bean Program Annual Report for 1976), considerable effort has been invested in production of erect, type IIa lines. Unfortunately, these lines have not shown the yield potential expected. One possible explanation is that because of their erect habit, the lines are incapable of achieving full canopy cover at the 60 cm row spacings used at CIAT. This hypothesis may be extended to a more general one that in order to achieve significant yield increases, both plant type and agronomic practices will have to be modified together. An erect habit may imply a less competitive plant type which conceivably would

Table 1. Yield, maximum pod growth rate, and other parameters of 20 lines. CIAT-Palmira 1985.

Line	Yield (g/m^2)	Days to maturity	Yield /day	100 Seed wt. (g)	Mean pod dry wt. (g/pod)	Pod growth rate (g/m^2 day)
G 4495	2400	78	30.8	19.6	1.33	3.49
RAB 24	2370	82	29.1	21.0	1.04	2.70
BAT 477	2360	77	30.6	20.0	1.16	3.42
A 149	2350	84	27.8	36.3	1.30	2.61
BAT 271	2290	81	27.8	19.1	1.21	3.55
G 4000	2200	83	26.6	17.0	1.05	2.92
G 5059	2190	80	27.4	19.2	1.13	2.51
BAT 85	2020	79	25.6	20.0	1.26	3.59
G 4446	1830	84	22.1	22.7	0.93	3.18
A 54	1830	83	22.0	21.2	1.27	3.25
G 13922	1820	82	22.2	38.9	1.44	2.44
BAT 304	1810	70	25.7	14.3	1.04	3.02
G 4498	1760	74	23.8	18.1	0.93	2.88
BAT 41	1740	68	25.6	15.2	0.89	2.27
G 3807	1650	71	23.5	14.4	0.72	1.91
XAN 146	1570	73	21.6	22.5	1.04	2.42
G 76	1510	70	21.6	39.4	1.39	3.50
G 4494	1410	74	19.1	41.9	1.30	2.92
G 3017	1110	58	19.0	14.8	0.79	3.91
G 1540	850	68	12.2	17.1	0.78	2.02
Mean	1850	76	24.2	22.6	1.10	2.93
S.E.	150	1	2.0	3.3	0.12	0.53

Table 2. Correlations among yield, pod growth rate, and other parameters measured in 20 lines. CIAT-Palmira, 1985.

	Yield	Days to maturity	Yield /day	100 Seed weight	Pod weight
Days to maturity	.74**				
Yield/day	.95	.50*			
100 seed wt.	-.03	.26	-.15		
Pod weight	.45*	.53*	.33	.71**	
Pod growth rate	.20	.00	.25	.02	.36
Pod growth rate (excluding G 3017)	.45*	.34	.41	.12	.59**

*, ** Significant at the 0.05 and 0.01 levels, respectively.

require not only narrow row spacings, but higher plant densities. Since such plants are showing a reduced tendency to partition assimilate to branches and new leaves, it is also possible that they will show a stronger nitrogen response (traditional varieties generally produce excessive vegetative growth at very high nitrogen levels). These considerations thus indicate a need to jointly evaluate effects of row spacing, density and fertilizer regime on erect lines.

In a first attempt to explore these factors, eight indeterminate lines were sown at 60, 45, 30 or 20 cm row spacings, all with density of 20 plants/m^2. BAT 477, BAT 1481, and G 4525 (ICA Pijao) represented traditional plant types, while BAT 1554, BAT 881, A 170, A 54 and FAT 5 b represented various erect plant types. The highest yielding treatment was BAT 1481 at the 45 cm row spacing (Table 3), and the 45 cm row spacing gave the highest mean yield across lines. While these results support the need for narrower row spacings, the yield increase (2630 vs 2480 = 6%) was not very impressive. Possible explanations are: (1) that the traditional materials exceeded their optimal LAI at the narrower row spacings; (2) that the small sample of erect plant types did not include materials which would show the best adaptation to narrow rows; and (3) that plant densities were sub-optimal in the narrow spacings. Partial support for an effect of excessive leaf area is given by data for crop dry weight at 56 days. The 20 cm row spacing resulted in highest dry weight, while the 60 cm spacing was lowest. These possibilities are being subjected to further study.

Table 3. Yields and crop dry weights (at 56 days) of eight lines grown at four row spacings. All plots at 20 plants/m^2. CIAT-Palmira, 1985B.

		Between row spacing (cm)			
		60	45	30	20
Yield (kg/ha)	BAT 881	2630	2840	2860	2500
	BAT 477	2780	2800	2700	2300
	A 170	2690	2720	2760	2370
	BAT 1481	2370	2950	2630	2550
	BAT 1554	2570	2670	2520	2180
	G 4525	2250	2480	2400	2130
	A 54	2390	2130	2390	2100
	FAT 5B	2190	2450	2150	2045
Mean		2480	2630	2550	2270
S. E. For difference of means of:			Treatment x Line =		153
			Treatment =		54
Crop dry wt at 56 days (g/m^2)	BAT 881	200	276	311	273
	BAT 477	279	248	220	329
	A 170	214	265	286	249
	BAT 1481	239	277	264	291
	BAT 1554	248	250	262	265
	G 4525	228	273	271	232
	A 54	213	250	240	261
	FAT 5B	216	268	259	266
Mean		230	263	264	271
S. E. for difference of means of :			Treatment x Line =		30
			Treatment =		10

Row spacing might prove most important for early maturing lines since their short period of vegetative growth limits their potential to fill rows. Four moderately early lines (XAN 145, BAT 41, RAB 60, and G 3807 maturing in 65, 66, 70, and 74 days, respectively) were planted as in the previous trials with the addition of a treatment of 30 plants/m^2 at 30 cm row spacing. The highest yielding spacing was 20 cm, and this spacing also resulted in highest crop weights at 55 days (Table 4). These data support the hypothesis that earlier maturing lines will yield better in narrower row spacings, but the similarity among yields at 30, 45, and 60 cm spacings suggests that presently early lines are fairly efficient in wide rows. Surprisingly, the additional treatment of 30 pl/m^2 at 30 cm spacing did not result in a significant yield increase.

Table 4A shows the results of our first attempt to compare a large range of materials at 30 cm vs 60 cm row spacings (while maintaining a density of approx. 30 pl/m^2 in both treatments). Some lines clearly improve markedly at narrower row spacings, while others perform better with wider spacings. ICA Tui was the only type II which did not show a yield increase, which fits with the idea that erect plant types should perform better at narrower row spacings. However, the type III's also showed yield improvement in many cases.

Table 4. Yields and crop dry weights (at 55 days) of four early maturing lines sown at four row spacings. All plots at 20 plants/m^2 except for an additional treatment with 30 cm between rows and 30 plants/m^2.

		Between row spacing (cm)				
		60	45	30	20	30 cm (30 pl/m^2)
Yield (kg/ha)	RAB 60	2520	2100	2290	2700	2310
	XAN 145	2340	2060	2240	2610	2450
	BAT 41	2110	2180	2090	2300	2030
	G 3807	1640	1890	1870	1950	1970
Mean		2150	2060	2120	2390	2190
S. E. for difference of means of: Treatment x line= 251						
Treatment = 102						
Crop Dry Weight at 55 Days (g/m^2)	RAB 60	333	359	386	315	365
	XAN 145	296	310	335	362	363
	BAT 41	317	362	375	410	343
	G 3807	286	355	372	460	342
Mean		308	346	367	387	353
S. E. for difference of means of: Treatment x line= 36						
Treatment = 17						

Table 4A. Results of yield comparison a broad range of materials at 30 and 60 cm row spacing.

Line	Yield (kg/ha) 60 cm	30 cm	Difference	Habit
BAT 271	2576	3627	1051	3
A 83	3202	3596	394	2
BAT 881	2958	3330	371	2
BAT 1224	2944	3327	382	3
BAT 477	2852	3235	383	3
G 4017	2911	3212	302	3
BAT 1198	2828	3163	334	3
ICA PIJAO	3065	3080	15	2
BAT 1289	2972	3059	86	3
A 54	3034	3041	6	2
XAN 90	2754	3033	278	2
A 250	2862	3031	168	2
ICA TUI	3154	2983	-171	2
EMP 84	2925	2982	57	2
G 5059	2112	2964	852	2
BAT 1671	2576	2958	382	3
A 90	2794	2912	118	3
BAT 1647	2586	2885	299	2
BAT 332	2584	2819	236	2
A 321	2575	2801	226	3
G 5201	2494	2757	263	2
SAN CRIST. 83	3157	2743	-413	3
A 162	2696	2726	30	3
G 76	2119	2713	595	1
BAT 1297	2536	2688	152	2
A 195	2671	2665	-6	1
A 465	2608	2651	43	2
G 3807	2683	2647	-36	1
A 70	2869	2636	-233	3
LINEA 24	2404	2623	219	1
BAT 304	2381	2619	238	3
V 8025	2838	2487	-351	3
A 442	2196	2344	147	3
G 1540	2269	2287	18	1
CALIMA	1900	2077	177	1
PVAD 1372	1664	1655	-9	1
MEAN	2660	2840	180	
S.E.	258	302	380	

Medium and Large Seeded Lines

Among the possible reasons for low yield potentials of medium and large-seeded lines is that such materials have been derived primarily from germplasm adapted to cooler regions. Thus, comparisons of indices of adaptation such as photoperiod response and cell membrane stability (see CIAT Bean Program Annual Report, 1984) should detect significant differences between small and large seeded materials. Table 5 presents such a comparison for 30 lines each of small vs. large-seeded materials selected to represent some of the best lines at CIAT-Palmira. Differences were detected for both indices, and these were consistent with the hypothesis that medium and large seeded lines are better adapted to cooler sites. However in comparing mean yields in Palmira and Popayan, the expected relation that medium and large seeded lines would perform relatively better in Popayan, the cooler site, was not found.

Table 5. Comparison of adaptation of 60 small and medium to large seeded lines as judged by photoperiod response of flowering and membrane stability score.

	Photoperiod response		
Seed size	Neutral	Intermediate	Sensitive
Small	21	9	1
Medium to large	2	7	9
		$Chi^2 = 20.3$	p .001
	Cell membrane stability score*		
	0.6	0.6-0.8	0.8
Small	8	23	1
Medium to large	0	21	7
		$Chi^2 = 6.2$	p .02

* Scale from 0 to 1, where higher values indicate greater levels of membrane damage, and thus intolerance to higher temperatures (40° or above).

Early Maturing Lines

Since early maturity necessarily implies reduced yield potential, efforts to incorporate earliness into new materials may require special measures to assure that yield potential is not reduced unnecessarily. Several researchers have suggested that early maturing lines should have higher harvest indices since a short growth cycle will require maximizing efficiency of utilization of resources. Seed size has also been mentioned as a potentially important variable, there being two opposed theories: one arguing for smaller seeds to permit more efficient allocation of resources, and the other, for larger seeds to permit faster establishment and production of relatively fewer pods for an equal level of yield.

Using the 41 most promising lines from previous screenings for earliness, plus G 4525 as a check of normal maturity, these and other conjectures were tested. As expected, correlation among yield, crop dry weight and days to maturity were high (Table 6). The data support the basic expectation that the later a plant matures, the larger it is, and the more it yields. However, the high correlation between yield/day and yield suggests that there is a disproportional increase in efficiency with later maturity.

Table 6. Correlations among yield and other parameters for 41 early maturing lines plus G 4525. Palmira, 1984b.

	Yield	Yield/day	Days to maturity
Yield/day	.99**	-	
Days to maturity	.80**	.72**	-
Crop dry weight	.87**	.85**	.77**
Harvest index	.39*	.43**	.29
100 seed weight	.21	.22	.26
Seeds/pod	.28	.26	.23
Pods/m^2	.68**	.68**	.49**
Excluding G 2883			
Harvest index	.18	.23	-.08
100 seed weight	.14	.14	.18

*, ** $p \leq .05$ and $p \leq .01$, respectively.

Harvest index appeared to have slight associations with yield and yield/day, but upon deletion of data for G 2883, the earliest (52 days to maturity) and lowest yield (26 g/m^2) line, the relations were not significant. Thus, contrary to expectation, harvest index is probably not an important selection criterion in early materials. Similarly, there were no clear associations among yield and yield components, including seed size, except the expected correlation between pods/m^2 and yield.

Late Maturing Lines

Although data such as that presented above for early maturity consistently suggest that yield potential can best be increased through late maturity, success in identifying late maturing lines with outstanding yields has been essentially nil. To understand this problem better, 41 late lines were evaluated for yield and other parameters. Although some lines matured as late as 94 days, highest yield (2.65 t/ha) was of RAB 25 in 82 days. Crop dry weight at harvest was positively correlated with days to maturity, but yield and harvest index were negatively correlated (Table 7). This suggests that late materials were late because of characteristics causing poor pod set or slow pod growth. A likely candidate as a cause of such a problem is poor photoperiod-temperature adaptation, and evaluations of the 41 lines showed that poorer-yielding and very late lines tended to be photoperiod sensitive (Table 8). One strategy to avoid this problem might be to search for lateness only among crosses of day-neutral lines.

Table 7. Correlations among yields and other parameters for 41 late maturing lines. Palmira, 1984b.

	Yield	Yield/day	Days to maturity
Yield/day	.99**		
Days to maturity	-.48**	-.60**	
Crop dry weight	.16	.08	.37*
Harvest index	.52**	.55**	-.56**
100 seed weight	.00	.00	-.05
seeds/pod	.07	.04	.24
Pods/m^2	.44*	.41*	-.08

*, ** Significant at the 0.05 and 0.01 levels, respectively.

Table 8. Comparison of photoperiod response in relation to yield and days to maturity for promising late materials. Palmira, 1984b.

	No. of lines with photoperiod response		
	Neutral	Intermediate	Sensitive
Yield (kg/ha)			
1500	0	1	5
1500-2000	1	3	15
2000	7	1	7
		Chi^2 = 10.7 p .005	
Days to maturity			
82	3	3	6
82-86	5	2	13
86	0	0	8
		Chi^2 = 7.1 p .05	

E. Photoperiod-Temperature Adaptation

Routine Screening

Utilizing data from the evaluation of photoperiod response (based on delay in flowering under 18 hour artificial vs. 12.5 hour natural daylength) of 450 lines in semester A and previous trials (1976-1984), a series of comparisons of photoperiod response in relation to seed size, growth habit, origin and yield performance were performed. It was hoped that these analyses would indicate photoperiod responses required for different regions, and detect combinations of seed types and growth habits that are particularly problematic.

Table 1 summarizes the distribution of photoperiod response in all materials evaluated, CIAT bred lines and traditional Latin American varieties in relation to growth habit and seed size. CIAT lines include a slightly higher proportion of day-neutral materials, but the overall patterns of variability are remarkably similar suggesting that the photoperiod responses bred into CIAT materials are similar to those in existing germplasm (Table 1). For all groups, Type II's are notable for the high frequency of day-neutrality, while Type IV's, for their sensitivity. Closely related to this is the tendency of small seeded materials to be less sensitive than medium to large-seeded ones.

Although these patterns are a useful guide, they mask important variation for different regions. To assess these differences, responses of germplasm accessions of known origin were tabulated by country or region (Table 2). For several countries (e.g. Canada, France, Germany, Japan, and Turkey), day-neutral Type I's seemed to dominate the distribution, so a second tabulation was performed, excluding Type I's. Among the more striking patterns were:

1. Colombia and Venezuela have very distinct distribution of photoperiod response. Presumably this reflects the fact that Colombia grows large-seeded Andean types, and production is concentrated in higher, cooler sites, while Venezuela produces small-seeded materials, generally at much lower altitudes.

2. In Central America, day-neutral materials predominate. The 20% of photoperiod sensitive lines are primarily climbers grown at higher elevations.

3. Materials grown in temperate regions are also predominantly day-neutral, although Argentina, Chile, the Netherlands, Spain, Portugal, and Turkey violate this pattern. Excluding the Netherlands, these countries have regions with Mediterranean climates which may permit exploitation of delayed maturity under longer daylengths.

Regional differences in needs for photoperiod response have also been detected using data from yield or adaptation in different environments. For 250 lines grown in Colombia in five locations (see CIAT Bean Program Annual Report, 1979), photoperiod sensitive

materials were superior at Pasto, the coolest site, while day-neutral materials were better at warmer sites (Table 3). Using data from the 70 lines of the BIDAN, planted at Davis, California and Chincha, Peru, these two environments were found to require opposing patterns of photoperiod response. Day neutral lines were superior at Davis, but performed poorly at Chiclayo (Table 4). Visual evaluations of adaptation can result in similar patterns, as seen in Table 5 where data for CIAT materials grown in Fort Collins, Colorado are given, and day neutral lines are clearly better adapted.

Taken together, these data relating photoperiod response and yield leave little doubt that the present screening system is capable of detecting some components of photoperiod-temperature adaptation, and thus that breeders should take this parameter into consideration when distributing materials. As a general rule, warmer temperatures and longer daylengths, require day-neutrality, but further studies are needed to improve targeting of lines to growing environments. On a short term, further study of photoperiod response of flowering in traditional varieties can provide guidance on appropriate combinations of response and environment. However, for more precise predictions, additional screening criteria are needed.

Table 1. Photoperiod responses of flowering: all evaluations, CIAT lines, and traditional Latin American varieties. All data are percentages of samples, except total number of lines.

			Photoperiod response								
			1	2	3	4	5	6	7	8	Number of lines
			Neutral		----------				Sensitive		
All Evaluations	Growth habit type	I	28	6	13	20	8	2	0	23	647
		II	57	9	16	8	1	1	0	8	1233
		III	25	8	16	14	6	2	1	28	975
		IV	6	3	7	11	8	4	1	61	649
	Seed size	Small	45	8	16	11	4	2	0	14	1264
		Medium	17	7	11	15	7	1	0	44	296
		Large	12	4	9	15	9	4	1	45	745
	Total		34	7	14	12	5	2	0	27	3685
CIAT Lines	Growth habit type	I	18	3	13	24	14	6	2	22	125
		II	52	7	15	15	1	1	0	10	452
		III	28	8	18	20	4	2	1	20	338
		IV	10	9	8	11	1	3	0	58	90
	Seed size	Small	37	2	6	20	20	6	2	12	256
		Medium	16	4	7	27	11	4	0	32	56
		Large	4	6	12	23	6	4	0	41	51
	Total		36	7	15	17	4	2	0	19	1005
Traditional Latin American varieties	Growth habit type	I	19	10	19	34	3	0	6	10	32
		II	67	0	19	0	5	5	0	5	21
		III	19	7	22	9	2	9	2	39	54
		IV	0	0	7	20	0	0	0	73	15
	Seed size	Small	41	10	20	11	4	1	3	10	71
		Medium	21	0	18	9	0	0	0	52	33
		Large	14	6	14	34	0	3	0	35	35
	Total		29	6	18	17	2	1	1	24	143

Table 2. Distribution of photoperiod responses of flowering for germplasm accessions grouped by countries or regions of origin.

Country or region	Number of accessions with photoperiod response					
	All growth habits			Excluding type I's		
	Neutral	Intermed.	Sensitive	Neutral	Intermed.	Sensitive
Argentina	2	4	2	2	3	1
Brazil	64	32	23	61	25	23
Canada	10	2	1	5	1	1
Colombia	27	26	85	19	13	20
Chile	8	11	18	6	5	18
Costa Rica	13	13	6	13	13	6
Ecuador	5	3	26	4	1	14
France and Germany	24	3	1	3	2	1
Guatemala	120	38	44	118	35	34
Honduras	14	9	4	14	9	4
Hungary	6	3	3	2	3	3
India	4	23	8	1	11	5
Japan	14	12	2	5	7	2
Kenya	3	2	3	3	1	1
Mexico	121	47	288	101	46	288
Netherlands	4	2	6	0	0	6
Nicaragua	11	12	1	10	12	1
Peru	3	10	22	0	6	14
Rwanda, Burundi, and Uganda	14	0	3	5	0	3
South Africa	2	4	4	1	2	3
Spain and Portugal	1	3	23	1	2	21
Turkey	31	29	38	9	16	38
U.S.A.	26	21	7	13	9	6
Venezuela	35	20	3	34	20	3
Zaire	4	3	1	1	1	1
Zambia	2	3	8	1	3	7

Table 3. Comparisons of photoperiod response and yield of lines evaluated at five locations in Colombia (See CIAT Bean Program Annual Report 1979).

Location	Yield range (kg/ha)	Number of lines with photoperiod response			Chi^2	Prob.
		Neutral	Intermed.	Sensitive		
Pasto	250	107	52	13		
(13 C)	250-500	4	11	3		
	500	5	4	11	34.9	.001
Popayan	2000	17	26	11		
(18 C)	2000-2500	43	33	9		
	2500	56	18	10	15.7	.005
Palmira	1800	8	12	4		
(24 C)	1800-3000	84	37	12		
	3000	24	18	11	11.9	.025
Patia	1000	32	21	11		
(26 C)	1000-1500	46	19	10		
	1500	38	27	6	4.8	.5
Santa Fe	1000	15	22	16		
(27 C)	1000-1500	57	26	5		
	1500	44	19	6	27.2	.001

Table 4. Comparison of photoperiod response of flowering and yield of lines of BIDAN at Davis, California and Chincha, Peru.

Photoperiod response	No. of lines yielding		
	100 kg/ha	100-400 kg/ha	400 kg/ha
Davis			
Sensitive	8	4	0
Intermediate	13	10	1
Day neutral	1	13	17
		Chi^2 = 40 p	.001
Chincha			
Sensitive	1	7	7
Intermediate	3	14	7
Day neutral	14	13	5
		Chi^2 = 13 p	.025

Table 5. Comparison of photoperiod response of flowering and visual evaluation of adaptation for CIAT materials evaluated in Fort Collins, Colorado.

Adaptation[a]	No. of lines with photoperiod response		
	Neutral	Intermediate	Sensitive
1-3	4	0	0
4-5	16	6	0
6-7	7	10	7
8-9	5	9	7
		Chi^2 = 6.3 p .05	

[a] Based on visual evaluation of plant growth. 1 = excellent, 9 = very poor

F. Drought Tolerance

Studies on drought tolerance emphasized validating present screening strategies, and testing modifications which will further improve their efficiency. However, recognizing that long term progress in drought tolerance will require a complete understanding of tolerance mechanisms, a major effort was also sustained in studies of such mechanisms.

Tolerance Mechanisms

Since previous research at CIAT-Palmira demonstrated that tolerance was associated with greater root growth, various attempts were made to detect differences in root growth in container-grown plants. In most studies, growth was so rapid that roots reached the bottom of 90 cm tubes with no problem. Suspecting that the density of the soil was too low, growth of tolerant BAT 477 and susceptible BAT 1224 were compared using three densities (1.45, 1.65, and 1.85 g/cc) in 20 x 90 cm tubes, and maintaining drought stress after seedling establishment. However, although the densities had a severe effect on root growth, there was no indication that BAT 477 had greater root growth (Table 1). If anything, BAT 1224 showed better growth. This consistent failure to detect differences in root growth suggests that such variation is not a direct result of simple morphological differences in root growth patterns. A more probable explanation is that differences detected in the field reflect either more subtle characteristics of root growth such as ability to maintain turgor pressure at low soil water potentials, or tolerance mechanisms which affect the overall vigor of the plant.

One such mechanism is orientation of leaves. A variety which orients its leaves can increase its water use efficiency since such movements can reduce leaf temperature and thus rate of evapotranspiration. Leaf orientation of six lines known to vary in drought tolerance planted both at Quilichao and Palmira were compared in stress and control plots, expressing orientation in relation to observed or calculated position of the sun. Although it was possible to detect significant differences (p .01) in leaf orientation among lines and drought and control plots, there was no clear relation with yield under drought conditions (Table 2).

Screening Techniques

Among the most important steps in planning drought nurseries is the selection of an appropriate experimental design. Since 1982, screening at CIAT has relied upon lattice designs on the theory that these designs will permit a significant reduction in error mean square (EMS) by adjusting means for variation in soil nutrient or moisture conditions. Any lattice may be analysed as a randomized complete block design, so data from seven drought trials were reevaluated using both designs, and the reduction in EMS calculated as an index of efficiency of the lattices (Table 3). The only trial where the EMS for the drought treatment was not reduced by at least 10% was Trial 8222 where the 71 kg/ha mean yield reflected a large number of plots with 0

yields. Data for the different levels of water applied in Trial 8449 are particularly revealing. With increasing levels of drought stress, the efficiency of the lattice design increased from 15% to 54%. These results fully support the usefulness of lattices for drought screening.

Another concern in managing drought trials has been possible interactions among varieties and agronomic management. To test whether different plant populations would affect yield under stress conditions, eight lines were sown at three densities (10, 17, and 23 plants/m^2) under both stress and control conditions. The overall tendency was clearly that low yield varieties were poor under all conditions and that evaluation would not be affected if lines are compared at densities within 10 to 23 plants/m^2 (Table 4).

Although screening in different semesters has provided a useful level of variation in conditions, and thus permitted evaluation of yield stability, other researchers have suggested that a line source irrigation system will permit more efficient evaluations. With this technique, irrigation sprinklers are placed in a single line, with sufficient overlap to produce a uniform level of water at a given distance parallel to the line, but a uniform decreasing level at any point perpendicular to the line. Thus, if varieties are sown in strips perpendicular to the line, they receive a gradient of moisture along the strips.

The system was applied to the 23 lines of the BIDYT, plus two local checks, using two replications each at planting dates 13 days apart. Mean yields across varieties ranged from 2630 kg/ha with 261 mm of water applied to 730 kg/ha with 104 mm of water. Since the ultimate goal of this system is to provide a better classification of materials than is possible with repeated yield trials, the data were analysed using a centroid clustering technique to produce different classifications according to the trials used. If a single season of the line source was as efficient as conventional trials, a classification using the line source should have been as good as a classification using the other trials. Table 5 presents two classifications each for the conventional and line source trials. For the conventional trial, one is based on the complete set of 11 trials (including drought and humid controls) and another uses only data from the seven drought trials. For the line source classification, data are for means of the two planting dates or for the planting dates treated as separate data. The first two classifications seem quite acceptable. The sister lines BAT 477 and BAT 85 are grouped with BAT 336 and BAT 1289, materials with similar growth patterns and performance. Similarly, in both classifications all four large seeded type I's are together. In contrast both classifications using data from the line source split these seemingly natural groupings. The classification treating the two planting dates separately seemed particularly unsatisfactory because it split off six materials into groups of one line each. Thus, although the decision is subjective, the conventional trials seemed to produce a more satisfactory classification than the line source, and would be preferred for drought screening of advanced lines.

Tolerance Evaluations

The emphasis on studies of mechanisms and screening techniques did not permit extensive screening of new materials. An evaluation of eight lines previously identified as having outstanding tolerance in acid soils (CIAT Bean Program Annual Report, 1984) merits note though. When the eight lines were grown under stress conditions in Quilichao, it was found that none of them equalled either of the two drought checks, BAT 477 and G 5059 (Table 6). This suggested that contrary to the common opinion that tolerance to drought and poor soils must depend on a common mechanism of deep root growth, the characteristics probably depend on separate mechanisms.

Table 1. Root growth in 20 cm x 90 cm tubes at three soil densities, using drought susceptible BAT 1224 and drought tolerant BAT 477.

		Soil density (g/cc)		
Variable	Line	1.85	1.65	1.45
Root dry wt. 24 days (g/plant)	BAT 1224	0.88	1.54	2.01
	BAT 477	0.45	0.72	0.92
Root dry wt. 33 days (g/plant)	BAT 1224	1.38	2.43	2.27
	BAT 477	1.19	2.08	2.08
Root dry wt. 41 days (g/plant)	BAT 1224	1.31	2.33	2.38
	BAT 477	1.28	2.36	2.22
Plant dry wt. 41 days (g/plant)	BAT 1224	8.46	13.35	14.30
	BAT 477	8.87	13.40	14.03

Table 2. Comparison of leaf orientation and yields for six lines grown at CIAT-Palmira. Data for orientation are means of angle of incidence of sunlight (0° = rays parallel to leaf surface), measured over 12 hours on day 58.

Line	Angle of orientation		Yield (kg/ha)	
	Drought	Control	Drought	Control
BAT 85	29	38	1020	2520
BAT 477	33	36	970	2660
G 5059	30	39	680	2110
G 4830	34	41	680	2670
A 70	33	41	650	2760
BAT 1224	31	36	420	2640
Mean	32	39	740	2560
S. E.	2.1		126	

Table 3. Comparison of the efficiency of randomized complete block (RCB) and lattice designs in drought nurseries. Data are presented for drought and control treatments plus their geometric means, all analysed independently. The relative efficiency is indicated by the reduction in Error Mean Square (EMS). For Trial 8449, a line source sprinkler was used to produce water regimes from 104 mm to 261 mm during the crop cycle.

Trial	No. of entries	Treatment	Yield (kg/ha)	Error mean square		Reduction in EMS
				RCB	Lattice	
Palmira, 8223	72	Drought	259	35194	28977	18%
		Control	1711	72068	67417	6%
		Geom. Mean	532	99715	77053	23%
Palmira, 8222	225	Drought	71	10083	9799	3%
Palmira, 8427	72	Drought	1645	97107	69935	28%
		Control	2656	128759	119534	7%
		Geom. Mean	2067	76291	60156	21%
Palmira, 8446	72	Drought	1079	97071	39217	60%
		Control	2550	91032	78125	14%
		Geom. Mean	1624	97395	40374	56%
Quilichao, 8447	72	Drought	815	36591	25379	31%
Palmira, 8448	25	Drought	1591	72458	64240	11%
Palmira, 8449	25	261 mm	2632	67247	57251	15%
		233 mm	2340	82357	73185	11%
		193 mm	2160	73870	62536	15%
		153 mm	1544	95554	70290	26%
		105 mm	941	89582	58574	35%
		104 mm	730	69941	38082	54%

Table 4. Yields of eight lines grown at three densities under both stress and control conditions.

Line	Yield (kg/ha)			
	Density in stress plot (plants/m)			Mean of control plots
	10	17	23	
BAT 85	1417	1330	1564	3675
BAT 477	1179	1409	1229	3543
Puebla 152	573	621	881	3816
A 54	1015	761	946	3366
Mulatinho	741	655	772	3094
BAT 798	214	348	243	3467
Calima	473	561	391	2818
Brazil 2	84	131	123	2940
Mean	712	727	769	3340

Table 5. Comparisons of classifications of 25 lines according to cluster analyses using sets of data from conventional drought trials and a line source trial with six moisture levels and two planting dates. The conventional trials were conducted in Palmira, Quilichao and Popayan, and the line source in Palmira.

11 dry and humid trials				7 dry trials	Line source mean of 2 dates	Line source 2 dates=12 values	
Line	Yield (kg/ha)	Growth habit	Seed size	Line	Line	Line	Yield (kg/ha)
A 54	1415	2	S	A 54	A 54	A 54	1887
A 59	1394	2	S	A 97	BAT 477	A 195	1726
A 97	1462	2	S	BAT 868	G 4830	BAT 477	1881
A 195	1361	1	L	G 4454	G 5059	BAT 1298	1940
BAT 125	1387	2	S		G 5201	G 4523	1730
BAT 1298	1621	3	S	A 195		G 4830	1904
BAT 1393	1411	1	L	BAT 1393	A 97	G 5059	1987
EMP 105	1386	2	S	G 4494	A 195	G 5201	1959
G 4454	1403	2	S	G 4523	BAT 85		
G 4494	1403	1	L		BAT 125	A 97	1537
G 4495	1779	2	S	BAT 85	BAT 336	BAT 125	1682
G 4523	1399	1	L	BAT 336	BAT 798	BAT 336	1682
				BAT 477	BAT 868	BAT 798	1662
BAT 85	1554	2	S	BAT 1289	BAT 1289	BAT 868	1541
BAT 336	1588	2	S	G 4830	BAT 1298	BAT 1289	1718
BAT 477	1641	3	S	G 5201	BAT 1393	BAT 1393	1648
BAT 1289	1773	3	S	V 8025	G 4454	EMP 105	1649
V 8025	1814	4	S		G 4523	G 4454	1545
				A 170	V 8025	G 4495	1526
A 170	1693	2	S	BAT 125		V 8025	1568
BAT 798	1577	3	S	BAT 798	G 4446		
G 4446	1487	3	S	BAT 1298	G 4494	A 59	1333
G 17722	1671	3	S	EMP 105	G 4495		
				G 4446	EMP 105	A 170	2158
G 4830	1714	2	S	G 4454			
G 5059	1486	2	S	G 17722	A 59	BAT 85	1836
G 5201	1587	2	S				
				G 5059	A 170	G 4454	1544
BAT 868	1488	3	S				
				A 59	G 17722	G 4494	1383
						G 17722	2263

Table 6. Comparison of yields under drought stress for eight lines tolerant to acid soils, and two lines tolerant to drought.

Line	Yield (kg/ha)
Tolerant to acid soils:	
A 257	862
A 254	843
Carioca	825
VA 67	815
NAG 60	815
G 4830	812
BAT 1297	810
A 440	713
Drought tolerant:	
BAT 477	1096
G 5059	870
Mean	846
S.E.	71

G. Tolerance to Acid Soils

Improving bean production on marginal land is one of the goals of the Bean Program. Much of this marginal land currently in bean production in Latin America is acidic with relatively high levels of toxic aluminum and low availability of P and other nutrients. The agronomy-soils subprogram has emphasized in 1985 the screening of varieties for tolerance to high Al and/or low available soil P and on experiments designed to increase our understanding of the physiological mechanisms involved in these tolerances. Past experiences have shown us that variability in beans for these characters is fairly low and thus, identification of lines with superior Al tolerance or P efficiency has been difficult. Some changes in experimental design have been introduced to improve the screening sensitivity.

Screening

In Quilichao the advanced bush bean lines from the 1985 EP, groups 10, 20, 30, 40, 45 and 50, were screened. Additionally, some lines from the 1984 EP and VA nursery were also screened. The screening consists of the following treatments: (1) no stress, receiving 120 kg/ha P and 2 t/ha dolomitic lime; (2) P stress, receiving 12 kg/ha P and 1 t/ha dolomitic lime; (3) Al stress, 60 kg/ha P and no lime (residual effects of an earlier lime application resulted in an Al saturation of 50% at the beginning of the experiment). Applications of nitrogen, potassium, sulfur, boron and zinc were also made such that these elements did not limit yield.

In addition to the varieties under evaluation the standard variety Rio Tibaji, was planted in plots in a diagonal pattern across each field section. The yields of the test varieties were then compared to that of this standard. This comparison partially compensates for soil variability across the experimental site and increases the sensitivity of the screening. Those varieties from each group which yielded better than Rio Tibaji (relative yield 1.0) under phosphorus stress are listed in Table 1. Also, their grain yields under non-stress and P-stress conditions are given.

Varieties which showed Al tolerance greater than the standard Rio Tibaji are shown in Table 2 along with their stressed and non-stressed yields. While crop management of this trial included the chemical control of pests and diseases, yields were depressed by fairly severe Macrophomina pressure. This reduced overall yields and may have reduced the differences between stressed and non-stressed treatments.

In addition to the above results the best lines from the 1984 EP and VA nurseries, which were planted in late 1984 and harvested in January, 1985 are reported in Table 3. The lines from the adaptation nursery for Brazil (VABRA) dominated this list accounting for six of the 12 lines.

Another screening experiment was planted in the second half of 1985 for P efficiency in Popayan. This experiment will be used to

Table 1. Yields of the best performing varieties under P stress from the 1985 EP. Mean yields in kg/ha.

Line	Non-stress yield	P-stress yield	Relative stress yield (Rio Tibaji)
Small Red, 20			
RAB 94	2002	1056	1.00
RAO 34	1715	946	1.75
RAB 234	1627	850	1.60
RAB 254	1576	897	1.42
RAB 184	1705	873	1.30
RAB 40	1851	932	1.01
Small White, 30			
PAN 79	1696	814	1.77
PAN 86	1643	808	1.76
PAN 58	1644	1006	1.73
PAN 99	1898	1029	1.50
PAN 76	1840	878	1.48
MITA L-226-10	1949	987	1.36
PAN 47	1691	824	1.10
PAN 61	1550	901	1.03
Medium and large, Cream Yellow			
BAN 23	1281	805	1.00
BAN 33	1597	713	1.06
Mexican Altiplano, 45			
COS 5	1618	658	1.11
Small Cream, 50			
RIZ 32	1555	1026	1.89
RIZ 34	1720	978	1.59
EMP 89	1656	811	1.37
DOR 351	1444	751	1.37

Table 2. Yields of the best performing varieties under Al stress from the 1985 EP. Mean yields in kg/ha.

Line	Non-stress Yield	Al-stress Yield	Relative Al-stress yield (Rio Tibaji)
Small Black, 10			
NAG 92	1921	1662	1.18
RIZ 48	1608	1467	1.16
NAG 37	1620	1423	1.07
NAG 91	1952	1404	1.05
NAG 102	1947	1454	1.03
NAG 75	1869	1478	1.01
Medium and Large Cream and Yellow			
BAN 21	2054	1635	1.22
BAN 29	1881	1246	1.12
BAN 26	1223	1033	1.11
11 SFRM-81-M-M	1807	1369	1.10
CAN 107 x PER 5-M-U	1725	1491	1.05
ZAA 33	1748	1380	1.02
Mexican Altiplano, 45			
COS 5	1618	1332	1.00
Small Cream, 50			
RIZ 45	1955	1348	1.28
RIZ 34	1720	970	1.33
DOR 342	1381	899	1.24
EMP 89	1656	1093	1.19
DOR 344	1645	822	1.13
VAR 4-IP	1695	921	1.09
EMP 143	1657	1113	1.05
DOR 351	1444	1049	1.00

Table 3. Yields of the best performing varieties under P or Al stress from the 1984 EP and VA nurseries. Mean yields in kg/ha.

Line	Non-stress yield	P-stress yield	Relative P-stress yield		Al-stress yield	Relative Al-stress yield	
			T1	T2		T1	T2
XAN 90	2673	1117	1.27	1.09	1422	1.00	1.04
NAG 12	2798	1005	1.03	1.03	1353	1.26	1.03
VABRA 120	2621	1181	1.00	1.20	1343	1.15	1.00
BAT 1658	2810	1005	1.14	1.00	1298	1.39	1.17
BAT 1432	2586	1070	1.10	1.10	1286	1.23	1.00
FEB 17	2815	1329	1.10	1.29	1249	1.59	1.19
A 283	2447	1375	1.43	1.33	1607	1.16	1.24
VABRA 380	2587	1511	1.48	1.36	1528	1.11	1.18
VABRA 386	2474	1125	1.05	1.00	1528	1.19	1.14
VABRA 379	2657	1358	1.41	1.31	1484	1.07	1.18
VABRA 449	2530	1259	1.19	1.10	1473	1.20	1.03
VABRA 332	1634	1070	1.00	1.11	1237	1.08	1.03

* T1 = Carioca
  T2 = Rio Tibaji

evaluate the suitability of using a Lattice Square design in future screening work. This design greatly increases the ability to account for and remove from the data variability due to spatial soil variability.

Al Stress

Al stress is normally corrected by the application of lime, which raises soil pH, reducing the Al saturation of the soils' cation exchange complex. However, there is some evidence that at least a part of the symptoms attributed to Al toxicity is actually due to calcium deficiency. To evaluate the significance of calcium availability in varietal performance an experiment was performed comparing three Ca sources; lime, Calfos and calcium sulfate. The latter two sources are very soluable compared to lime but have a negligible effect on soil pH. The response to these sources were determined for seven varieties which in previous screening experiments had exhibited a range of tolerances to acid soils.

There was a significant yield response to calcium application, however, there was no difference between sources. Table 4 shows the performance of the varieties across sources and rates. Varieties which had been shown to tolerate acid soil conditions also performed well in this trial with the exception of Rio Tibaji which is not well adapted to the climatic conditions of Popayan. These preliminary results suggest that the response to calcium may be an important factor in increasing yields on acid soils with high Al saturation and that Ca uptake and the growth response to Ca applications deserver further study as a possible means of improving our ability to identify acid soil tolerant lines.

Tolerance to Low Soil Phosphorus

In soils with low P availability the performance of bean varieties is determined either by their ability to absorb P at very low concentrations in the soil or through their ability to make the most productive use of the P that is taken into the plant. However, very little information about P uptake and the growth responses to P availability is available for beans. Several experiments were conducted in 1985 to clarify how the timing and amounts of P uptake relate to development of the yield components in numerous bean lines.

The current system of using grain yield as the sole selection criterion probably hides efficient germplasm from us since yield integrates the crop's response to so many edaphic and climatic variables. If a particular morphological character or a specific period of crop development can be identified as being critical to varietal performance under low P availability regimes, its use could greatly increase our ability to identify superior germplasm.

Experiments in Quilichao and Popayan were conducted using several rates of P application, two P sources (triple superphosphate and Huila rock phosphate) and four bean varieties. The pattern of P uptake

during the growing season in the varieties was determined by periodically harvesting plants. At maturity the grain yield and the yield components were measured.

The data were analyzed using path analysis which can be used to determine the relative importance of the various components of a model of how bean yield develops during the growth of the crop. In the first analysis the significance of various periods of P uptake in determining the final yield was estimated (Table 5). The first period, 0-15 days after germination, was consistently the least important, indicating that early establishment and P uptake are not very important to P efficiency. In two varieties, Iguacu and NAG 60, the other three periods of P uptake were of about of equal importance in determining grain yield. Rio Tibaji was the only variety to strongly show one particular period to be more important than other periods of uptake. This result indicates the P uptake during floral initiation is very important in this variety.

Table 4. Variety performance under several sources and rates of calcium, Popayan 1985 A.

Line	Yield (kg/ha)	Previous screening Evaluation** Al	P
VABRA 380	2968 a*	+	+
VABRA 445	2752 ab	-	-
A 283	2691 abc	+	+
BAT 1432	2657 abc	-	+
A 249	2445 bcd	+	-
A 257	2417 cd	-	-
Rio Tibaji (Check)	2359 d	+	+
No. Observations	246		

* Means followed by the same letter are not significantly different (p = 0.05) according to Duncan's Multiple range test.

** + = Tolerant; - = Non-tolerant.

Table 5. Path coefficients - direct effects on yield.

Period of P Uptake	Variety			
	Iguacu	NAG 12	NAG 60	Rio Tibaji
0-15 days	-.04	N.S.*	.14	-.11
16-28	.46	N.S.	.41	.27
29-42	.41	N.S.	.40	.97
43-56	.46	N.S.	.31	.35
Model r^2	.49	N.S.	.42	.77
Yield component				
Pods/plant	.78	.80	.68	.79
Seeds/pod	.79	.14	.45	.60
100 grain weight	.21	.18	.32	.20
Model r^2	.98	.98	.99	.97

* Not significant

Another analysis conducted to determine which yield components are most important in P response is also shown in Table 5. Both the number of pods per plant and the number of seeds per pod were important in P response while the 100 grain weight was less sensitive to P nutrition. There was also evidence of significant yield component compensation which suggests that measuring individual yield components may not be very useful in the identification of efficient varieties.

Complete data from Popayan and another trial with a larger number of varieties conducted in Quilichao is not yet available. A rigorous test of whether there is a critical period of P uptake that separates efficient from inefficient varieties must wait for this data.

Acid Soil Tolerance Studies in Brazil

Beans in Brazil are generally grown on acid soils with low soil phosphorus, high aluminum content and which are deficient in calcium. The water retention capacity is poor because of clay mineral properties and low organic matter content. Liming is a common practice but application never reaches deeper than 20 cm so that bean roots cannot penetrate deep enough in the soil where soil moisture is available. Phoshorus, on the other hand, is immobile in the soil. Its availability in the rhizosphere depends on water. Furthermore, plant roots can deplete the available P rapidly. To ensure the constant supply of P during the growth cycle the plant must constantly produce new roots to explore a greater volume of soil. To overcome these limiting factors the bean plant should have:

1. Rapid and deep root development
2. Constant root growth
3. Efficient P metabolism (transport and utilization)

Root studies

(1) Varietal differences in early root development.

Root studies in an artificial environment are conducted in a rooting box of which one side of the box wall is inclined. The bean seed is germinated in plastic tubes (30 cm long and 3 cm diameter). The plastic tubes are inserted in the box under the inclinations. Due to geotaxis of the root, the tap root will grow along one side of the plastic tube. Every day the length of the root is measured. Two types of soils are used, one oxisol from the Virgen Cerrado site and the other from the field where soil corrections have been made over the years. Table 6 shows the characteristics of these soils. Soil humidity is standardized to 65% of the field capacity by adding water prior to filling the plastic tubes. Every plastic tube receives the same amount of soil, and compaction is standardized by tapping the tube several times against the floor. Eight repetitions are used for this preliminary study and 22 well known advanced breeding lines and cultivars are used.

Table 6. Soil characteristics used in the rooting tube.

	pH	OM %	P ppm (Bray II)	n e / 100 nd/soil			Al saturation rate %
				K	Ca+Mg	Al	
Stressed soil	4.3	0.7	0.5	0.06	0.34	1.6	80.0
Fertile soil	6.0	1.2	1.3	0.16	4.60	0.1	2.1

Tables 7 and 8 show the accumulated growth velocity (cm/day) for roots and shoots on stressed and non-stressed soil.

Preliminary results show that:

- Roots develops as soon as seed germinates and at a certain length the development slows and the shoot starts emerging.
- Under stress conditions accumulated root growth velocity shows variation from 10,3 to 24,7 cm/day, up to eight days after planting and the average is lower than those under non-stressed concentration.
- Under stressed conditions accumulated shoot growth velocity varies less than that of root growth velocity (from 2,7 - 6,7 cm/day), up to eight days after planting and if the average is higher than those under non-stressed concentrations.
- Tolerance to acid soil by known cultivars such as A 283, A 113, Rosinha G-2, G 4000, A 89 and G 4000, produced the highest root growth velocity.
- Varieties with rapid root growth can have a poor shoot growth and vise versa under stressed soil conditions.
- Under non-stress conditions the acid tolerant lines do not differ from the non-tolerant lines although there is still a wide range of accumulated root growth velocity (from 11,2 -26,1 cm/day).
- In non-stressed soil, the root develops earlier and reaches the total length of the plastic tube (27cm) two days earlier than those grown on stressed soil.

2. The effect of seed size

Three groups of lines (large, medium and small-seeded) were planted in the plastic tubes to study root growth velocity under artificial conditions. Table 8 shows the root and shoot growth development under stressed soil conditions. Large seeded varieties tend to develop roots slower than the medium and the small-seeded materials. Within each seed size group there is also great variation but small-seeded materials develop their roots faster. The shoot development shows the same tendency as the root but the differences are not as large.

This preliminary work suggests that there are differences among genotypes in root and shoot development in early root formation, under stressed and non-stressed soil conditions. Improved techniques are needed to reduce the variations within treatments.

Low soil P efficiency studies

Screening for low soil P efficiency is carried out in the field using yield as the parameter. A large quantity of seed is needed and only advanced breeding lines can be tested. Therefore, progress in low soil phosphorus breeding is slow. Furthermore, genetic variation for low soil P efficiency in beans is low. Differences detected thus far between P efficient and P inefficient lines are small so that the interferences from the field experiment make the results inconsistent. Other techniques for screening, using new paramenters are needed. Studies on the acid phosphatase enzyme are conducted at CNPAF Goiania.

Table 7. Accumulated root and shoot growth velocity (cm/day) up to eight days after planting of 22 lines and cultivars grown under stress (Virgen Cerrado soil) and non-stress (ameliorated soil) coditions.

	Root		Shoot	
	Stress	Non-stress	Stress	Non-stress
A 143	10.3	11.2	2.7	2.8
CNF 10	11.5	17.8	3.0	2.6
ICTA Quetzal	14.7	17.3	4.8	2.8
Carioca	16.7	12.3	4.2	1.9
Puebla 152	17.0	15.6	4.9	2.9
A 300	17.4	15.7	4.8	2.8
BAT 332	17.6	16.4	6.4	3.5
A 59	18.0	21.2	6.5	4.3
A 338	18.4	22.0	5.1	3.1
BAT 185	18.5	26.1	5.3	4.5
BAT 160	18.9	20.0	6.4	4.2
ICA Pijao	19.0	22.0	5.8	3.8
A 176	19.3	22.9	5.3	3.4
NAG 24	20.3	15.1	5.9	2.9
G 5059	20.3	19.3	6.7	4.7
A 96	20.5	21.3	5.5	3.7
A 89	20.6	23.2	4.8	3.9
A 295	20.6	20.6	5.5	2.9
G 4000	21.3	18.6	5.3	3.2
Rosinha G-2	21.5	24.4	5.2	3.4
A 113	22.5	23.4	5.7	3.9
A 283	24.7	15.2	5.3	2.6
$\overline{X}$	18.6	19.2	5.2	3.4

Table 8. The effect of different seed size on accumulated root and shoot growth velocity (cm/day) grown under stress conditions up to eight days after planting.

Identification	Seed size	Root	Shoot
DOR 197	L	5.1	2.0
BAT 1407	L	6.9	1.2
BAT 1258	L	7.1	1.4
G 4458	L	12.1	3.9
$\bar{X}$		7.8	2.1
G 6616	M	6.6	2.5
PVMX 1679	M	9.6	2.6
PVMX 1546	M	13.7	3.3
JALO EEP 558	M	15.9	3.8
PVBZ 1778	M	17.0	4.8
PVMX 1637	M	21.2	4.6
$\bar{X}$		14.0	3.5
IPA 1	S	15.0	4.0
ICTA Quetzal	S	16.2	4.4
A 300	S	18.2	4.2
CNF 10	S	19.8	3.7
Rosinha G 2	S	20.7	3.9
A 295	S	22.9	5.3
$\bar{X}$		18.8	4.3

Experiments with acid phosphatase assay

Acid phosphatase is an adaptive enzyme which means that the activity of this enzyme changes with environmental conditions or P status in the growth medium. In other plant species, the activity of the nonspecific acid phosphatase enzyme of the intact root of the young plant depends on the P status of the growth medium. Decreasing the P status in the growth medium increased the phosphatase activity of the roots. The function of the elevated phosphatase activity due to P deficiency is not clear.

It is postulated that at a given P status, plant efficiency in P utilization will have a lower acid phosphatase activity due to the suppressing effect of the amount of the inorganic phosphorus taken up by the P efficient plant.

The objective of these studies is to determine whether acid phosphatase activity on intact roots will provide a basis for identifying plant efficiency in using the low soil phosphorus. (The effect of the pH of the buffer solution and time and temperature of incubation on optical density shift in bean cultivars). Seed preparation is essential to avoid contamination. Seed is rinsed with 96% alcohol for three minutes and subsequently immersed in Calcium hypochlorite (10%) for five minutes and then washed. Seeds are then germinated in sterilized vermiculite with and without phosphorus in the nutrient solution.

Acid phosphatase activity is measured by adaptation of the technique of McLachlan (1976) using buffered paranitro-phenyl-phosphate (pNPP) and expressed in optical density /root weight (in mg).

The experiment was conducted with Carioca grown with P and without P in the growth solution. Increased substrate temperature (from 20° to 30°C) and increased assay time (from 30° to 120° minutes) increased the phosphatase activity (Table 9). The highest optical density shift was obtained when the attached root of bean was incubated in substrate with a pH of 5.5 at 30" C. For the time of incubation, periods of 60 minutes gave the highest difference in optical density shift between -P and +P treatment in growth solution. The bean plant used, was 14 days old and may still use some P from the cotyledon. Therefore, the differences between plants grown under P stress and those grown under non-P stress are not large enough. Further testing will be carried out with one month old plant roots.

By adding Triton x-100 to the substrate at the rate of 0.1% (volume base) and putting the assay under vacuum (-500 mm Hg) for 1 hour, an increase in optical density is obtained (Table 10).

Varietal differences. Three varieties were used; Carioca which is efficient and responsive to added P as compared with EMP 84 and CNF 10 which are inefficient but responsive.

Table 11 shows that acid phosphatase activity in the Carioca plant part (root as well as leaf section) is lower than in the inefficient varieties (EMP 84 and CNF 10).

Further testing using a wide variation of lines will be carried out. These results suggest that there is genetic variation among the cultivars that can be detected. This method can also be applied to earlier generations. An experiment is underway to determine whether a plant, after being subjected to this enzymatic assay, can recover.

Table 9. The effect of pH of the buffer solution, time and temperature of the incubations on acid phosphatase activity (expressed in optical density/mg root dry weight) of the 14 day old Carioca grown with and without P.

pH	Centigrade	-P	+P	-P	+P	-P	+P	pH	PH-treatment
4.5	20	3240	3020	4430	5180	6500	6090	4890	5140
	30	3800	4280	4020	5100	6030	6200	4910	5330
								4900	
5.5	20	4400	4100	5930	5510	6440	6130	5550	
	30	4910	5850	6180	5750	6540	6400	5940	
								5750	
6.5	20	3060	3960	4670	5320	6500	6360	4980	
	30	3370	4600	4240	5730	6470	6500	5150	
		3800	4590	4910	5530	6410	6280	5065	
Mean (P-treatment)		5040	5430						

Table: 10 The effect of additive Triton x-100 to buffered pNPP under atmospheric and under -500 mmg pressure.

Buffer solution	Acid phosphatase activity optical density/mg/hr	
	Pressure	
	-500 mmg	Atmospheric
Buffer solution + Triton x-100	6.3	2.4
Buffer solution	3.1	2.9

Table 11. Acid phosphatase activity (optical density/g fresh weight) in leaf and root of three bean cultivars.

Cultivars	Optical density/g fresh weight	
	Leaf	Root
Carioca	1355	237
CNF 10	1423	326
Emp 84	1657	337

H. Increased N Fixation

Breeding for Enhanced Nitrogen Fixation.

In the 1984A season, 110 crosses were made between RIZ coded materials and advanced lines from other programs. Larger seed size and resistance to common bacterial blight, anthracnose and BGMV were the most important characters considered lacking in the RIZ lines and were thus the criteria used in choosing parents.

Five hundred and ninety single plant selections of F_2 and F_3 populations were progeny tested in Popayan and Palmira in 1984B and an additional 473 materials in 1985A. Grain type, vegetative vigor and pod load, when grown under mild N stress, were the selection criteria used at this stage.

During the 1984B season, 89 elite families were evaluated in replicated yield trials in Popayan, Santander and Palmira. Nodulation and plant vigor at flowering, final grain yield under low soil nitrogen conditions and wide adaptation, were the primary selection criteria. Progress was indicated by the improved performance of the new materials for many (although seldom all) of the characters. The outstanding lines will be evaluated in sand culture to confirm nitrogen fixation potential and the best will be coded RIZ and included in the following VEF. During the 1985A season, 81 elite families were evaluated for the same characters at the same three locations. Nodulation was scored not only at midflowering but three times during the growth cycle to better evaluate the duration of fixation in the different materials. The visual nodulation scoring method proved to be inadequate for the early score (V4), and a modified scale is being developed and tested.

Quantification of N_2 Fixation and Evaluation of the Breeding Program

The recurrent selection program for improving the N_2 fixation potential of indeterminate bush beans has evolved over the past seven years. The selection criteria for fixation have included vegetative vigor, nodule number and mass at mid-flowering, acetylene reduction activity, total N and grain yield of materials grown in sand culture and in field trials with mild N stress. The correlations between these different characters has often been low and their relation to the amount and proportion of N from fixation in different genotypes unknown. A collaborative project with Rothamsted Expt. Station, UK, was initiated to enable the use of the ^{15}N isotope dilution method used for quantifying N_2 fixation and evaluating the relation between different associated characters and actual N_2 fixed.

Four RIZ lines were evaluated in CIAT-Palmira during the 1984B season alongside five other lines that had been used as parents in the recurrent selection program. BAT 76 and 332 had been used as parents because of their reasonably good fixation potential. High yield, good architecture and anthracnose resistance were the criteria for including BAT 1297, 1554 and A268 respectively, as parents in the crossing program. The nine indeterminate small seeded bush beans have

similar growth habit and duration. A dwarf sorghum variety SC 326-6 was used to estimate the pool of available soil nitrogen. All materials were inoculated with a mixed strain granular inoculant and estimates of fixed and soil N in the crop were carried out during podfill (56 days), before leaf senescence. At this time the roots contained a small proportion of total dry weight and a very small amount of N (Table 1). In most of the genotypes 30-40 % of the N was in the pods; however, there were significant differences in the partitioning of N, a factor that cannot be ignored in the breeding program to improve N_2 fixation. Both a substantial amount and proportion of bean nitrogen came from fixation, and differences between genotypes of similar growth habit and duration were demonstrated (Table 2). The RIZ lines were superior in fixation to all the BAT genotypes. The other non-RIZ line, A 268, a line that had been selected under general low fertility conditions, fixed a large amount of N_2. Total plant N in the bean genotypes did not give the same ranking as either the amount or proportion of N fixed, or of fertilizer recovery. This indicates genetic variability in both the ability to fix N and to take up mineral N from the soil. Those lines with the highest fertilizer recovery had the best root growth throughout the 56 days (RIZ 36, 29 and BAT 76). Root and shoot weights as well as N accumulation curves of the different genotypes are shown in Figure 1. The number of nodules was quite large ($290/m^2$ = 15/plant) only 13 days after sowing in A 268, RIZ 36 and RIZ 27 (Figure 2). With the exception of BAT 332 and BAT 1554 maximum number and mass of nodules were observed at the 41 day harvest. Differences in nodulation patterns between genotypes were observed and the genotypes with the smallest amounts of N_2 fixation were the slowest to form nodules. Although significant correlations (5% level) were not observed between any of the nodulation parameters and N fixed, the number of nodules at 13 days had the best predictive value. An early nodulation evaluation has since been incorporated into the program as a selection criterion. Final grain yields of the genotypes were around 3000 kg/ha. They were not related to any of the other parameters measured.

RIZ 30, which had a large amount of fixation, did not form nodules early nor in great abundance indicating clearly that genotypes differ in the combination of characters whereby they achieve large amounts of N_2 fixation. The amount of carbohydrate available for fixation and the efficiency with which it is used are two possible contributing factors. Recently, methods have been developed at Rothamsted which allow nodule respiration coupled to nitrogenase to be distinguished from growth and maintenance respiration; and thus the efficiency with which carbohydrate is utilized in fixation can be calculated. Two experiments were conducted in environmentally controlled conditions to compare the efficiency of N_2 fixation by several bean genotypes with a single Rhizobium strain (CIAT 899). The results of the two experiments were similar and the data from one are presented in Table 3. Variation between genotypes in the efficiency of carbohydrate use for fixation was observed with BAT 1432 being the most efficient, followed by BAT 1554 and RIZ 30. BAT 76 and BAT 1297 were somewhat less efficient (Table 3). The specific nodule activity (µmoles of C_2H_2 reduced per g of nodule weight) was also higher in RIZ

Table 1. Dry weight and nitrogen content (kg/ha^{-1}) of component parts of beans harvested at 56 days.

Genotype	Dry weight (nitrogen content)					
	Stem & leaves		Pods		Roots	
A 268	1820	(43)	970	(33)	180	(2)
RIZ 30	1650	(42)	960	(32)	180	(2)
RIZ 36	1780	(44)	810	(28)	230	(3)
RIZ 27	1720	(46)	490	(18)	160	(2)
RIZ 29	1910	(48)	880	(30)	230	(3)
BAT 76	1840	(44)	690	(23)	230	(3)
BAT 1297	1300	(32)	1140	(34)	140	(2)
BAT 332	1330	(37)	670	(24)	170	(2)
BAT 1554	1440	(37)	450	(16)	200	(3)
SE	98	(2.6)	60	(2.1)	92	(0.1)

Table 2. Nitrogen fixation in genotypes harvested at 56 days.

Genotype	Shoot N (kg/ha)	% fertilizer recovery	Mean atom % ^{15}N excess	N-fixed (kg/ha)	% N from fixation
A 268	75	8.7	0.338	36	47
RIZ 30	73	8.8	0.352	33	45
RIZ 36	71	9.0	0.367	30	43
RIZ 27	64	7.6	0.346	29	46
RIZ 29	77	10.6	0.398	29	38
BAT 76	67	8.8	0.395	27	40
BAT 1297	65	8.5	0.385	27	40
BAT 332	61	8.7	0.418	21	35
BAT 1554	53	7.5	0.434	18	32
Sorghum	28	6.5	0.648		
SE	2.5	0.76	0.031	3.7	4.8

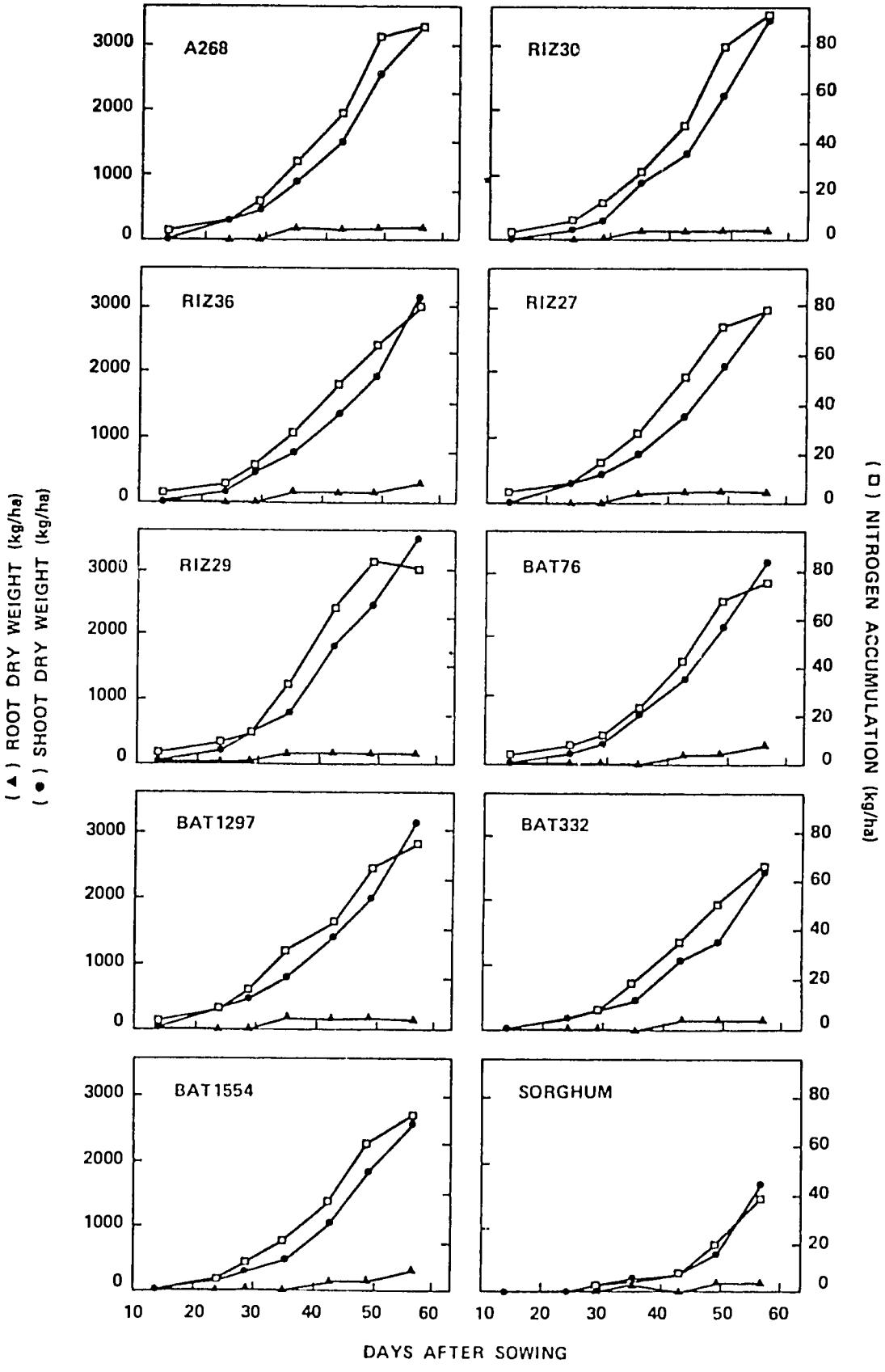

Fig. 1 Dry weights of total shoot (●) and root (▲) and shoot N content (□) of 9 bean genotypes and sorghum.

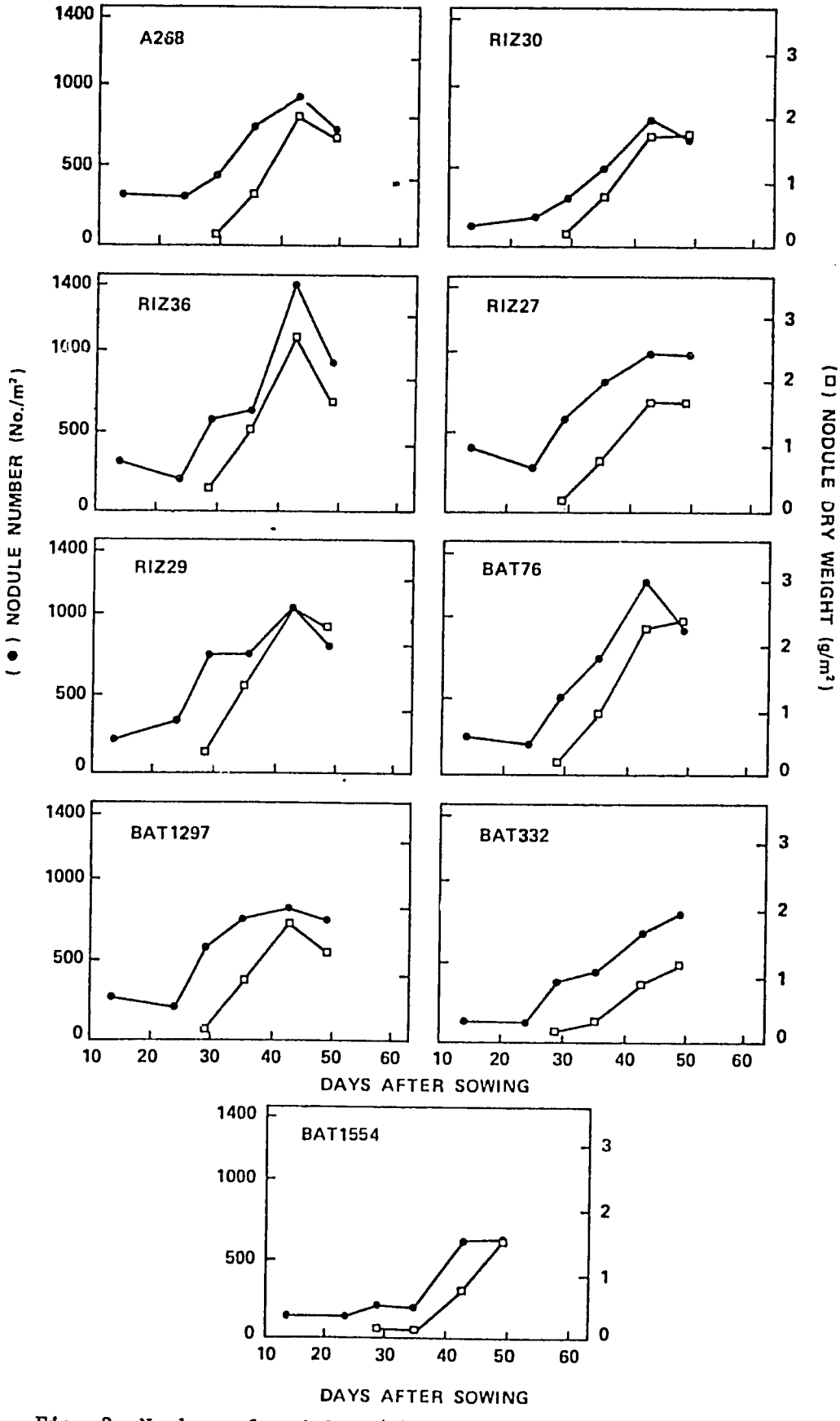

Fig. 2 Number of nodules (●) and nodule dry weight (□) on 9 genotypes.

Table 3. Efficiency of carbohydrate use for fixation.

GENOTYPE	SHOOT WT. (g/pot)	NODULE WT. (g/pot)	SHOOT + NODULE N (mg/pot)	EFFICIENCY (MCO_2/MC_2H_4)	MAX SPECIFIC ACTIVITY (uMC_2H_4/g nod.hr)	RELATIVE EFFICIENCY
BAT 1432	2.51	0.277	66	2.317	0.513	0.60
BAT 1554	2.46	0.268	61	2.572	0.504	0.51
RIZ 30	3.88	0.549	120	2.574	0.504	0.51
BAT 76	4.33	0.532	113	2.746	0.313	0.60
BAT 1297	4.43	0.681	140	3.169	0.248	0.61
SE	0.416	0.0581	11.3	0.1741	0.0812	0.035

30 than BAT 76 and BAT 1297. In the field RIZ 30 fixed a greater amount of N although nodule number and weight were not greater the higher specific activity and efficiency of fixation by RIZ 30 may explain the greater fixation by this genotype. The relative efficiency values were lower than the theoretical value of 0.75 (one H_2 evolved per N_2 fixed, or a conversion ratio of C_2H_4 produced/N_2 fixed of 4:1) but are similar to published values for other legumes. Further studies are in progress to determine if genotype ranking for efficiency remains constant for different Rhizobium strains.

The results of these experiments indicate that in spite of varying methods and the lack of information regarding the importance of different selection criteria, some progress has been made. The breeding program has yielded materials with improved N_2-fixation, and with a greater understanding of the associated plant characters, choice of parents to combine these different characters and refinement of the selection criteria, even more progress is likely.

Rhizobium Strain Collection and Testing.

In addition to low N_2 fixation potential in the legume host, the inability of inoculant Rhizobium strains to compete against the native semi-effective Rhizobium populations is a major factor limiting the symbiosis. Two sets of Rhizobium strains were evaluated for their ability to compete against native strains and give a nitrogen yield response in pots of soil from CIAT-Palmira and CIAT-Quilichao. In the first experiment the growth of BAT 76 and RIZ 30 was compared in non-inoculated soil, inoculated with 20 different Rhizobium strains and fertilized with nitrogen treatments. No significant (5% level) responses to nitrogen fertilizer or Rhizobium inoculation were observed. This was probably due to the high rates of N mineralization that resulted when the soil was dried, ground and mixed. In the second experiment, the accumulated NO_3^- was leached from the soil by excessive watering after the pots were prepared, but before planting. This lowered the NO_3^- levels from 24 ppm to 3 ppm but also resulted in a deficiency of other nutrients. Varying fertilizer rates and other methods for lowering mineral N availability are being tested - the addition of high C:N ratio organic matter and the undisturbed soil core system developed in the CIAT Pastures Program.

In the second experiment a preliminary screening of 30 strains was done using the microbiologically defined Leonard jar system with BAT 76. Seventeen strains were selected based on nodule number, acetylene reduction activity and plant growth. In addition to the best strains, the worst (364) was chosen for comparison in soil-plant systems. The nitrogen yield of BAT 76 grown in soil from CIAT-Palmira and Quilichao and inoculated with 17 different Rhizobium strains is shown in Figure 3. There was no significant correlation (5% level) in growth response between the two soil types nor between the Leonard jar evaluation and either of the soils. However, strains 652 and 118 performed well in all three tests. Three other strains of interest are: 638 (one of the best in Palmira soil) and 639 and 876 (the best in low pH Quilichao soil). A wide range of biochemical tests was done on all the strains in an attempt to identify characters associated

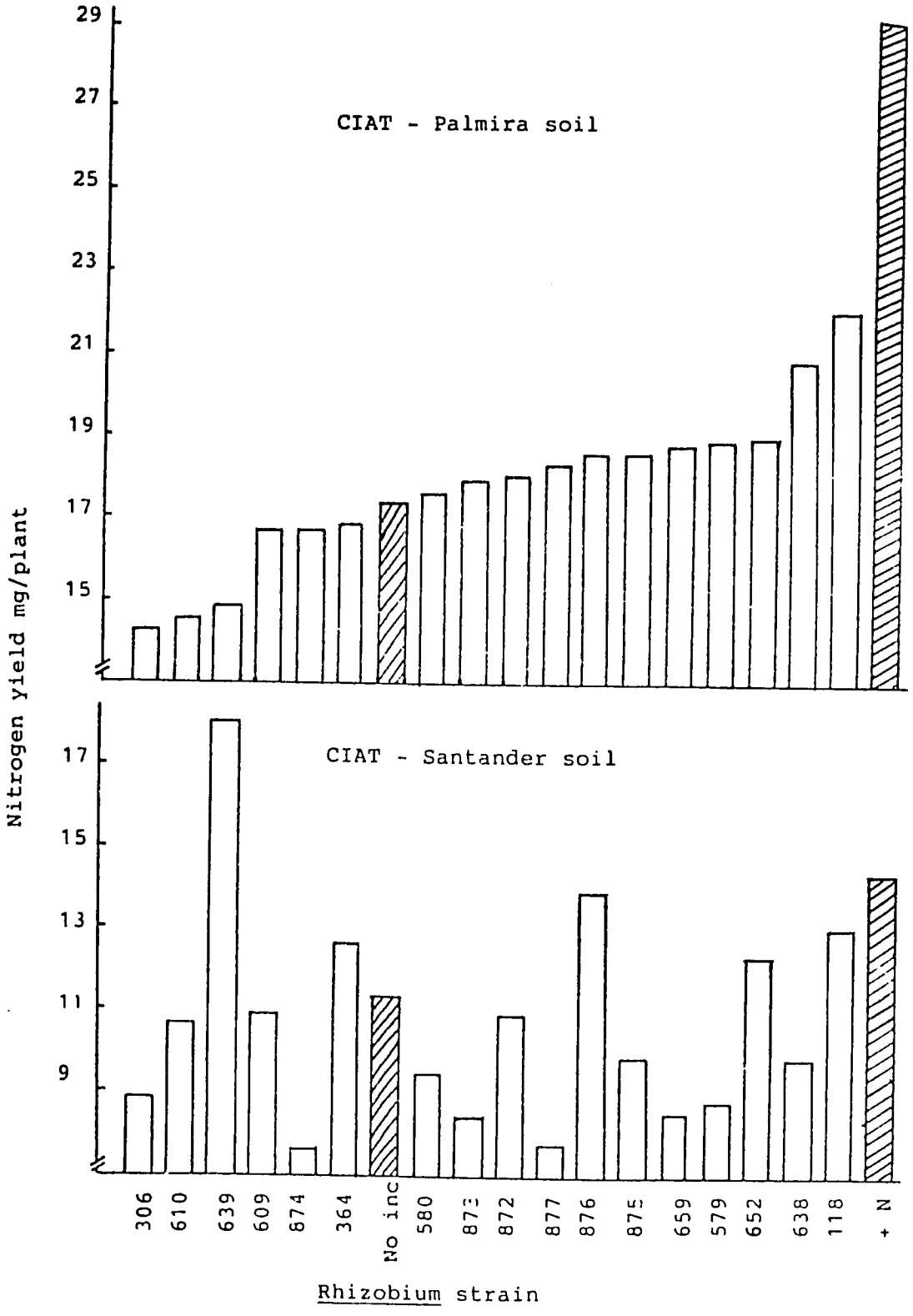

Fig. 3 Nitrogen yield of BAT 76 grown in pots of soil from Palmira and Santander, inoculated with 17 different Rhizobium strains (Harvested at 56d; means of 6 reps. pooled before N analysis).

with competitiveness. Noteworthy with respect to the five best strains were the following: strains 638, 639 and 652 were the only ones able to grow in media containing high salt (2% NaCl); 638 and 652 were among four able to grow at pH 5.0; 118, 639, 652 and 876 were among the seven with resistance to the antibiotic chloramphenicol and 638 was the only strain with resistance to ampicillin; and 639 and 652 were among the seven that reduced tetrazolium (an indication of the presence of uptake hydrogenase-an enzyme that increases the efficiency of energy use for fixation). Taken in combination, the different biochemical tests appear to give some indication of general competitiveness, however further refinement of the plant-soil system for screening large numbers of Rhizobium strains in the glasshouse is a more promising approach. More competitive and effective strains, with greater potential for increasing N_2 fixation in the field, should be identified using this method than with the traditional Leonard jar screening system.

A collaborative project with the Boyce Thompson Institute (BTI) (funded by UNDP) was initiated with the aim of examining native R. phaseoli populations in greater detail. Four regions (Valle, Santander de Quilichao, Popayan and Ipiales) were chosen and soil samples collected from two sites in each; one site where beans have been grown consistently for a number of years and one site where beans have never been grown. Using BAT 76 and E 605 as trap plants, nodules were collected, Rhizobium isolated and purified strains have been sent to BTI for further characterization.

Collection trips for new Phaseolus materials to be added to the CIAT germplasm bank included nodule sampling. As the best time for collecting nodules is midflowering and trips were arranged to coincide with seed maturity, it was not always possible to find living nodules. One hundred and seventy four Rhizobium strains were isolated from 21 different populations of P. vulgaris aborigenes in Argentina. The collection sites varied in altitude, soil type and annual rainfall. Host range studies have been initiated with these materials to look at infectiveness and effectiveness.

Rhizobium strains were also isolated from nodules collected from cultivated P. vulgaris in northern Peru; 90 strains from 17 populations were purified. No Rhizobium could be isolated from nodules collected at 10 other sites. The third Phaseolus germplasm exploration trip that included nodule sampling was one to southern Nuevo Leon, Mexico. Poor nodulation was observed on the P. vulgaris landraces, however, the 11 strains isolated from three sites will be of particular interest for tolerance to high temperatures and salinity.

An experiment was done, in collaboration with the Gembloux project, to observe nodulation of tetraploid populations C_3, C_4 and C_5 of P. acutifolius x P. vulgaris crosses. Two treatments were: noninoculated and inoculated with a three strain mixture of R. phaseoli; the inoculation treatment with a strain from P. acutifolius had to be omitted because of problems in the inoculant preparation. Nodule numbers per plant at the midflowering stage for the

noninoculated treatment were the following (means of 4 reps, 6 plants each): P. vulgaris Pico de Oro =38.9; P. acutifolius G 40034 = 1.3; C_5 = 20; C_4 = 1.3; C_3 = less than 1. The inoculated treatment was little different with Pico de Oro = 40.4; G 40034 = 2.8; C_5 = 1.9; C_4 = 2.3; C_3 = 4. The inability of these materials to nodulate with native Rhizobium populations and R. phaseoli inoculant strains will be of particular importance and require further study as promising bean varieties are developed from the interspecific crosses.

Requests for 139 R. phaseoli strains were received and filled; they were from 10 different labs in five countries. Inoculant, prepared in sterile peat, was sent to two scientists who requested it.

I. Variability from Interspecific Hybridization

Introduction

The objectives of the collaborative project between CIAT and the Faculty of Agronomy of Gembloux (Belgium) are focused on the improvement of *Phaseolus vulgaris* L. through a program of wide crosses with other *Phaseolus* species. Several species were evaluated and used in crosses, mainly of the group of *P. coccineus*. Direct crosses were made with *P. vulgaris* used as the female parent. In order to solve the incompatibility problems between *P. coccineus* cytoplasm and the *P. vulgaris* genome, complex hybrids were undertaken, using *P. coccineus* subsp. *formosus* or some *P. coccineus* subsp. *coccineus* wild forms as a bridge.

Methodology

Up to now, a single plant selection scheme has been followed by planting in the next season the seeds harvested on the selected plants. Due to insect activity, the natural rate of cross pollination would maintain the variability within the hybrid populations and allow the accumulation of interesting resistance genes. The hybrids too similar to *P. coccineus* are backcrossed to some *P. vulgaris* elite materials used as the male parent. This scheme soon runs into problems because of the linkages between the interesting and undesirable characters of the *coccineus* parent. Selecting for disease resistance leads to selection of *coccineus*-like parents which are very late (maturing) with a *coccineus* seed type. On the other hand, the search for productivity or *vulgaris* seed type leads to a rapid loss of disease resistance. Moreover, backcrossing to *P. vulgaris* often causes a complete return to the *vulgaris* parent.

As a result, accumulative selection seems more appropriate. At each generation, the plants with the best appearance are intermated to accumulate the interesting genes present, and to break linkages. After several cycles of intermating, the resulting hybrids are backcrossed with *P. vulgaris* elite materials to recover favorable productivity characters without losing the interesting *coccineus* traits.

In selecting for *Ascochyta* leaf spot resistance, high disease pressure appears too late to cross the selected plants, which have already finished flowering. So cuttings are made from the selected plants, which can be crossed the next season.

Results

The work on interspecific hybrids consisted of the multiplication of F1 populations and of the evaluation of various F1 to F4 direct and complex hybrid populations. These populations were evaluated for characters such as architectural traits and disease resistance, mainly *Ascochyta* leaf spot.

The multiplication of the P. coccineus germplasm, continued and several accessions were evaluated for their Ascochyta leaf spot and bean fly resistance.

P. vulgaris x P. coccineus trials

In 1985, many direct hybrids between P. vulgaris and P. coccineus were multiplied at Popayan to get enough seeds for further selection. The seeds harvested were planted in the next season and the F2 was selected for Ascochyta leaf spot resistance, using ICA Llanogrande (Ecuador 1056) as P. vulgaris susceptible check.

Some 23 plants were selected from the F2, the best ones coming from two selections [(P. coccineus subsp. coccineus wild x P. vulgaris) x P. vulgaris] x P. coccineus subsp. polyanthus crosses (Table 1). Single plant selection was also conducted in F4 hybrid populations. Segregation is still important for plant vigor, seed production, disease resistance and other characteristics. A total of 36 plants showing Ascochyta resistance or tolerance were selected and harvested. The more interesting ones came from four P. vulgaris x P. coccineus subsp. coccineus crosses and two P. vulgaris x P. coccineus subsp. polyanthus ones. They are listed in Table 1.

In the complex populations, the F1 generation has already been submitted to single plant selection, using the same P. vulgaris check as was used for the direct hybrids. Two combinations were involved, the direct hybrid wild P. coccineus x P. vulgaris being crossed first either with a P. coccineus accession then with a P. vulgaris elite material ([(PCw x PV) x PC] x PV), or with vulgaris then with coccineus ([(PCw x PV) x PV] x PC). Some 24 hybrid plants were selected in the F2 generation, the best coming from three [(PCw xPV) xPV] xPCp combinations. (Table 1).

In the F3, the plants were generally vigorous but productivity was low, giving 8 to 132 seeds per plant. Sixteen plants were selected for Ascochyta resistance or tolerance, the best ones coming from two (P. coccineus subsp. coccineus wild x P. vulgaris) x P. coccineus subsp. coccineus combinations (Table 1).

To conduct a cumulative selection, cuttings were made from some of the selected plants of the F2, F3 and F4 generations with good vigor and either Ascochyta resistance or interesting architectural characteristics such as long and outrigger racemes. They were planted in the field with most of the P. coccineus and P. vulgaris parents, to form a crossing block. (Seeds harvested from the same plants have been planted and the following generation will be studied and compared with the maternal material.) Crosses will be made between the hybrids, and backcrosses to the P. vulgaris used as male parent.

The hybrids obtained from intermating and backcrosses will be selected. The plants chosen will then be intermated for the second time or when already backcrossed to improve yield. This methodology will be more convenient to maintain resistances and other selected traits.

Table 1. Selections in the F2, F3 and F4 hybrid generations for *Ascochyta* resistance and architectural traits.

Generation	parents	Cross combination[a]	No. plants
F2	(NI889 x BAT 1274) x DGD 78/030	(PCw x PV) x PCc	4
	(NI889 x BAT 1274) x DGD 78/045	(PCw x PV) x PCc	2
	[(NI889 x NI637) x Guate 1076] x VRA1078	[(PCw x PV)x PCp] x PV	1
	[(NI889 x NI637) x Guate 1076] x Kabanima	[(PCw x PV)x PCp] x PV	1
	[(NI889 x NI637) x G12488] x NI 757	[(PCw x PV)x PV] x PCp	3
	[(NI889 x NI637) x G12488] x Guate 1076	[(PCw x PV)x PV] x PCp	2
	[(NI889 x NI637) x L24] x PI282.119	[(PCw x PV)x PV] x PCe	1
	[(NI889 x NI637) x BAT1274] x DGD 78/030	[(PCw x PV)x PV] x PCe	1
F3	[(NI889 x BAT1274) x DGD78/045	(PCw x PV) x PCc	7
	(NI889 x D 145) x NI 15	(PCw x PV) x PCc	3
F4	Cargamanto x 31 BK	PV x PCc	2
	Guate 467 x Guate 1259	PV x PCc	2
	Pasto x Guate 1259	PV x PCc	5
	Cargamanto x 88-1	PV x PCc	4
	BAT 450 x Piloy	PV x PCp	3
	Pasto x G 35122	PV x PCp	1

a PV = *Phaseolus vulgaris*, PCw = *P. coccineus* subsp. *coccineus* wild form; PCp = *P. coccineus* subsp. *polyanthus*; PCc = *P. coccineus* subsp. *coccineus*; PCf = *P. coccineus* subsp. *formosus*.

P. coccineus Multiplication and Evaluation

P. coccineus is an allogamous species, in which bumblebees are the main pollinators. To avoid genic mixtures between the accessions, a controlled pollination method had to be devised for seed multiplication. The scheme adopted uses hand pollination within each accession, and a minimum population of 12 plants to maintain the original variability.

During 1985, 394 accessions from the coccineus collection have been multiplied in the field in Rio Negro Colombia. Most of the accessions belong to the cultivated subspecies coccineus and polyanthus and a few to wild subspecies of this group. Flowers are hand pollinated with pollen from the same plant or from plants of the same accession, and paper bags are used to prevent open pollination. Seeds from controlled pollination constitute the base stock for germplasm conservation and those from open pollination are available for distribution to collaborators. Preliminary data on morphological characters and disease resistance are also available.

In Popayan, 70 accessions, 12 plants each, are now being multiplied twice a year. They are planted in 50 individual mesh cages and in one which houses 20 accessions. The same hand pollination method is used as in Rio Negro without the paper bags since the mesh keeps the insects outside the cage. The seeds come only from controlled pollination.

P. coccineus subsp. polyanthus Evaluation for Ascochyta Leaf Spot Resistance

Some 26 accessions of the subspecies polyanthus were evaluated in Popayan 1985A for their reaction to Ascochyta leaf spot (Table 2). Eleven accessions were planted in association with maize in a trial with two replications using Ecuador 1056, as the susceptible check, and Guate 1076, P. coccineus subsp. polyanthus, as the resistant check. Also, 15 other accessions were planted in sole crop with three replications using the same checks.

Almost all accessions had good resistance, but G 35336, G 35337 and G 35372 were the best, showing no lesions and were free of other diseases such as powdery mildew, anthracnose, angular leaf spot and halo blight. The foliage of the P. vulgaris check presented many lesions early on and was almost totally destroyed at harvest time.

P. Coccineus Resistance to Bean Fly (Ophiomyia phaseoli)

Within the Great Lakes Project, 22 accessions of the subspecies coccineus and polyanthus were evaluated in Rwanda in a trial with two replicates. Rubona 5, a local P. vulgaris bush variety (Type I) was used as the check. G 35337 (subspecies polyanthus) and G 35346 (subspecies coccineus) presented the best level of resistance (Table 3).

The evaluation of the *P. coccineus* collection will continue next year for both *Ascochyta* leaf spot and bean fly resistance.

Table 2. Reaction of some *P. coccineus* subsp. *polyanthus* accessions to *Ascochyta* leaf spot in Popayan.

CIAT number	Identification	Local register	Origin	*Acochyta* reaction(a) average
G35336 (b)			Guatemala	1
G35337 (b)	Nanesque-ayecote	X-16019	Mexico	1
G35347 (c)		X-16727	Mexico	2
G35348 (c)	Gordo	F-012	Mexico	3
G35349 (c)	Gordo	F-015	Mexico	3
G35350	Exoyeman	MA-1249	Mexico	2
G35351 (c)	Xoyeman o Acalete	MA-1301	Mexico	4
G35359	De Vida 3		Colombia	1
G35360	De Vida 4		Colombia	2
G35372 (b)	Cacha (Petrerillo)		Colombia	1
G35373	Sibundoy 2	Señado 0024	Colombia	1
G35380	M8151 Palostle		Mexico	2
G35391 (c)		X-15962	Mexico	5
G35415	De Red	X-16543	Mexico	1
G35417 (c)		X-16559	Mexico	4
G35441	Ibes	X-16701	Mexico	1
G35447 (c)		X-16730	Mexico	4
G35452	Acalete	F-006	Mexico	2
G35456 (c)	Exoyeman o Gordo	F-443	Mexico	3
G35458 (c)		MA-1245	Mexico	3
G35461	Acalete	MA-1392	Mexico	1
G35467 (c)	Exoyeman	CP-176	Mexico	4
G35468	Exoyeman	CP-179	Mexico	2
G35472 (c)	Acalete	CP-229	Mexico	3
G35473	Exoyeman	CP-230	Mexico	1
G35481	Gordo Exoyeman	CP-332	Mexico	1
	E 1056			8
G35182	Guate 1076		Guatemala	2

(a) Evaluation on a 1-9 scale, where 1 = symptomless and 9 = highly susceptible.
(b) Best accessions
(c) Associated with maize

Table 3. Reaction of some *P. coccineus* accessions to bean fly (*Ophiomyia phaseoli*)

CIAT number	Subspecies	Identification	Local register	Origin	Damage Severity average[b]
G35336(a)	polyanthus			Guatemala	6
G35337	polyanthus	Nanasque-Ayocote	X-16019	Mexico	4
G35338(a)	polyanthus	Acalete	X-16483	Mexico	6
G35339	coccineus	Mateado	X-16497	Mexico	8
G35340(a)	coccineus	Mateado	X-16498	Mexico	6
Rubona 5					9
G35341	coccineus		X-16499	Mexico	8.5
G35342	coccineus		X-16500	Mexico	8.5
G35343	coccineus	Ayocote	X-16504	Mexico	8
G35344(a)	polyanthus		X-16545	Mexico	6
G35345	polyanthus	Ibes	X-16596	Mexico	6
Rubona 5					8
G35346	coccineus	Frijolon	X-16639	Mexico	5
G35347(a)	polyanthus		X-16727	Mexico	5
G35348(a)	polyanthus	Gordo	F-012	Mexico	5
G35349	polyanthus	Gordo	F-015	Mexico	6
G35350	polyanthus	Exoyeman	MA-1249	Mexico	6
Rubona 5					8.5
G35351(a)	polyanthus	Xoyeman o Acalete	MA-1301	Mexico	6
G35352	coccineus		CP-346	Mexico	7
G35353	coccineus		CP-367	Mexico	9
G35354	coccineus	Ayocote	CP-370	Mexico	7.5
G35355	coccineus		CP-378	Mexico	6.5
Rubona 5					8.5
G35356(a)	coccineus	Ayocote grande	CP-382	Mexico	5.5
G35023	coccineus	Ware/Manning 1076 frijolan	PI-165436	Mexico	7

(a) Better than average.
(b) Scale 1-9: 1 = No symptoms; 9 = Severe damage

J. Nutritional Quality

The principle activities carried out in the nutrition and quality laboratory were as follows:

(1) The evaluation of groups 20, 25, 30, 35 and 70 of the EP/85 from semester B. (See Chapter 3.3.b for a comparison of the EP.)

(2) A study on the influence of the site, planting time and the variety of the cultivar on cooking time, hardness and crude protein content.

(3) Second evaluation of the problem groups of the EP/84; low water absorption of groups 20 -25; and low protein content of group 70.

(4) A comparison of the percentage of water and the hardness of the grain of the improved line PAT 29 with other Calima grain types.

Routine Culinary Evaluation of the EP/85

The following culinary quality characteristics were evaluated: grain quality, percentage of water absorption from dry weight, presence of hard and broken grains, average cooking time, broth quality (percentage of solids) and protein content. The same methodology was used which was described in the CIAT Bean Program Annual Report for 1984.

Results of the analyses

Significant differences were found in the average values of all the characteristics measured in the EP/82, 84, and 85 with the exception of protein content of the EP/82 and in 84 and for solids in the broth. There were significant differences among the groups for all the characteristics evaluated in 1985 (Table 1).

As in previous years, the absorption of water in group 20 was significantly less than that of the other groups over the three year period. At the same time, this group had the greatest hardness for 1982/84, and 85 and a highly significant and negative correlation between water absorption and the percentage of hardness (-.7, -.7, -.86), respectively. Just as in previous years, group 35 composed of white bush beans with a medium seed size produced the least amount of solids in the broth.

For 1984 and 85, group 70 had the least protein content while in 1982 this group was among the highest in protein content. In 1985 a significant and negative correlation (-.44) was found for protein content and cooking time, which was also found with a higher significance for the same five groups evaluated in 1984 (-.72), however, this tendency was not as marked when all 12 groups of the EP/84 were analyzed.

As in previous years, correlations were observed among the grain characteristics and culinary quality factor, nevertheless, the influence of the tone on water absorption and the presence of solids in the broth was less marked, Table 2.

Table 1. A comparison of averages for the characteristics measured in the EP/82, 84 and 85 in all the groups.

Characteristics	1982	1984	1985g
% water absorption	99.7 ± 11**	84.4 ± 22 **	96.58 ± 14.6 **
% hardness	- 9 ± 20.1 **	4.79 ± 13.2 **	
Cooking time (min)	21.6 ± 5 **	25.9 ± 6	27.50 ± 7.44**
% solids en broth	10.2 ± 3 **a	9.93 ± 4.8 **a	9.55 ± 2.5 **a
% protein content	21.0 ± 2 **a	21.2 ± 2.1 a	24.18 ± 1.6 **a

g= Groups evaluated from the EP/85:20,25,30,35 and 70.

a= NS between years

** Significant differences among the groups. $P < 0.01$.

Table 2. Influence of tone on water absorption, grain hardness, solids in the broth, protein content and cooking time.

Tonal category	Water absorption (%)	Hardness (%)	Solids (%)	Protein (%)	Time (min)
Brilliant	93.25	8.85 a*	9.92 b	24.01 c	28.34
Semi-brilliant	102.97*	.76	9.16	24.12	27.98
Opaque	95.25	.07	9.18	24.75	24.33d*

a = Same as in 1982, 84 (was not measured in 1980,81).

b = NS in 1981. In 1982, the opaque seed was significantly greater.

c = NS in 1982, 1984

d = As same as 1980, 1981, 1984

* $P < 0.01$

The shiny grains tended to resist water absorption during soaking. They also differed from the other tones in that they tended to require a longer cooking time and are significantly harder. The opaque grains have the least cooking time. They do not demonstrate significant differences in the percentage of solids in the broth. Once again this year, it was found that the size of the grain can influence some culinary and nutritional characteristics of the grain (Table 3).

This year as in 1984, big grains absorbed significantly greater quantity of water than the medium and small-sized grains and require more cooking time; the small grains require less cooking time and as in previous years appear to have a higher protein content and significantly more solids in the broth.

For 1981, 82 and 85, a weak and positive correlation although significant of .24, .23, and .29 was found for size and cooking time so that the biggest grains require a longer cooking time than the small ones (Table 3) (once again hard grains were not evaluated for cooking time).

Table 3. Influence of grain size on some culinary quality and nutritional characteristics of the grain.

Size	Water absorption (%)	Solids (%)	Protein (%)	Time (min)
Large	106.03*	8.96	23.94*	28.22
Medium	94.31	9.84	23.33*	28.42
Small	92.26	9.68	25.18*	26.10**

* P .05

** P .01

Comparative Study on the Influence of the Location, Harvest period and Variety on Cooking Time, Hardness and Protein Content

The objective of this study is to identify if genetic variability exists or not, or if it is environmental variability or the interaction of both which influences some culinary and nutritional characteristics of the grain. The results of this study facilitate the establishment of a plan to evaluate the feasibility of initiating a breeding project for quality characteristics. Additionally, a project of this type was begun in Rwanda, Africa in 1984.

Results of the first harvest of the comparative evaluation

Some 30 lines of different grain types were planted in 1984B in Palmira and Popayan. The same 30 lines will be planted for three more seasons.

There were significant differences between sites with respect to the quality of the broth (percentage of solids), protein content and harness of the grain while cooking time and water absorption were not significantly different (Table 4).

Significant differences were observed among the varieties with respect to percentage of water absorption, hardness, cooking time and protein content. There were also significant interactions among varieties and localities for all the characteristics with the exception of cooking time.

Table 4. Results of the first harvest of the comparative trial in Palmira and Popayan. 1984B.

	Absorption	Hardness	Cooking time	Solids	Protein	Yield
Location	NS	*	NS	**	**	NS
Variety	*	**	**	NS	*	NS
Location x variety	**	**	NS	**	**	**

Additionally, upon evaluating globally the varieties which were planted in Palmira, significantly higher values were found for protein content, solids, yield and hardness than in Popayan.

There were differences in the behavior of the varieties for some characteristics in the two locations. BAN 6 had the least water absorption and was one of the those with the least harness. The three varieties with the longest and shortest cooking time as well as the five varieties with the highest and lowest protein content are listed in Table 5.

Second Evaluation of the Problem Group of the EP/84; 20, 25 and 70

For all the characteristics evaluated in the EP/84, some groups were significantly different from others, such is the case with groups 20, and 25 which showed lower values for water absorption and therefore were higher in grain hardness. Group 70 had the lowest average of crude protein content.

Results of the second evaluation. Group 25

Twelve varieties were evaluated for harness which came from three sites; Popayan, Palmira and Rionegro, all of which were harvested in 1984.

Significant differences were observed in the percentage of hardness in each of the three locations. The grains from Rionegro were the hardest (Table 6). Also, significant differences were obtained among varieties in the three differences were obtained among varieties in the three locations. PVA 908 was the hardest (68%) differing significantly from PVA 905 and PAI 20 which were less hard.

An interaction was observed between location and variety although the percentage of hardness did not change for PVA 908. This line had the highest values in each of the three locations.

Group 20

Twelve varieties were evaluated for harness which came from two different harvests in Palmira. Significant differences were observed among the varieties and the two harvests. The same tendency was observed in group 25 for the three locations.

In addition, there was a highly significant interaction between harvests and varieties. Greater hardness was found in the lines harvested during the first semester of the year.

RAB 59, which was the hardest (58%) differed from the other lines with the exception of RAB 58 while RAB 107 was the least hard (Table 7). Although a significant interaction was observed among varieties and harvests, only the varieties RAB 3, RAB 160 and RAB 126 presented changes in the quantity of hard seed produced from one harvest to the next.

Table 5. Varietal performance for several characteristics in Palmira and Popayan. 1984B.

Absortion	%	Hardness	%	Time	(Min)	Protein	%
BAN 6	130.53	PVA 908	53.66	PVA 875	33	V 8360	25.28
ZAV 8398	115.75	PVA 1046	35.00	PVA 908	31	RAB 23	24.52
FEB 15	110.33	PAI 80	27.33	PVA 1046	28	ZAV 8398	24.44
		RAB 23	12.66	PAI 80	18	NAG 12	24.09
		RAB 9	12.00	BAN 6	18	RAB 9	24.06
				RAO 11	18	PVA 1408	20.88
						PAD 12	20.76
						WAF 5	20.73
						ZAV 8341	20.61
						ZAV 8358	20.40

Table 6. Evaluation of grain hardness in varieties from group 25 from the EP/84 as averages according to location - Palmira, Popayan and Rionegro - and as average/variety.

Location	Hardness %	Variety	Hardness %
Rionegro	75.33 a	PVA 908	68.22 a
Popayán	34.43 b	PVA 1046	58.22 ab
Palmira	23.81 c	PVA 1369	47.11 abc
		PAI 39	43.56 abc
		PVA 1422	40.00 abc
		PVA 905	35.89 bc
		PAI 28	18.67 c

Table 7. Evaluation of the percentage of grain hardness in 12 lines from group 20 of the EP/84, harvested in 1984A and B in Palmira.

Harvest	% hardness	Variety	% Hardness
84A	39.92	RAB 59	58.00 a
84B	22.06	RAB 58	49.20 ab
		RAB 87	40.00 bc
		RAB 126	36.00 bc
		RAB 23	35.20 bc
		RAB 11	31.60 bcd
		RAB 160	30.80 bcd
		RAB 4	24.80 cd
		RAB 9	15.20 de
		RAB 3	14.80 de
		RAB 15	11.60 de
		RAB 107	3.20 e

Group 70

The average protein content of the EP/84 was 21.1% + 2.1. The second evaluation of the protein content in this group gave an average protein content of 20.65% with a range that oscilates between 18-22%. This result indicates that group 70 in general does not have a lower protein content than the other groups of the EP/84.

Comparison of the Percentage of Water Absorption and Grain Hardness of the Improved Lines PAI 29 with other Calima Types

The objective of this experiment was to compare the culinary quality characteristics of PAI 29 with other improved lines of the same type principally BAT 1297, PAI 27, PAI 92, PAI 76 and Calima. PAI 29 is a promising line for the coffee zone of Colombia which is presently in regional trials and is characterized by: high yield, resistance to diseases, and larger grain size and brilliance than BAT 1297.

Results of the comparison

Two analisis were done, one for freshly harvested seed in Palmira during the semester A of 1985 and the other for seed which had been stored for more than six months and harvested in Darien.

Significant differences among the varieties were observed not only for grain hardness but also for water absorption (Table 8). PAI 29 and PAI 27 were significantly harder (76.67 and 50.42%) than the other lines. They were also among those with the least absorption of water. These results with respect to the harness and water absorption of PAI 29 and PAI 27 is an indication that improved lines with deficient acceptability characteristics are candidates for release as varieties.

Significant differences were also found in the quantity of the hard seed produced in the two locations. The seed from Darien was harder (84.23%) than that of Palmira (78.43%).

Table 8. Comparison of grain hardness and water absorption of PAI 29 with other improved lines and Calima from Palmira and Darien.

Variety	% Hardness	% Absorption
PAI 29	76.67 a	25.82 a
PAI 27	50.42 b	53.42 b
PAI 92	12.92 c	94.87 c
PAI 76	.42 c	102.93 c
Calima	.13 c	109.85 c
BAT 1297	.00 c	101.09 c

II. 2. Character Development

A. Central America and the Caribbean

Flow of Germplasm to the Region

This region is extremely diverse with respect to grain preferences, agronomic practices and production problems. The flow of experimental lines from CIAT to national programs of the region is channeled through Adaptation Nurseries (VA's), each country receiving the VA which corresponds to local grain color preferences: black, red, mottled or yellow/beige (See Table 1). Each VA of a given color class is a uniform nursery, thus facilitating compilation of data and observations over sites. The VA system continues to function well and national program scientists continue to be enthusiastic about the nursery. In comparison with past years, the 1985 red VA represented advances in earliness but grain color was slightly inferior. The black VA contained a greater proportion of lines resistant to common bacterial blight and with improved web blight resistance.

While experimental lines and segregating populations are generated in CIAT, their distribution, testing and selection are closely coordinated with the regional outreach project financed by the SDC and with logistical support of IICA, in Costa Rica, and the ICTA in Guatemala.

For example, through the regional project a workshop was organized in January 1985 which was attended by almost all participants in the red and black VA's. Collaborators had the opportunity to share data with colleagues and benefit mutually. That was the first time that the compiled VA data was made available in time to be used in selection of lines within each national program.

The regional project continued to strengthen cooperation on the VA among national program scientists by sponsoring a field workshop in November 1985 with visits to Guatemala, El Salvador, Honduras, Nicaragua, and Costa Rica. As a result of this workshop, the national program scientists themselves proposed a new format for regional cooperation, taking into account the relative advantages of each program in solving specific production problems of a regional nature. For example, research into BGMV (partially financed by the regional project) has been led by Guatemala, with the collaboration of Mexico, El Salvador, and the Dominican Republic; Apion in Guatemala and Honduras; slugs in Honduras with the collaboration of the Pan American School; web blight in Costa Rica with collaboration of Guatemala and the Dominican Republic; rust in Cuba and the Dominican Republic; common blight in Cuba and Nicaragua; on-farm research in Costa Rica, Honduras and the Dominican Republic.

The plan proposed by the workshop participants would place principal responsibility for each project in that national program with the most selective advantage. The VA (renamed VIDAC - Vivero de América Central) would be distributed every other year, and would be constituted in great part by entries proposed by the national programs

Table 1. Distribution of adaptation nurseries by colors, 1985.

	Black	Red	Mottled	Small white	Medium white	Yellows/ beiges
Mexico	+					+
Guatemala	+	+	+a			+b
El Salvador	+	+				
Honduras		+				
Nicaragua	+	+				
Costa Rica	+	+				
Panama			+			
Cuba	+	+	+			
Haiti			+			
Dom. Republic			+			
Guadalupe			+			
Puerto Rico			+			
Peru				+	+	+
Chile	+			+	+	
Ecuador					+	+
Brazil	+	+				

a Evaluated for web blight resistance

b Evaluated for BGMV resistance

themselves. Elements of this plan include: 1) selection of progenitors in Central America among native and/or introduced germplasm; 2) hybridization and advancement to F_3 generation in CIAT; 3) selection in Central America in the national programs most prepared to work on a given problem, for example, web blight in Costa Rica; 4) formation of a Central American VA composed largely of candidates developed in the region and proposed by the national programs. For example, any of the national programs might plan crosses for web blight resistance, but these could be selected centrally in the nursery in Costa Rica. Field workshops bringing together national scientists would facilitate selection by interested parties in these centralized nurseries. Having advanced lines through their own testing system, each program would propose a set number of lines to the VIDAC, in which the Colombian-based CIAT breeding program would also participate with a given number of entries.

Genotype x Environment Interaction

In 1985 an M.Sc. thesis was completed which should help orient CIAT-based and Central American-based breeding activities. The study was designed to measure g x e interaction between Colombian and Central American environments, with special reference to a comparison of bred and landrace varieties, and with the purpose of identifying the most adequate environments for breeding and testing lines.

A group of 27 genotypes were selected as follows: Group 1, 13 landrace varieties, mostly of Central American origin; Group 2, 9 bred lines whose selection was completed in CIAT, Colombia, before being sent to Central America; Group 3, 8 bred materials which were selected principally in Central America, although some of these were selected in early generations in Colombia. All 27 materials are listed in Table 2.

The 27 genotypes were evaluated in an RCB design with three repetitions, in each of 15 environments, represented by combinations of six locations (three in Colombia and three in Central America); two planting systems (monoculture and relay) and two planting dates (one in each semester). The locations included Ahuachapan (AHU) and Los Lagartos (LGT) in El Salvador; Quezada, in Guatemala (GUA); and Restrepo (RES), Palmira (PAL) and Santander de Quilichao (STQ) in Colombia. Environments will be identified as a combination of location, semester (1 or 2), and planting system (M = monoculture, R = relay), for example, "AHU-1-M".

The g x e interaction was calculated initially by a combined ANOVA, according to the method of Cochran and Cox (1965). The stability parameters were estimated by the model developed by Eberhart and Russell (1966), wherein "b" is the regression of the varietal yield against the mean of each environment, and S^2d is the deviation of each variety from its regression.

When the group means of the three groups of genotypes were compared, it was evident that the lines developed in Colombia (Group 2) were the best adapted in the locations and planting systems in

Table 2. Yield in metric tons/ha, regression coefficients and deviations from regression of 27 genotypes in 15 environments.

Group	No	Varieties	LGT-2-R	PAL-2-M	RES-1-M	STQ-2-M	AEU-1-M	AEU-2-M	AEU-2-R	RES-2-R	PAL-1-M	STQ-1-M	LGT-1-M	RES-2-M	PAL-2-F	GUA-1-M	GUA-2-R	X	Combined B	Combined S^2d
1	1	Forty Days	3.09a	2.30	0.91	1.88	2.01	1.30	1.70a	1.77a	1.31	1.10	1.71a	0.85	1.25a	0.77	0.42a	1.48	0.84	0.22**
	2	G-2006	2.46a	2.39	1.95	1.76	1.67	1.48	1.48	1.29	1.62	1.62	1.50	0.87	0.71	0.66	0.26	1.43	0.91	0.04
	3	Guarenteño	2.99	2.54	1.11	1.78	1.62	1.46	1.35	1.55a	1.51	1.39	1.56	0.79	0.98a	[illegible]	0.31	1.40	0.85	0.15**
	4	Rojo Sola	2.23	2.45	2.01	2.35a	2.05	1.54	1.63	1.53a	1.38	1.47	1.39	0.85	1.10a	1.16	0.46a	1.57	0.84	0.09
	5	Desertural 1	3.31a	3.94a	2.57	2.27a	2.57a	1.44	2.12a	1.93a	1.70	1.33	1.22	0.98	1.26a	0.93	0.54a	1.82	1.21*	0.15**
	7	México 80	2.16	2.73a	2.35	2.09a	1.83	1.08	1.95a	1.94a	1.47	1.24	1.15	1.15	0.85	0.78	0.37	1.54	0.96	0.10
	8	Nabido Rojo	2.69a	2.67	1.61	2.35a	1.99	1.72	1.89a	1.41a	1.12	1.73	1.03	0.98	1.44a	1.09	0.40	1.59	0.78	0.18**
	9	Orgulloso	2.55a	2.25	1.70	2.10a	1.80	1.25	1.55	1.57a	1.18	1.56	1.78a	0.97	0.91	0.60	0.36	1.46	0.87	0.10
	11	R. Nacional	3.14a	2.13	2.01	1.82	1.64	1.86	1.86a	1.03	1.09	1.41	0.99	0.75	0.94	0.86	0.28	1.49	0.97	0.19**
	13	Gente Pobre	3.08a	2.65a	2.32	2.37a	2.30a	2.27	1.63	2.05a	1.49	1.75	2.03a	1.26	0.74	1.07	0.46a	1.81	1.04	0.11
		Group 1 Mean																1.56	0.92**	0.19**
2	10	Acacias 4	2.55a	2.77a	2.51	2.49a	2.61a	1.91	1.97a	1.44a	1.81	1.50	1.00	0.91	0.95	0.78	0.47a	1.74	1.18*	0.05
	14	A-40	2.62a	2.93a	1.94	2.52a	2.08	1.76	1.69a	1.49a	1.66	1.42	1.57a	0.98	[illegible]	0.95	0.29	1.64	1.07	0.08
	15	BAT 41	3.15a	2.11	3.84a	1.97	2.28a	1.73	2.05a	1.49a	1.79	1.55	1.89a	1.37	0.83	0.88	0.27	1.81	1.18	0.25**
	16	BAT 1500	2.13	2.77a	2.53	2.66a	1.81	1.53	1.82a	1.86a	1.77	1.28	0.42	0.82	1.00a	0.74	0.51a	1.59	1.04	0.15**
	17	BAT 1501	2.68a	2.85a	2.72	1.90	1.99	2.01	1.75a	2.15a	1.99a	1.48	1.77a	1.27	0.66	0.65	0.47a	1.74	1.08	0.08
	18	BAT 1514	2.68a	2.96a	3.34a	2.15a	2.41a	1.66	1.82a	1.75a	1.60	1.54	1.27	0.79	0.84	1.34	0.50a	1.79	1.15	0.12
	19	BAT 1155	1.91	2.52a	2.40	2.34a	1.98	1.48	1.95a	0.95a	1.47	1.22	1.12	0.92	0.85	0.80	0.23	1.48	0.97	0.03
	20	BAT 1192	2.56a	2.66a	2.85	2.31a	2.36a	1.81	1.85a	1.94a	1.73	1.45	1.32	0.68	1.01a	0.88	4.45a	1.74	1.10	0.07
	21	BAT 1215	2.44a	2.82a	2.79	2.72a	2.36a	1.87	1.56	1.67a	1.67	1.70	2.05a	1.15	0.63	1.15	0.56a	1.80	1.04	0.07
		Group 2 Mean																1.70	1.09**	0.15**
3	6	Honduras 46	3.08a	2.72a	2.42	2.18a	1.95	1.68	1.93a	1.92a	1.32	1.51	1.52	0.77	0.64	0.92	0.46a	1.66	1.14	0.04
	12	Huetar	2.18	2.61a	2.61	2.31a	2.07	1.35	1.79a	1.73a	1.29	1.33	1.44	1.30	0.84	1.01	0.27	1.62	0.96	0.08
	22	RAB 56	2.38	2.52a	1.84	1.83	2.42a	2.23	1.86a	2.16a	1.73	1.24	1.27	1.25	1.36a	1.02	0.41a	1.69	0.79*	0.12
	23	RAB 77	2.10	2.56a	2.68	2.00	1.63	1.38	1.61	1.76a	2.02a	1.15	0.39	1.00	0.95	1.00	0.42a	1.53	0.90	0.15**
	24	RAB 142	2.41a	3.12a	2.44	2.31a	2.65a	1.77	2.02a	1.38a	1.83	1.10	1.31	1.12	0.94	0.73	0.51a	1.75	1.15	0.14*
	25	DOR 125	2.49a	2.64a	2.30	2.11a	2.12	1.75	1.96a	1.67a	2.17a	1.27	1.00	1.20	1.03a	0.82	0.48a	1.67	0.97	0.08
	26	DOR 148	2.20	2.57a	1.96	2.16a	1.80	1.52	1.27	1.50	1.19	1.38	1.09	0.91	0.65	0.95	0.52a	1.45	0.87	0.06
	27	DOR 164	3.19a	2.52a	2.00	1.70	2.04	1.97	1.63	1.39a	1.66	1.19	0.85	0.96	1.35a	0.75	0.33	1.57	1.02	0.15**
		Group 3 Mean																1.62	0.98NS	0.15**
Mean Squares			0.22**	0.09**	0.31**	0.11**	0.09**	0.18NS	0.05**	0.17*	0.03*	0.07NS	0.05**	0.07NS	0.06**	0.03NS	0.006**			
X			2.62	2.59	2.27	2.16	2.08	1.66	1.77	1.66	1.60	1.41	1.31	1.00	0.95	0.89	0.41			

Yields within columns with the same letter are not significantly different.
* = significant at 5% level; ** = significant at 1% level; NS = not significant.

which they were selected, that is, in monoculture and in Colombia. However, when the Colombian-bred lines were evaluated in Central American environments or in relay, they lost their comparative advantage, and yielded no better than the Group 1 landraces, this in spite of the fact that the landraces are in general much earlier than the bred lines. Besides having local adaptation, the land races generally are plant habit III which makes them better fit for the relay system.

When the groups were compared on the basis of their stability parameters (Table 3), the land races displayed a b 1, indicating adaptation to unfavorable environments (or in other words, unresponsiveness to favorable environments). The CIAT-bred lines presented a b 1, indicating adaptation or responsiveness to favorable environments.

One would have expected that bred lines with a greater component of local selection (Group 3) would have performed best of all in Central America, but this was not the case, as there was no significant difference between any of the three groups in Central America. The mediocre performance of Group 3 may be attributed to several causes. First, much of the selection in Central America was realized on experiment stations, hence we may be observing yet another case of g x e interaction, even within Central America. Secondly, the Group 3 genotypes were quite diverse in their history, some having been selected in early generations in Colombia and only later in Central America, while others were selected from F_2 generation onwards in Central America. Thus, it may have been a bit artificial to have grouped these genotypes together, and viewing them as a group, tendencies in the parameters may have been negated by counteracting reactions of the diverse genotypes. Neverthless, no single genotype was outstanding on its own merits in this group.

When the relationship between yields and regression coefficients was graphed for the 27 genotypes over all environments, the landraces were concentrated in the lower left corner (low yields and non-responsive) while the CIAT-bred lines occupy the upper right corner (high yields and responsive). This illustrates very well that landraces often have low but stable yields. This is related in part to their earliness which is a limitation on yield potential and on responsiveness to favorable environments, but which assures some yield in the face of stresses such as late season drought.

It is noteworthy that the performance of two of the landraces, Desarrural 1 and CENTA Izalco consistently were among the best yielding of all genotypes across planting systems and environments. Both are products of selections from national germplasm collections, and are not necessarily typical of landraces; evidence of this is the fact that their regression coefficients are greater than 1, especially Desarrural which had the largest coefficient of all genotypes (b = 1.21).

Other genotypes worth mentioning are BAT 41, BAT 1514, and BAT 1215, all with high yields over environments. BAT 41 was particularly

Table 3. Correlations between environments

	GUA-1-M	AHU-2-M	GUA-2-R	LGT-2-R	AHU-2-R	LGT-1-M	PAL-1-M	STQ-1-M	PAL-2-M	PAL-2-R	RES-1-M	STQ-2-M	RES-2-M	RES-2-R
AHU-1-M	0.31*	0.47	0.45	0.21	0.54	0.28	0.25	0.06	0.51	0.16	0.42	0.39	0.37	0.37
GUA-1-M		0.22	0.30	-0.06	-0.01	0.05	0.18	0.32	0.12	0.02	0.26	0.33	0.04	0.13
AHU-2-M			0.22	0.31	0.10	0.21	0.36	0.31	0.16	0.04	0.13	0.06	0.29	0.19
GUA-2-R				-0.02	0.07	-0.04	0.15	0.04	0.58	-0.00	0.17	0.43	-0.01	0.61
LGT-2-R					0.14	0.34	0.00	0.23	-0.20	0.21	-0.06	-0.31	-0.09	0.05
AHU-2-R						-0.13	0.33	-0.21	0.25	0.26	0.45	0.21	0.24	0.18
LGT-1-M							-0.25	0.51	-0.02	-0.40	0.03	0.03	0.38	0.18
	C.A. x C.A.						C.A. x COLOMBIA							
PAL-1-M								-0.28	0.40	-0.04	0.45	-0.06	0.31	0.20
STQ-1-M									-0.18	-0.35	0.18	0.25	0.03	-0.09
PAL-1-M										-0.30	0.39	0.48	0.12	0.50
PAL-2-R											-0.41	-0.22	-0.10	0.04
RES-1-M												0.31	0.33	0.14
STQ-2-M													0.44	0.11
RES-2-M														0.40
RES-2-R							COLOMBIA x COLOMBIA							

Values between 0.33 and 0.38 are significant at 10%
Values between 0.39 and 0.46 are significant at 5%
Values between 0.47 are significant at 1%

specific in its adaptation with large deviations from regression (S^2d = .25**). CENTA Izalco and BAT 1215 had very good adaptability and stability in the combined analysis.

Correlations were calculated on varietal means between locations to determine which of the locations produced results which could be extrapolated to other sites, and thus should serve best as a site for selection and testing of lines. These correlations are presented in Table 3, which is divided into sectors representing those correlations between Central American sites (CA x CA), between Central America and Colombia (CA x Colombia), and between Colombian sites (Colombia x Colombia). The correlations which are of interest are obviously those involving the target area, i.e. the Central American sites. Among the Central American sites, Ahuachapan was clearly the best, especially with the May planting date in monoculture which presented all positive correlations in relation to other Central American sites; of the six CA x CA correlations of AHU-1-M, three were significant at the 5% level. On this basis we conclude that Ahuachapan is an excellent site for a Central American breeding program.

Among the Colombian localities, Restrepo presented more significant positive correlations than other sites, but excluding the (Colombia x Colombia) correlations, it did not correlate much better with Central American sites than the Palmira and Santander environments. STQ-2-M produced three significant correlations with Central America (10% level), while PAL-2-M, RES-1-M, RES-2-M, and RES-2-R each presented two significant correlations out of a total of seven (CA x Colombia) correlations per site. Different Colombian sites produced positive correlations with different CA sites, and thus tended to complement one another. This confirms the policy of multi-site testing in the Colombia based selection program, to identify genotypes with broader adaptation.

It was significant to note that high-yield environments did not necessarily correlate with other high-yield environments, nor low with low. For example, PAL-2-M (2.59 t/ha) correlated well with GUA-2-R (.41 t/ha, r = .58), but not with LGT-2-R (2.62 t/ha, r = -.20). This demonstrates the need to be very discriminating with respect to environmental factors influencing yield, and not to assume that selection in a high (or low) yield environment assures projection of results to other areas with similar yield potential.

The same study has now been planted in yet a wider range of environments in Costa Rica, Nicaragua, Honduras, and in Santander de Quilichao under fertility stress, with the purpose of broadening the analysis of correlations between environments reported here.

B. Mexican Highlands

Bean growing regions in the Mexican highlands can be divided into humid and semiarid. In humid areas both climbing (Type IV) and non-climbing (Type I and III) cultivars are grown but in the semiarid region Type III cultivars predominate.

In the 1985 adaptation nursery of non-climbing beans for the humid highlands (VAMAH) with entries sent from CIAT to INIA were evaluated in Chapingo, Mexico, and at Tepatitlan and Tojomulco in the state of Jalisco. General adaptation and resistance to rust (at Chapingo) and anthracnose and angular leaf spot (at Tepatitlan and/or Tojomulco) were noted among the improved materials. At each site several dozen entries were superior to the local checks. Also, over two dozen entries from past nurseries were being tested in the preliminary and regional yield trials in which lines A 417, A 321, A 439, A 443, A 445 and MAM 13, were doing well.

The adaptation nursery of climbing beans (VAMAT with 156 entries) was grown only at Tepatitlan. In general, the performance of the materials was much better than the previous years, especially the climbing ability of materials bred in Colombia. Nonetheless, quite a few lines were too late or had problems of climbing ability and the local check, Garbancillo Zarco, was still among the best entries in the nursery. It was encouraging to see that F_4 selections made locally from the F_2 hybrid populations sent last year were far superior to any other source of germplasm. These combined desirable field resistances to rust, anthracnose and/or angular leaf spot and were less agressive climbers than Garbancillo Zarco. Also, new hybrid populations involving local landraces such as Frijola, Garbancillo Zarco, Cejita, etc., looked promising, thus emphasizing the need and value of local evaluation and selection in segregating populations.

The adaptation nursery (VAMAS with 435 entries) in the semiarid regions was evaluated at Aguascalientes, Zacatecas and Durango. Once again the local checks (landraces) at each site were better than all materials introduced from Colombia and elsewhere. From the performance of materials for the past four years it was obvious that an intensive breeding program involving evaluation and selection in early hybrid generations must be done locally in the semiarid region to improve upon regional landraces. Crosses planned jointly by INIA and CIAT researchers could be made at CIAT and advanced in bulk up to F_4, or F_5, if needed, but eventual evaluation and selection must be done in the semiarid regions of the Mexican highland states, since the growing conditions there are unique from those in Colombia.

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C. Argentina and West Asia

White seeded bean cultivars grown in these and other regions include large cylindrical-shaped Alubia (for Argentina, Spain, Italy, and France), large kidney-shaped Horos or Baladi (for Turkey, other West Asian and East Block countries), medium-seeded flat Great Northern or Dermason grain type (for Turkey, Greece, and Italy), medium-seeded round Bolita Cristal or Caballeros (for Peru and Chile) and small-seeded navy beans (Chile and other West Asian countries). For the past four years breeding efforts at CIAT have concentrated on improvement of the Alubia and Horos types. The first group of crosses for Dermason types were initiated in 1984. After breeding responsibilities were reassigned in mid 1985, improvement of Bolita Cristal and Navy beans was also transfered to this section for which crosses will be initiated in 1986.

The second adaptation nurseries of Alubia and Horos types was evaluated at five sites in Argentina (VAPA with 250 entries) and at seven sites in West Asia and East Block countries (WANABAN with 100 entries) in 1985. All entries had resistance to BCMV and quite a few were superior to the cultivar Alubia in the northwestern provinces of Argentina. The performance of WAF 3, WAF 6, WAF 7, WAF 9, WAF 15, WAF 18, and ABA 2, could merit special mention. Seed of these lines was multiplied both by INTA in Argentina and CIAT for more extensive testing in growers' fields in 1986. While some WANABAN lines looked good in Turkey and Bulgaria, in general, most of the materials were late. This could be reflect the fact that neither the germplasm from that region has been utilized in developing those lines at CIAT nor had the germplasm been evaluated and selected at higher latitudes before. Therefore, in order to maximize the usefulness of CIAT germplasm in West Asian and European countries both utilization of local germplasm in the crossing program and evaluation and selection in hybrid populations in the region must be emphasized. A pathologist/breeder from Turkey spent three months at CIAT at the beginning of 1985. A limited number of crosses (50) were jointly planned, made, and shipped for evaluation in the Anatolian plateau of Turkey in 1986.

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D. Yield Breeding

Analyses of data from genetic studies of yield and its components were completed. Eighty bush-bean cultivars and improved experimental lines for different agronomic traits were crossed in the Design II mating system. From the resulting 200 F_2 hybrid populations evaluated at CIAT farms at Palmira and Quilichao, importance of the male and female parents (additive genetic variance) over male x female (non-additive) was evident (Table 1) and supported our previous findings of diallel analysis (CIAT Bean Program Annual Report, 1983) in which only the general combining ability effects were significant in the F generations. All high yielding small-seeded bush bean cultivars extensively grown in Latin America, both old and new releases, had negative GCA for yield at either one or both locations (Table 2). Eighteen lines which had positive GCA (Table 3) for yield were all bred materials and most of which had high yielding cultivars with negative GCA as parents in their pedigree.

Narrow sense heritability values based on a plot-mean basis were low for seed yield and pods m^{-2}, intermediate for seeds/pod and high for 100-seed weight (Table 1). Highest genetic gain for seed yield from selection would be expected if seed weight was used as selection criteria followed by selection for yield *per se* (Table 4). Indirect selection for pods m^{-2} and seeds pod^{-1} would have either negative or little effect on yield. Based on the results of these studies necessary modifications were made in our overall breeding strategy and selection experiments were initiated for yield.

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Table 1. Portion of mean square, estimates of variance components, and heritability (h^2) for yield and its components in dry bush bean from a design II mating system, sown at two locations in Colombia in 1983.

Source	d.f.	Yield (g/m^2)	Pods/m^2	Seeds/pod	Seed weight (g/100)
Males/S	32	3521.8**	2441.1**	2.1141**	54.558**
Females/S	32	2515.9	2802.5	1.8192**	69.020**
Males x females/S	128	1104.7	1033.3	0.3680	5.802
Pooled error	384	866.6	727.4	0.1967	3.007
σ^2_m		88.14±47.5	28.8±33.6	.0668±.016	2.271±.67
σ^2_f		9.7± 40.7	53.3±42.3	.0756±.022	2.970±.84
σ^2_{fm}		54.0±43.9	62.9±72.3	.0583±.014	0.317±.22
σ^2_a		97.8	82.2	0.1424	5.247
σ^2_p		260.2	213.2	0.2421	5.921
h^2		0.37 ±0.24	0.39±0.25	0.59±.14	0.88±0.18

$\sigma^2_m = \sigma^2_f = 1/2\ \sigma^2_a$, h^2 was calculated on the basis of entry means.

Table 2. General combining ability effects of some commercial bean cultivars from a Design II analyses in 1983.

	Yield		100 seed weight	
	Palmira	Quilichao	Palmira	Quilichao
BLACK				
ICA Pijao	0.5	-16.0	-0.32	-0.73
Jamapa	-22.7	-12.5	-1.47	-1.66
Porrillo Sintético	-1.5	-26.2	-0.21	-0.85
Rio Tibagi	-12.6	9.3	-2.64	-1.81
BAT 58	-24.7	5.5	-2.45	-0.83
BAT 304	5.0	-17.1	-0.47	-0.70
EMP 84	1.8	-5.1	0.15	-0.86
Moruna 80	-2.4	-2.8	0.72	2.08
NON-BLACK				
Aete 3	9.1	-0.2	-0.87	-0.98
Aroana 80	-8.1	0.7	-0.23	0.00
Carioca	-17.5	7.8	-0.03	0.75
Catu	-4.0	1.0	-0.95	-0.72
Cena 164	-6.4	2.5	-0.04	-0.66
IPA 7419	-16.5	1.8	-1.51	-0.17
RAI 54	-13.1	8.8	-2.89	-0.66
Location mean	137.3	157.0	23.28	23.71
S. E. of GCA effects	6.7	11.3	0.35	0.69

Table 3. General combining ability of selected bean lines, from a Design II analyses in 1983.

Identification	Yield		100 seed weight	
	Palmira	Quilichao	Palmira	Quilichao
A 57	6.8	1.4	0.87	0.17
A 59	8.3	11.3	2.85	1.68
A 213	18.2	12.7	1.02	3.08
A 252	24.4	12.9	1.10	3.91
A 259	13.3	4.2	1.41	-0.26
A 310	10.9	47.4	1.79	1.44
A 373	17.5	5.3	2.25	0.91
A 275	37.6	26.7	4.20	4.44
A 445	27.4	15.4	1.55	0.54
BAT 477	24.0	22.5	0.67	-0.71
BAT 1458	2.6	3.4	-0.63	0.30
BAT 1510	2.6	25.6	0.46	-1.26
BAT 1617	18.3	12.5	4.03	2.67
BAT 1659	11.5	5.3	-1.29	-1.43
BAT 1670	2.6	38.2	1.00	1.00
Carioca 80	8.0	8.0	2.95	1.10
RIZ 11	8.2	40.0	0.85	0.91
XAN 105	13.9	9.4	3.18	2.36
Location mean	137.3	157.0	23.28	23.71
S. E. of GCA effects	6.7	11.3	0.69	

Table 4. Expected direct (on diagonal) and correlated (off diagonal) gain from selection[a] (pooled over two locations) for yield and its components in dry beans.

Selection criteria	Yield (g/m^2)	Pods/m^2	Seeds/pod	Seed weight (g/100)
Yield (g/m^2)	5.77	-2.28	1.57	6.46
Pods/m^2	-2.67	5.06	-6.54	-1.85
Seeds/pod	1.41	-5.04	10.01	-3.31
Seed weight (g/100)	6.84	1.67	-3.89	12.83
Mean performance	147.10	155.70	4.05	23.50

[a] Percentage of trait mean.
Direct response = $k\ \sigma^2_1 / \sigma_{p1}$, correlated response = $k\ Cova_{12}\ h_1 0^2_{a2}$

E. Andean Region

Cultivar improvement for the Andean Region was continued in 1895 in collaboration with the national programs of Colombia, Ecuador and Peru. In Colombia, research is conducted primarily at La Selva (2100 masl) and Obonuco (2600 masl) in collaboration with ICA; in Ecuador at Santa Catalina (2700 masl) and Cuenca (2200 masl) with INIAP; and in Peru at Cajabamba (2600 masl) and Cuzco (2680 masl) with INIPA. Seed shipments to these areas consist of crossing blocks, F_2 and F_4 segregating populations, and advanced lines (VEF, EP and IBYAN international nurseries). In 1985, a total of 541 crosses were made for the Andean zone among climbing and bush beans growth habits.

For climbing beans, the principal objectives of the breeding program are to combine resistance to anthracnose, Ascochyta and halo blight into commercially acceptable cultivars that are suitable for intercropping or relay with maize. For bush beans, the major emphasis has been on combining resistance to BCMV, common bacterial blight, rust, and angular leaf spot, into medium to large seeded lines of Type I or II growth habits; although, bush beans for cooler elevations (above 1700 masl) also require resistance to the same diseases that attack climbing beans. Both climbing and bush beans are evaluated in association with maize as well as in monoculture in the F_3 and F_5 generations in order to access the genotypes' potential in either cropping system.

COLOMBIA

The majority of the cultivar improvement programs for Colombia are conducted in collaboration with ICA at La Selva and Obonuco, although breeding materials for Colombia may also be managed at CIAT Palmira, Santander de Quilichao and Popayan.

Group 25 (404 materials) and Group 85 (154 materials) of the VEF, and Group 85 (99 materials) of the EP were evaluated in several locations in the Andean region of Colombia during 1985. Advanced lines from CIAT and ICA breeding programs of both bush and climbing beans were also tested in regional trials in collaboration with other institutions such as the Federation of Cafeteros and the CVC.

ICA-La Selva

At ICA-La Selva, located in Rionegro, Antioquia, the collaborative breeding program continues to evaluate climbing bean genotypes that can be used in rotation with maize or in monoculture in trellises. Germplasm lines, crossing blocks, segregating generations and advanced lines are evaluated and selected for resistance to diseases (principally anthracnose and Ascochyta) and yield.

In 1985, 108 crosses were made among the 378 materials that composed the crossing block for this production region, and 141 advanced lines were selected on the basis of their agronomic characteristics, disease

resistances and yield. The best of these lines will enter on-farm trials in various regions of Antioquia.

The culmination of various years of evaluations and on-farm testing resulted in the release of a new climbing bean - Frijolica LS 3.3 (previously identified as La Selva 1) in August of this year. This cultivar originated from a cross between Mexico 235 and Bola Roja, is resistant to anthracnose and adapted from 1700-2600 masl.

Several new breeding lines were also tested in a uniform yield trial (Table 1). Bean line LS 46 was superior to Frijolica LS 3.3 for yield and resistance to anthracnose on the research station. However, further trials are needed to verify the value of this new line over cropping systems and seasons.

Evaluation of bush bean lines with adaptation to medium-cool climates were continued. PVA 357 was selected as a promising line in seven trials throughout Antioquia, though in general, it was not superior to the local check Catio in yield (Table 2). Of the 161 EP bush bean lines evaluated at Tulio Ospina in Antioquia, 31 lines were selected for further evaluations in 1986 (Table 3).

ICA-Obonuco

Breeding for cold highlands continued at ICA-Obonuco in Pasto, Nariño. Although the majority of the breeding efforts are for climbing beans to be grown in association with maize, like La Selva, evaluations of bush bean materials, which could be used in rotation with barley, were also conducted.

Two varieties of beans were released in Obonuco this year:

1) Frijolica O-3.2 (previously known as E 605) is a climbing bean adapted from 2400-2850 masl with tolerance to anthracnose, halo blight and resistance to rust. This cultivar matures between 240-255 days and is 30 days earlier than the local check Mortiño.

2) Frijolica O-3.1 (ICA L-33462) is a bush bean of indeterminate growth habit, adapted from 2000-2710 masl, with resistance to anthracnose and halo blight. It matures in 150-180 days and has a medium-large seed size.

Presently the major problem encountered in breeding beans for cold climates (above 2000 masl), especially in the transfer of certain resistance factors, is the poor adaptation of most bean germplasm to these areas. A total of 425 crosses were made this year to incorporate resistance to anthracnose and halo blight into bush and climbing beans, but only 2% of these crosses were effective since the resistance sources were generally non-adapted to the region and the crosses failed to take. However, promising germplasm adapted to these altitudes was identified and materials such as TIB-3042 and ICA L-32980-1-41 climbing beans, and ICA L-33341, ICA L-33411 and ANT 8-1-40-M bush beans were selected for further testing and to be used as parents in the crossing block.

Table 1. Agronomic characteristics and yield of climbing bean lines in La Selva (1985)

Identification	Anthracnose	Ascochyta	Yield (kg/ha)	Grain color
LS 46	2	7	1728	Red
LS 40	4	7	1435	Cream/Red
LS 39	5	7	1417	Cream/Red
LS 33	3	4	1414	Cream/Red
LS 36	3	5	1406	Cream/Red
FRIJOLICA LS 3.3	3	5	1334	Cream/Red
LS 38	3	6	1301	Cream/Red
LS 42	6	7	1289	Cream/Red
LS 30	6	7	1288	Cream/Red
ICA Llanogrande	2	7	1255	Cream/Purple
LS 47	2	6	1248	Cream/Red
LS 41	2	6	1236	Cream/Red
LS 34	4	6	1221	Cream/Red
LS 43	2	7	1201	Cream/Red
LS 35	2	7	1195	Cream/Red
LS 48	2	6	1178	Cream/Red
LS 31	2	7	1171	Cream/Red
LS 45	2	7	1138	Cream/Red
LS 37	3	7	1109	Cream/Red
LS 44	2	7	1094	Cream/Red
ICA Viboral	8	7	1084	Cream/Red
LS 32	4	7	1043	Cream/Red
LS 49	2	7	987	Cream/Red
V 6785	2	7	844	Cream/Red
LSD (P=0.05)			310	

Table 2. Results of bush bean trials in five locations in Antioquia (1985)

Bean lines	Locations [a]					Seed color
	BELLO	VENECIA	HELICONIA	CISNEROS[b]	CISNEROS[b]	
PVAD 7	1380	2663	576	240	98	Red
PVAD 357	1443	3254	703	335	153	Purple/cream
PVAD 476	1523	2885	772	310	154	Red/cream
PVAD 698	1427	2567	672			Red/cream
CATIO (Check)	1876	2991	680	317	138	Red/cream
LSD (P=0.05)	518	579	524	-	-	

a Locations: Bello (1438 masl)
Venecia (1520 masl)
Heliconia (1600 masl)
Cisneros (less than 1000 masl)

b Beans grown in association with maize.

Table 3. Yield trial of new CIAT bush bean lines in Tulio Ospina (1985).

Bean lines	Yield (kg/ha)	Weight of 100 seed	Seed color
ZAA 42	711	31.3	Red/cream
ZAA 36	1561	39.7	Red/cream
PVA 605	1199	47.1	Red/cream
ZAA 60	2378	41.6	Red/cream
ZAA 58	2355	35.8	Red/cream
PAD 44	1294	36.6	Red/cream
PAV 705	1217	39.6	Red/cream
ZAA 44	1811	42.0	Red/cream
ZAA 52	1426	37.6	Red
PVA 273	1744	37.6	Red/cream
ZAA 7	1904	45.7	Red/cream
PAD 50	1861	33.1	Purple/cream
ZAA 47	994	36.8	Red/cream
PVA 366	750	38.0	Red/cream
PVA 660	1700	44.5	Red/cream
PVA 109	1937	48.5	Red/cream
MCD 256	1939	44.4	Red
ZAA 78	2650	39.3	Red/cream
ZAA 74	2283	40.5	Red/cream
ZAA 85	1311	54.0	Purple/cream
ZAA 45	1828	41.9	Red/cream
ZAA 48	1689	40.8	Red/cream
PAD 43	1289	37.0	Red/cream
ZAA 105	416	44.8	Red
ZAA 82	1922	38.3	Red/cream
PVA 359	1322	47.2	Red/cream
ZAA 102	905	41.4	Red
KID 5	916	35.4	Red/black
PVA 15	1305	57.6	Red
PVA 782C	1433	37.9	Red/cream
PVA 96	2220	45.1	Red/cream
PVAD 357 (Check 1)	1844		Red/cream
PVAD 698 (Check 2)	1200		Red/cream
CALIMA (Check 3)	1124	50.5	Red/cream

Regional and verification trials

The regional trials in Colombia consist of advanced bean lines from CIAT and ICA breeding programs of both bush and climbing bean growth habits. From the 1983-1984 bush bean regional trials which consisted of 13 materials, six lines: A 36, A 486, PVA 916, PVA 1261, PAI 29, and PAI 92 were selected to enter subsequent verification trials (previously known as confirmation trials) which are planted in larger field plots, over more locations, than the regional trials.

The entries in the bush bean regional trials were also changed to include new material from CIAT and ICA. The new lines are: MCD 257, PVA 782, PVA 1437, PVA 1193, PVA 1438, ICA 10212, ICA 10204, ICA 10115, PVA 1441, BAT 1297, Calima and the five lines from the verification trial. The regional and verification trials of climbing beans for medium to cold climates were maintained as in 1984 in order to have an additional season of data since fewer of these trials are planted each semester.

In total, 12 regional and 32 verification bush bean trials were distributed in 1985, and five regional and nine verification climbing bean trials.

ECUADOR

Virtually all the bean lines in trials in Tumbaco, Cuenca and Santa Catalina (Quito) consisted of materials from crosses made at CIAT. Crossing block, F_2 and F_4 populations, and advanced lines from the VEF, EP and regional trials were evaluated.

From the VEF, several materials were selected, of which ZAA 11, ZAA 12, ZAA 87, ZAA 91, ZAA 93, ZAA 94, ZAA 95, ZAA 96, and PVA 994 appeared to represent a new advance over the old materials which are still awaiting varietal release.

From F4 populations, 231 individual plant selections were made for testing in Tumbaco and Santa Isabel. Nearly all the best materials come from crosses with Ecuadorian germplasm, such as E 1056, E 521, E 525, and E 605, especially for crosses among climbing beans. E 1056 is now being grown by a number of farmers in the Cuenca area and is being sold in the market, though it has not yet been officially released.

Bush beans are also being planted and the seed sold, though they are not traditional crops in the Cuenca area. Regional trials have identified E 1486, ICA L-24 and A 36 as being the best lines (Table 4). E 101 (ICA Guali) is presently being grown by some farmers and appears to have a potential market.

PERU

The predominate cropping system in the Sierra region (Cajabamba and Cuzco) of Peru is climbing beans grown in association with maize under subsistence agricultural conditions, although in the southern regions of the Sierra, bush beans in monoculture or associated with maize are also

Table 4. Regional yield trials of bush bean lines in the Sierra region of Ecuador

Bean lines	Yield (kg/ha				
	Pimampiro	Santa Rosa	La Concepcion	Santa Isabel	X
E 816	1876	2662	985	1929	1863
Local Check	2231	-	815	-	1523
E 101	2346	2822	873	1841	1970
E 1484	2505	3391	1576	2194	2416
PVA 1426	2813	2910	802	1713	2059
A 36	2626	3527	931	1778	2215
PVA 1427	2277	2581	826	2191	1969
ICA L-24	2669	2924	1111	2668	2343
PVA 1428	2420	3045	926	2062	2113
PVA 1441	2121	2540	906	2335	1975
$\overline{X}$	2388	2934	975	2079	2094

important. The predominate grain types are large white beans (Caballeros) in the North, and large yellow and red beans in the South.

Three bean cultivars were officially released by INIPA for the Sierra region in 1985:

1. Blanco Salkantay, (a selection of Blanco Caballero) a large white seeded climbing bean with tolerance to anthracnose, and adapted from 2200-3000 masl.

2. Gloriabamba, (CIAT accession G 2829) a pink seeded climbing bean with resistance to anthracnose and early maturity, adapted from 2000 to 2800 masl.

3. Rojo Mollepata, (CIAT accession G 0076, Red Kloud) a large, red seeded determinate bush bean with tolerance to halo blight and early maturity, adapted from 500 to 2900 masl.

Other promising materials for the Cajabamba region are Puebla 444 and Cajamarca 64 climbing beans, and BAT 1254 and W-126 bush beans for Mollepata. F4 bulks from CIAT of kidney bean types were sent in 1984 and 33 F5 selections were made in Mollepata (2680 masl). These selections were then planted in Sahuayaca (800 masl) from which nine materials were selected to plant in regional yield and observation trials. The methodology that was employed in 1983 of sending F_4 bulk populations from crosses made at CIAT to Peru, from which selections are made by the INIPA agronomists and CIAT staff, appears to be an appropriate procedure for overcoming the adaptation problems encountered when selections are first made at CIAT.

II. 3. Evaluation in Uniform Nurseries

The three-stage progeny evaluation program tested 2,300 new materials whose distribution among the nurseries was as follows:

First stage	(VEF):	1451	entries
Second stage	(EP):	394	"
Third stage	(IBYAN):	210	"

Table 1 shows the number of sets of these nurseries distributed to different countries during 1985. This year, for the first time the VEF was to be dispatched to cooperators around the world.

A. VEF

The 1,451 entries screened were distributed in 15 groups according to seed color and size, growth habit (climbing and bush), climatic adaptation (for climbers only) and use (dry and green) as shown in Table 2.

The frequency of growth habits, grain characteristics and days to flowering and to maturity within each group are shown in Tables 3 and 4.

Yield of the best lines based on unreplicated plots within each group are recorded in Tables 5 and 6.

Reaction to rust and common bacterial blight (Table 7), angular leafspot (Table 8) and anthracnose and Ascochyta (Table 9) are shown for each group.

Table 10 shows the list of 86 VEF entries with an intermediate or resistant reaction to rust, common bacterial blight, angular leafspot, anthracnose and Ascochyta, evaluated in three sites, Palmira, Quilichao and Popayan during two semesters.

International VEF

This year for the first time the VEF was to be dispatched to cooperators around the world. Table 11 shows the number of sets forwarded to different countries; the number of entries per set was not uniform, since nurseries dispatched were arranged based on individual requests which ranged from a few lines from one particular group to the whole VEF nursery.

Table 1. Number of sets of international nurseries (IBYAN, VEF, EP) dispatched during 1985 to different countries.

	No. of sets		
	IBYAN	EP	VEF
Argentina	8		
Angola	16		
Belize	1	1	
Bulgaria	2		1
Colombia	32	1	3
Chile	1		
China			1
Costa Rica	17		8
Cuba	8		
Cyprus	2		
Ecuador	2		1
El Salvador	6		6
Guatemala	4	6	7
Chana	1		
Guine-Bissau	2		
Haiti	5		
Honduras	8		6
Kenya		1	1
Iran	1		
Mauritius	2		
Mexico	11		1
Nicaragua	8		6
Nigeria		7	
Panama	3		1
Paraguay	6		
Peru	8		1
Puerto Rico			8
R. F. Islamique des Comores	2		
Republica Dominicana	4		
Rwanda	1		4
Santa Lucia	2		
South Africa	9		1
Surinam	2		
Tanzania	2		1
Thailand	3		
Turquia	5		
Tunez	1		
USA	1		
Uganda	2		
Venezuela	4	1	1
Zambia	10	3	3
Zaire	2	3	6
Zimbabwe	1		
	205	23	67

Table 2. Distribution of the 1,451 entries of the 1985 VFF over 15 groups.

Group	Growth habit	Use	Seed color	Seed size	Climatic adapt.	No. of entries	No. of set dispat	No. of countries
10	Bush	Dry	Black	Small	Warm	102	20	8
20	"	"	Red	Small	Warm	162	19	8
25	"	"	Red-mottled	Med/large	Warm/med	405	7	6
30	"	"	White	Small	Med	84	4	4
35	"	"	White	Med/large	Med	18	2	2
40	"	"	Yellow, light-tan	Med/large	Med	26	3	3
45				Med/large	Med	5	3	3
50	"	"	Cream, cream				4	4
			striped	Small	Warm/med	44	–	–
60	Climbing		Black	Small	Warm	5	–	–
65	"	"	Black	Small	Medium	7	–	–
70	"	"	Red	Small	Warm	55	–	–
75	"	"	Red	Med/large	Medium	141	–	–
80	"	"	Light-colors	Small	Warm	7	–	–
85	"	"	Light colors	Med/large	Med/cool	154	3	2
90	Bush & climbing	green	Diverse	Med/large	Warm/med	236	2	2

Table 3. Number of bean entries in the VFF/85 within each group according to growth habit and phenological characteristics and seed size. Palmira, Colombia.

Group no.	Growth habit I	II	III	IV	Days to flowering 38	39–44	45	Days to physiological maturity[a] 75	75–90	90
10	–	81	21	–	44	58	–	93	9	–
20	1	71	89	1	98	63	1	147	15	–
25	350	52	–	–	379	26	–	327	78	–
30	14	57	12	–	34	46	4	60	24	–
35	13	2	2	–	16	2	–	17	1	–
40	14	7	5	–	15	11	–	23	3	–
45	4	1	–	–	5	–	–	4	1	–
50	15	20	8	1	14	29	1	38	5	–
60	–	–	–	–	–	–	–	–	–	–
65[a]	–	–	–	7	–	–	–	–	–	6
70										
75[a]	–	–	63	77	–	–	–	–	–	98
80	–	–	5	1	–	–	–	–	–	–
85[a]	–	–	76	65	–	–	–	–	–	107
90	–	–	–	–	–	–	–	–	–	–

[a] Data recorded in Rio Negro, Col.

Table 4. Number of bean entries in the 1985 VEF within each group according to seed characteristics.

Group no.	Brilliance			Seed size (gr/100 Seeds)		
	Shiny	Opaque	Semi shiny	25 (Small)	25-40 (Medium)	40 (Large)
10	2	98	1	101	1	-
20	120	8	34	146	16	-
25	67	40	151	15	209	181
30	12	37	34	80	3	-
35	3	2	2	3	10	5
40	23	1	2	6	17	2
45	1	-	4	-	2	3
50	7	25	12	38	6	-
60	3	1	1	3	2	-
65	5	-	2	7	-	-
70	14	7	34	21	34	-
75	114	3	24	18	79	9
80	6	-	1	5	2	-
85	47	25	82	7	51	64
90	49	24	163	-	-	-

Table 5. Yield (kg/ha) and main characteristics of the top five lines in 1985 VEF within each group of bush beans. Palmira.

Line		Growth habit	g/100 seeds	Days to maturity	Yield[1]	Rust[2]	CBB[2]	Antr.[3]	ALS[4]
Group 10									
MUS	14	2	25	75	3959	S	S	I	I
DOR	251	3	22	68	3757	I	S	I	I
DOR	168	2	22	68	3738	I	S	R	R
NAG	108	3	19	76	3638	R	S	I	I
NAG	146	2	24	71	3627	R	I	R	I
Group 20									
RAB	308	3	21	77	4459	I	S	R	R
AFR	139	3B	20	81	4027	I	S	R	R
AFR	114	3B	21	81	3841	R	S	R	R
RAB	290	3	18	75	3822	S	S	R	I
RAB	293	2	22	76	3743	I	S	I	I
Group 25									
PAD	66	1	44	79	3630	I	I	I	R
AFR	159	1	51	77	3581	R	I	R	R
AND	312	1	47	73	3554	R	I	R	R
AFR	192	1	56	75	3473	R	I	I	I
AFR	169	2	36	73	3424	R	S	R	R
Group 30									
PAN	126	2	19	80	3981	I	S	R	R
EMP	161	2	16	77	3503	I	S	R	R
PAN	120	2	16	80	3449	R	S	I	R
EMP	175	2	18	77	3359	I	S	R	R
BPE	2	2	15	73	3332	R	S	R	R

(Continued)

Table 5 (Continuation)

Line		Growth habit	g/100 Seeds	Days to maturity	Yield[1]	Rust[2]	CBB[2]	Antr.[3]	ALS[4]
Group 35									
EMP	154	2	22	75	2932	R	S	I	R
G 17331		1	40	65	2116	I	S	S	R
WAF	19	1	34	68	1995	I	S	I	R
WAF	12	1	37	67	1741	I	S	S	R
WAF	9	1	28	66	1730	I	S	I	I
Group 40									
VF	279	3B	31	79	2011	I	S	S	R
BAN	45	1	35	73	1989	I	S	S	R
BAN	44	2	27	73	1924	I	I	I	R
CAN	30	2	38	66	1924	R	I	R	R
G 1823		1	33	66	1827	R	S	S	R
Group 45									
AFR	162	1	39	77	1895	I	S	R	R
AND	300	1	43	68	1857	I	I	R	
AND	299	1	50	68	1830	R	I	S	
AFR	200	2B	39	75	1757	I	S	I	R
AND	301	1	45	67	1473	I	S	R	
Group 50									
AFR	116	3B	25	75	3551	R	S	I	R
AFR	81	3	20	71	3335	S	S	R	R
AFR	80	2	21	71	3205	I	S	R	R
AFR	78	3A	21	73	3176	I	S	R	R
EMP	169	2B	21	75	3165	I	S	I	R

1 Based on $5m^2$ plots
2 Palmira
3 Popayan
4 Quilichao

Table 6. Yield (kg/ha) and main characteristics of the top five lines in the 1985 VEF within each group of climbing beans.

Line		Growth habit	g/100 seeds	Days to maturity	Yield[1]	Rust[2]	CBB[2]	Antr.[3]	ALS[4]	BCMV NI.3
Group 60										
AFR	230		28		4944	R	S	I	R	V 31
BRU	5		15		4135	R	S	R	R	N 01
BRU	6		11		3602	R	S	I	R	V 13
AFR	231		28		3538	R	S	R	R	N 01
IGX	1		25		1081	R	S	I	R	N 01
Group 65[5]										
ASC	6	4A	21	148	459	R	S	R	R	M 03
ASC	7	4A	20	143	430	I	S	R	R	N 01
ASC	2	4A	25	143	331	I	S	R	R	N 01
ASC	3	4A	18	143	275	I	S	I	R	N 01
ASC	1	4A	17	148	263	R	S	R	R	V 31
Group 70										
AFR	229		31		6775	I	S	R	R	N 01
AFR	238		34		6660	R	S	R	R	M 03
AFR	221		30		5931	R	S	R	R	N 01
AFR	240		28		5890	R	S	R	R	N 01
AFR	227		32		5558	R	S	R	R	N 01

(Continued.)

Table 6 (Continuation.)

Line		Growth habit	gr/100 seeds	Days to maturity	Yield[1]	Rust[2]	CBB[2]	Antr.[3]	ALS[4]	BCMV NL3
Group 75[5]										
AFR	51	4A	25	118	5079	R	S	R	R	M 03
AFR	43	4A	27	123	4954	R	S	R	R	M 03
AFR	58	3B	27	118	4916	R	S	R	R	M 03
AFR	54	3B	26	118	4914	R	S	R	R	M 03
AND	200	3B	31	128	4888	S	S	R	R	M 03
Group 80										
AFR	223	3B	28		5558	R	S	R	R	N 01
BRU	7	3B	15		4571	I	S	R	R	N 01
BRU	9	3B	18		3158	I	S	R	R	M 03
BRU	10	4A	13		2538	R	S	R	R	M 03
BRU	8	3B	11		1871	I	S	R	R	V 13
Group 85[5]										
AND	7	4A	53	138	3316	I	S	R	R	M 03
AND	228	4A	52	133	3261	R	S	R	R	M 03
AND	215	4A	64	138	3099	R	S	R	R	M 03
AND	6	4A	57	143	3029	R	S	R	R	M 03
AND	9	4A	56	133	2944	R	S	R	R	M 03

1 Based on 5 m^2 plots
2 Palmira
3 Porayan
4 Quilichao
5 Rio Negro

Table 7. Number and proportion of bean entries in each basic group of VEF/85 according to their reaction to rust and common bacterial blight in Palmira, Colombia.

Group no.	Number of entries	RUST				CBB			
		R[a]	I	S	(S_i)	R	I	S	(S_i)
10	102	46	43	12	1	3	54	45	-
20	163	33	106	23	-	1	75	86	1
25	405	217	185	3	-	90	292	22	1
30	84	37	41	6	-	2	39	43	-
35	18	2	16	-	-	-	3	15	-
40	26	14	12	-	-	1	19	6	-
45	5	1	4	-	-	-	5	-	-
50	44	14	25	4	1	1	18	24	1
60	5	5	-	-	-	-	3	2	-
65	7	2	4	1	-	3	4	-	-
70	55	34	19	2	-	-	55	-	-
75	141	91	46	4	-	2	113	23	3
80	7	2	5	-	-	-	6	1	-
85	154	78	61	5	10	11	111	25	7
90	236	144	91	1	-	-	203	33	-
TOTAL	1452	720	659	61	12	114	1000	325	13
	49.6%	49.6%	45.4%	4.2%	.8%	7.8%	68.9%	23.4%	0.9%

[a] R = Resistant
I = Intermediate
S = Susceptible
S_i = No data

Table 8. Number of bean entries in each group of the VEF/85 according to their angular leaf spot reaction in Quilichao Colombia.

Group no.	R[a]	I	S	Total
10	-	88	12	100
20	5	140	4	149
25	30	345	16	391
30	3	58	1	62
35	1	31	1	33
40	1	23	1	25
45	-	6	-	6
50	-	25	13	38
60	-	1	4	5
65	-	4	3	7
70	-	18	34	52
75	-	30	75	105
80	-	2	4	6
85	-	62	47	109
90	3	46	178	227
TOTAL	43	879	393	1315

[a] R = Resistant
I = Intermediate
S = Susceptible

Table 9. Number of bean entries in each group of the 1985 VEF according to their anthracnose and *Ascochyta* reaction at Popayan, Colombia.

Group no.	ANTHRACNOSE				ASCOCHYTA			
	R[a]	I	S	Total	R	I	S	Total
10	3	47	49	99	–	98	3	101
20	51	71	40	162	–	142	21	163
25	143	151	86	380	–	255	141	396
30	15	31	19	65	–	59	9	68
35	4	15	12	31	–	21	12	33
40	1	8	8	17	–	11	12	23
45	3	2	1	6	–	4	2	6
50	10	20	7	37	–	35	8	43
60	2	2	–	4	–	5	–	5
65	4	2	1	7	1	6	–	7
70	49	3	–	52	–	35	17	52
75	104	4	1	109	17	76	47	140
80	6	–	1	7	3	4	–	7
85	107	19	4	130	18	59	69	146
90	51	89	72	212	–	225	4	229
Total	553	464	301	1318	39	1035	345	1419

[a] R = Resistant
I = Intermediate
S = Susceptible

Table 10. Entries from the VEF/85 that had a resistant or intermediate reaction to five diseases (rust, common bacterial blight, angular leafspot, Anthracnose and Ascochyta leafspot). during two semesters in three localities, Palmira, Quilichao and Popayan.

Resistant to rust, intermediate to CBB, Anth, ALS, Asco: AFR 192, AND AND 261, AND 262, AND 273, AND 298, AND 303, AND 308, AND 315, AND 317, AND 319, AND 351, AND 352, AND 364, ICA 15122, ICA 15385, ICA 15397, ICA 15399, ICA 15409, ICA 15479, ICA 15500, ICA 15515, ICA 15531.

Resistant or intermediate to Rust, Ant, Als, Asco, and resistant to CBB: ICA 15516, PAD 51.

Resistant or intermediate to Rust, CBB, ALS, Asco, and resistant to Ant: AFR 171, AFR 172, AFR 188, AFR 204, AFR 214, AND 291, AND 294, AND 304, AND 307, AND 312, AND 323, AND 331, AND 337, AND 359, AND 370, ICA 15119, ICA 15133, ICA 15136, ICA 15141, ICA 15142, ICA 15150, ICA 15252, ICA 15334, ICA 15342, ICA 15368, ICA 15383, ICA 15393, ICA 15412, ICA 15418, ICA 15451, ICA 15473, ICA 15474, ICA 15480, ICA 15481, ICA 15483, ICA 15496, ICA 15497, ICA 15506, ICA 15509, ICA 15520, ICA 15555.

Resistant or intermediate to rust, CBB, Ant, Asco and resistant to ALS: AND 370, ICA 15141, ICA 15257, ICA 15342, Kidney Mot. SC, PAD 59 70.

Table 11. Number of sets of VEF nurseries dispatched to 20 countries around the world.

Group no.	No. of sets	No. of countries	Countries	No. of sets
			Bulgaria	1
10	20	8	Colombia	3
20	19	8	China	1
25	7	6	Costa Rica	8
30	4	4	Ecuador	1
35	2	2	El Salvador	6
40	3	3	Guatemala	7
45	3	3	Honduras	6
50	4	4	Kenya	1
85	3	2	Mexico	1
90	2	2	Nicaragua	6
			Panama	1
	67		Puerto Rico	8
			Peru	1
			Rwanda	4
			South Africa	1
			Tanzania	1
			Venezuela	1
			Zambia	3
			Zimbabwe	6
				67

B. EP

From the 1,004 entries tested in the 1984 VEF, 394 lines were selected for evaluation in the 1985 EP. To make meaningful comparisons lines were grouped according to growth habit, seed size and the commercial grain type. Table 12 shows the details of the 18 preliminary yield trials organized with the lines selected for this second stage of testing.

Among the black-seeded lines we could single out RIZ 48 which in Palmira showed higher yields than those of two outstanding varieties in that color group, BAT 271 and ICA Pijao. In Popayan, RIZ 36 outperformed the rest and DOR 227 and NAG 87 were among the best entries at both testing sites (Table 13).

Eighteen lines were as good in Palmira as in Popayan among the 47 small seeded red lines tested in three different trials. Type IIb entries showed higher yields than those of growth habit IIa and III (Tables 14, 15 and 16).

Although BAT 1297 is a small seed sized-line of growth habit IIb it was used as check in all the trials where red-mottled lines were tested, whether these were small, medium or large sized, types I, II or III. Table 17 shows that compared with lines of similar seed size and growth habit BAT 1297 is not the best line available. Although in comparison with larger seed-sized lines BAT 1297 exhibits a superiority, although there are lines like ZAA 20 (Table 18) and PVA 1321 (Table 19) which can compete favorably with this check. PVA 3025, KID 3, PVA 3026 (Table 20) and ZAA 65 and KID 8 (Table 21) are large-sized lines which showed a good performance.

Among the small white lines PAN 55, PAN 103 and PAN 68 were the outstanding entries (Table 22). BLM 9 among the large white (Table 23), G 13094, BAN 38, BAN 21 for the Bayo and yellow types (Table 24), COS 5, COS 3 for the Mexican highland-types (Table 25) and RIZ 45 and DOR 350 for the Brazilian types (Table 26) were the outstanding lines in their respective groups.

The performance of the small red-seeded climbing lines was dissimilar in Palmira from Popayan. ACV 21 the outstanding line in Popayan, did not show above average yields in Palmira and none of the six lines with above average yields in Palmira had a similar performance in Popayan (Table 27).

International EP

Twenty three sets of EP trials were sent to eight countries. Sets were arranged according to the color groups used by the CIAT Bean Program.

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Table 12. Types of preliminary yield trials (1985 EP) assembled with the entries selected from the 1984 VEF and tested at two locations in Colombia.

Group no.	Trial	Description	No. of New lines	No. of Checks	Record of yield data
	Bush bean trials				
10	Small black-seeded lines	Growth habit II-III	18	3	Table 11
20	Small red-seeded lines	Growth habit IIa	9	1	Table 12
		Growth habit IIb	25	1	Table 13
		Growth habit III	13	1	Table 14
25	Red-mottled, small-seeded lines	Growth habit IIa, IIb 35gr/100 seeds	18	2	Table 15
	Red-mottled, med/large-seeded lines	Growth habit IIb, III, 35-55 gr/100 seeds	15	1	Table 16
		Growth habit I, 35-45 gr/100 seeds	21	1	Table 17
	Red-mottled, large-seeded lines	Growth habit I, 45-50 gr/100 seeds	29	1	Table 18
		Growth habit I, 50 gr/100 seeds	18	2	Table 19
30	Small white-seeded lines	Growth habit II a	10	2	Table 20
		Growth habit IIb and III	28	2	Table 20
35	Large white-seeded lines	Growth habit I, II	7	1	Table 21
40	Yellow and light-tan-seeded lines	Growth habit I	22	2	Table 22
45	Mexican highland-type lines	Various colors, growth habit I, II, III	10	2	Table 23
50	Brazilian-type lines	Various colors, growth habit II	13	1	Table 24
		Various colors, growth habit III	11	1	Table 24
	Climbing bean trials				
70	Small red-seeded lines	Growth habit 4a.	13	1	Table 25

Table 13. Experimental lines with above-average yields (kg/ha) in two sites at Colombia. 1985 EP. Small, black-seeded lines. First semester.

PALMIRA				POPAYAN			
Line		Yield		Line		Yield	
RIZ 48		1706	a*	RIZ 36		3502	a
BAT 271	(E)	1594	ab	NAG 105		3428	ab
ICA Pijao	(L)	1536	abc	NAG 91		3403	ab
DOR 227		1533	abcd	DOR 227		3397	ab
NAG 75		1485	abcde	NAG 95		3367	ab
NAG 98		1412	abcde	NAG 87		3359	ab
DOR 241		1383	abcdef	EMP 148		3347	ab
RIZ 52		1340	bcdefg	ICA Pijao	(L)	3341	ab
NAG 94		1315	bcdefg	BAT 527	(E)	3340	ab
NAG 87		1306	bcdefg				
Mean (n=21)		1260				3294	
Range		957-1706				3132-3502	
CV		14.8%				4.9%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 14. Experimental lines with above-average yields (kg/ha) in two sites in Colombia. 1985 EP. Small, red-seeded lines of growth habit IIa. First Semester.

PALMIRA			POPAYAN		
Line	Yield		Line	Yield	
RAB 244	1576	a*	RAB 249	3393	a
RAO 30	1210	b	RAB 210	3334	ab
RAB 210	1204	b	RAB 256	3297	ab
RAB 249	1148	b	RAB 130	3267	ab
BAT 1674	1056	bc	RAO 30	3212	abc
RAB 175	1027	bc	Zamorano (L)	3183	abc
Zamorano (L)	679	d			
Mean (n=10)	1024			3165	
Range	605-1576			2858-3393	
CV	18.3%			6.3%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan´s test.

Table 15. Experimental lines with above-average yields (kg/ha) in two sites in Colombia 1985 EP. Small, red-seeded lines of growth habit IIb. First semester.

PALMIRA			POPAYAN		
Line	Yield		Line	Yield	
RAO 24	1875	a*	RAB 230	3473	a
RAB 201	1783	ab	DOR 308	3432	ab
RAB 40	1728	abc	RAB 147	3391	ab
RAB 203	1635	abcd	RAB 254	3384	ab
RAB 211	1522	abcd	RAB 245	3372	ab
DOR 308	1501	abcd	RAB 219	3370	ab
RAB 204	1498	abcd	RAB 234	3323	ab
RAB 147	1476	abcd	RAB 181	3320	ab
RAB 181	1462	abcde	RAB 239	3313	ab
RAB 164	1437	abcde	RAB 204	3300	ab
RAB 206	1410	abcde	Zamorano (L)	3289	ab
RAB 172	1384	abcde			
RAB 254	1378	abcde			
RAB 251	1377	abcde			
RAB 233	1371	bcde			
Zamorano (L)	639	f			
Mean (n=26)	1370			3292	
Range	639-1875			3199-3473	
CV	18.3%			4.6%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 16. Experimental lines with above average yields (kg/ha) in two sites in Colombia. 1985EP. Small, red-seeded lines of growth habit III. First semester.

PALMIRA			POPAYAN		
Line	Yield		Line	Yield	
RAB 246	1249	a*	RAB 180	3299	a
RAO 32	1225	a	RAB 247	3238	ab
RAO 35	1207	a	RAO 34	3228	ab
RAB 205	1103	ab	Zamorano (L)	3205	ab
RAO 33	1095	abc	RIZ 53	3160	abc
RAB 180	1083	abc	RAB 96	3108	abc
RAO 34	1066	abc	ZAA 25	3089	abc
Zamorano (L)	607	d			
Mean (n=14)	1011			3028	
Range	607-1249			2738-3299	
CV	17.2%			5.3	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 17. Experimental lines with above-average yields (kg/ha) at Palmira, Colombia 1985 EP. Red-mottled (<35 g/100 seeds) seed lines of indeterminiate growth habit. First semester.

Line	Growth habit	Yield	
PAI 110	III	1565	a*
PAI 118	IIa	1482	ab
PAI 127	IIa	1439	ab
PAT 9	IIa	1372	ab
PAI 126	IIb	1354	ab
PAI 112	IIa	1309	ab
PAT 5	IIb	1307	ab
PAT 13	IIb	1301	ab
PAI 130	IIa	1277	ab
PAI 119	IIa	1265	ab
PAT 6	IIa	1174	abc
PAT 2	IIa	1141	abc
BAT 1297 (E)	IIb	1083	abcd
Mean (n = 20)		1124	
Range		460-1565	
CV		22.2%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 18. Experimental lines with above-average yields (kg/ha) at Palmira, Colombia. EP/85. Red-mottled medium and large-seeded lines (35-55 g/100 seeds) of indeterminate growth. First semester.

Line	Growth habit	Yield	
BAT 1297 (E)	IIb	1997	a*
ZAA 20	IIb	1947	ab
ZAA 13	III	1678	bc
ZAA 19	IIb	1638	c
Austria 287	IIb	1610	c
PVA 800A	III	1515	cd
PVA 800B	III	1459	cd
ZAA 105	IIb	1459	cd
PVA 1384	III	1437	cd
Mean (n=16)		1358	
Range		870-1997	
CV		12.0%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 19. Experimental lines with above-average yields (kg/ha) at Palmira, Colombia. EP/85. Red mottled, medium and large-seeded lines (35-45 gr/100 seeds) of determinate growth. First semester.

Line	Yield	
BAT 1297(E)[a]	1695	a*
PVA 1321	1320	b
ZAA 14	1072	bc
PAD 49	1064	bc
PVA 957	1042	bc
PVA 1327	1034	bc
PAD 37	1018	bc
ZAA 5	984	bc
ZAA 29	918	bc
Mean (n=22)	908	
Range	499-1695	
CV	23.8%	

[a] Growth habit IIb

* Values followed by the same letter are not significantly different at the 0.5 level of probability according to Duncan's test.

Table 20. Experimental lines with above average yields (kg/ha) at Palmira, Colombia. 1985 EP. Red-mottled large-seeded (45-50 g/100 seed) lines of determinate growth. First semester.

Line	Yield	
BAT 1297 (E)[a]	1440	a*
PVA 3025	1218	b
KID 3	1192	b
PVA 3026	1158	b
KID 7	1027	bc
PAD 45	907	cd
PAD 47	837	cde
ZAA 64	832	cde
ZAA 88	806	cdef
ZAA 102	804	cdef
ZAA 111	783	cdefg
ZAA 6	780	cdefg
ZAA 66	770	cdefg
Mean (n=30)	748	
Range	540-1440	
CV	18.0%	

[a] Growth habit IIb.

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 21. Experimental lines with above-average yields (kg/ha) at Palmira, Colombia. 1985 EP. Red-mottled large-seeded (50 g/800 seed) lines of determinate growth. First semester.

Line	Yield	
BAT 1297 (E)[a]	1502	a*
ZAA 65	1074	b
KID 8	1064	b
ZAA 55	1013	bc
ZAA 8	998	bc
PVA 844	982	bc
KID 14	973	bc
ZAA 79	954	bc
PVA 1377	923	bc
PVA 846	911	bcd
PVA 1122	910	bcd
Mean (n=20)	908	
Range	558-1502	
CV	19.8	

a Growth habit IIb

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 22. Experimental lines with above-average yields (kg/ha) at Palmira, Colombia. 1985EP. Small, white-seeded lines of growth habit IIa, IIb and III. First semester.

Growth habit IIa			Growth habit IIb and III		
Line	Yield		Line	Yield	
PAN 55	1349	a*	PAN 68	1826	a
PAN 103	1300	a	PAN 65	1750	ab
PAN 52	1214	ab	BLM 8	1720	ab
Ex Rico 23 (L)	1176	ab	PAN 39	1715	ab
MITA-L-227-1	1175	ab	MITA-L-226-10	1669	bc
PAN 66	1155	ab	PAN 97	1664	bc
PAN 48	1147	ab	PAN 38	1650	bc
			PAN 72	1646	bc
			PAN 102	1643	bc
			Ex Rico 23 (L)	1638	bc
			PAN58	1613	bcd
			PAN 96	1598	bcd
			DOR 333	1574	bcde
			PAN 79	1552	bcde
			PAN 86	1540	bcde
			PAN 87	1534	bcde
Mean	(n=12)		1117 (n=30)	1504	
Range			843-1349	1327-1826	
CV			17.1%	14.8%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 23. Experimental lines with above-average yields (kg/ha) at Palmira, Colombia. 1985 EP. Large, white-seeded lines. First semester.

Line	Yield	
BLM 9	1518	a*
BLM 12	1179	ab
BLM 5	975	bc
Alubia cerrillos (L)	883	bc
Mean (n=8)	942	
Range	504-1518	
CV	21.2%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 24. Experimental lines with above-average yields (kg/ha) in Palmira, Colombia. EP/85. Yellow and light-tan seeded lines. First semester.

Line	Yield	
G 13094	1641	a*
BAN 38	1589	a
BAN 21	1586	a
BAN 22	1534	ab
BAN 29	1477	abc
BAN 28	1477	abc
BAN 27	1392	abcd
BAN 30	1386	abcd
Culiacan 200	1370	abcd
Mayocoba (L)	1359	abcd
Can 107 x Per 5-M	1347	abcd
Bayo Titán (L)	1302	abcd
II SFRM-81-M-M	1288	abcd
ZAA 33	1276	abcd
Ahome	1276	abcd
Mean (n=24)	1267	
Range	726-1641	
CV	21.1%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 25. Experimental lines with above-average yields (kg/ha) in two sites of Colombia. 1985 EP. Lines of various colors for the Mexican highlands. First semester.

PALMIRA			POPAYAN		
Line	Yield		Line	Yield	
COS 5	1731	a*	Ojo de Cabra (L)	3565	a
COS 3	1692	a	ZAA 83	3454	ab
Canario 107 (L)	931	b	COS 3	3419	ab
Ojo de Cabra (L)	838	b	COS 4	3386	ab
			COS 5	3366	b
			ZAA 18	3354	b
			Canario 107 (L)	3116	c
Mean (n=12)	1033			3273	
Range	691-1731			3071-3565	
CV	16.1%			3.0%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 26. Experimental lines with above-average yields (kg/ha) in Palmira, Colombia, 1985 EP. Pink cream and cream-striped lines of small seed size. First semester.

GROWTH HABIT II			GROWTH HABIT III		
Lines	Yield		Lines	Yield	
RIZ 45	2236	a*	DOR 350	1569	a
EMP 147	1901	ab	DOR 351	1487	ab
DOR 335	1888	ab	EMP 143	1465	ab
RIZ 50	1705	bc	DOR 344	1454	ab
RIZ 46	1636	bcd	RIZ 32	1322	abc
Carioca (L)	1518	bcd	Carioca (L)	1135	abc
Mean (n=14)	1582		(n=12)	1298	
Range	1105-2236			1048-1569	
CV	17.2%			12.4%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

Table 27. Experimental lines with above-average yields (kg/ha) in Palmira, Colombia. 1985EP. Small red-seeded climbing lines. First semester.

GROWTH HABIT IVa			GROWTH HABIT IVb		
Lines	Yield		Lines	Yield	
ACV 4	1913	a*	ACV 21	2144	a
ACV 22	1843	a	ACV 36	1854	ab
ACV 30	1843	a	ACV 5	1779	ab
ACV 1	1827	a	ACV 7	1670	abc
ACV 31	1688	a	ACV 17	1665	abc
ACV 2	1329	ab	ACV 34	1601	bc
Rojo 70	391	c	ACV 55	1592	bc
			ACV 12	1526	bc
			Rojo 70	367	d
Mean (n=14)	1124		(n=16)	1235	
Range	391-1913			367-2144	
CV	29.3%			21.7%	

* Values followed by the same letter are not significantly different at the 0.05 level of probability according to Duncan's test.

C. IBYAN

As usual, this report includes the results of the second semester plantings in the two Colombian locations of the trials of the previous year and the results of the first semester plantings at the same locations of the trials of this year. Also, a summary of the worldwide results of the IBYAN of the previous year is included. A more complete analysis of the data is published in a separate report.

1984 IBYAN

During 1984 CIAT distributed 195 bush and 47 climbing IBYAN trials. The outstanding lines by color groups were the following lines: NAG 55, NAG 20, NAG 42. NAG 15 (Table 28), RAB 59, RAB 30 (Table 29), PVA 901, BAT 1297, A 471, PVA 1258 (Table 30), MCD 257, PVA 359, MCD 253, PVA 781 (Table 31), WAF 9, A 321, A 445, PVBZ 1782 (Table 32), ACV 8311, ZAV 8344, ZAV 8332, ZAV 8305, ZAV 8399, ZAV 8394 (Table 33).

Trials in the second semester of 1984 in two locations in Colombia confirmed the outstanding performance elsewhere of the black-seeded lines NAG 55, NAG 15 and the red line RAB 59 (Table 34).

Among the red-mottled lines that yielded well both at Palmira and Popayan are: PVA 1258, A 471, MCD 257 and the check BAT 1297 (Tables 35, 36). For the Mexican highland types A 445 (Table 37) and for the Brazilian types PVBZ 1782 (Table 38) are singled out as the best materials adapted to both contrasting testing sites in Colombia.

Among the climbers the black seeded lines VNA 81017, V 8367 (Table 39) and the small red seeded ACV 8351, ACV 8363 (Table 40) were the only ones that performed well at both Colombian locations. The light color-seeded climbing beans for warm climates showed high yields at Palmira particularly ZAV 8313 with 5 t/ha (Table 41); yields for the medium/cool climate materials were not as high but most of the material outperformed the local checks (Table 42).

1985 IBYAN

The trial was formed by eight different nurseries that were dispatched to 39 countries. The present report only includes results from the IBYAN trials planted by the Bean Program in Colombia in the first semester of 1985 (Tables 43 to 50).

Outstanding materials in these trials performing well at both sites, Palmira and Popayan were the following: NAG 12, a type IIa erect black seeded line (Table 43), NAG 46 and XAN 151 (Table 44), RAB 58, RAB 102 and RAB 59, three small red-seeded lines (Tables 45, 46), RAO 16 a small, opaque red-seeded bean (Table 47). None of the large-sized red- mottled beans outperformed the small sized type IIb line BAT 1297 but among the lines with similar grain and plant characteristics two of them were as good as BAT 1297 (Table 48). ZAV 8306 proved to be a promising line: it ranked first at both locations

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and yielded 5 t/ha at Popayan. MAM 7 was another good line for both locations (Table 49). The new small, red-seeded climbing lines outperformed by a wide margin both commercial Central American varieties used as checks, Table 50.

Table 28. Yield (kg/ha) of the top two lines of the 14 sites where 12 black-seeded entries were tested. IBYAN 1984.

LOCATION		LINE	YIELD	LINE	YIELD	LSD.05
Mairana	BOL	BAT 304	3085	NAG 66	3077	571
Palmira A	COL	BAT 271 (T)	3523	NAG 55	3086	753
Palmira B	COL	NAG 15	3501	NAG 55	3493	514
Popayán A	COL	NAG 26	3866	NAG 42	3740	630
Alajuela	C. RICA	BAT 304	1004	NAG 66	897	274
Alajuela	C. RICA	NAG 20	806	N. Huasteco	757	276
Alquizar	CUBA	NAG 55	3580	NAG 15	3165	515
Graneros	CHILE	NAG 44	2882	NAG 20	2847	623
Chillan	CHILE	NAG 55	3885	Testigo L.	3750	474
Padilla	MEX	Jamapa	1778	NAG 15	1743	446
Mazatlan	MEX	NAG 20	1763	NAG 26	1548	376
Saman Mocho	VEN	NAG 77	1925	NAG 55	1859	420
San Miguel	VEN	NAG 42	2530	NAG 20	2517	900
Maracay	VEN	Jamapa	2560	NAG 42	2330	720

Table 29. Yield (kg/ha) of the top two lines of the seven sites where 12 red-seeded entries were tested. IBYAN 1984.

LOCATION		LINE	YIELD	LINE	YIELD	LSD.05
Alajuela	C RICA	RAB 30	1222	RAB 59	917	239
Alajuela	C RICA	RAB 30	806	RAB 141	748	235
Palmira A	COL	RAB 59	2989	RAB 30	2934	538
Palmira B	COL	RAB 59	3197	RAB 141	3156	548
Popayán A	COL	RAB 93	3644	RAB 71	3584	465
Alquizar	CUBA	RAB 59	2829	RAB 93	2754	1061
St. Andrew	JAMAICA	RAB 94	1761	RAB 124	1534	732

Table 30. Yield (kg/ha) of the top two lines of the 11 sites where 12 medium-sized, red-mottled entries were tested. IBYAN 1984.

LOCATION		LINE	YIELD	LINE	YIELD	LSD.05
Central Farm	BELIZE	BAT 1297	1272	A 471	1199	434
Palmira A	COL	BAT 1297	2551	PVA 875	2318	391
Palmira B	COL	PVA 1258	2341	PVA 875	2300	354
Popayan A	COL	PVA 1258	3114	A 471	2477	721
Popayan B	COL	PVA 901	2479	PVA 1258	2218	826
Alquizar	CUBA	PVA 880	2534	PVA 555	2512	1258
Damien	HAITI	BAT 1297	3125	A 471	2465	552
Chilanga	ZAMBIA	BAT 1297	1847	PVA 901	1706	449
Chipata	ZAMBIA	PVA 1360A	527	PVA 901	464	199
Mbala	ZAMBIA	MCD 230	620	PVA 901	542	84
Gwebi	ZIMBWE	PVA 901	1658	PVA 1360A	1239	191

Table 31. Yield (kg/ha) of the top two lines of the 11 sites where 12 large-sized, red-mottled entries were tested. IBYAN 1984

LOCATION		LINE	YIELD	LINE	YIELD	LSD.05
Central Farm	BELIZE	PVA 791	1276	PVA 359	1222	241
Palmira A	COL	MCD 257	2374	PVA 1180	2360	326
Palmira B	COL	MCD 257	2198	Calima	2009	358
Popayan A	COL	MCD 257	3545	Calima (T)	2243	632
Popayan B	BELIZE	PVA 359	1671	MCD 257	1485	672
Alquizar	CUBA	MCD 254	2757	MCD 253	2175	398
Damien	HAITI	MCD 253	2118	MCD 252	2083	758
Chipata	ZAMBIA	PVA 781	664	MCD 253	662	155
Mbala	ZAMBIA	PVA 359	470	PVA 781	421	110
Chilanga	ZAMBIA	PVA 702	1495	PVA 1180	1224	406
Harare	ZMBAWE	PVA 781	1812	PVA 791	1771	179

Table 32. Yield (kg/ha) of the top two lines of the light colored-seed entries tested in different sites. IBYAN 1984.

LOCATION		LINE	YIELD	LINE	YIELD	LSD.05
		Large sized, white lines n = 12				
Santiago	CHILE	WAF 2	3891	WAF 3	3283	774
Chillan	CHILE	WAF 9	4161	WAF 7	3839	681
Valdivia	CHILE	WAF 2	2193	WAF 9	2023	434
		Mexican highlands - bean types n = 12				
Palmira A	COL	A 321	3791	A 445	3386	390
Palmira B	COL	A 445	3447	PVMX 1597	2737	505
Popayan B	COL	A 445	3662	A 429	3095	585
Tepatitlan	MEX	A 321	1664	Local C	1378	362
Peña del Panal	MEX	A 321	1610	A 411	1548	297
Chapingo	MEX	Local C	2098	A 321	1988	363
La Huerta	MEX	A 445	1981	A 439	1789	421
		Brazilian-bean types n =12				
Mairana	BOL	Catu	3639	IPA 7419	3359	459
Palmira A	COL	PVBZ 1726	2374	IPA 7419	2360	326
Palmira B	COL	PVBZ 1782	2983	PVBZ 1894	2946	592
Popayan A	COL	PVBZ 1896	4105	Carioca	4063	448
Popayan B	COL	PVBZ 1782	2901	PVBZ 1782	2688	1020
Alquizar	CUBA	PVBZ 1881	3504	PVBZ 1726	3314	554

Table 33. Yield (kg/ha) of the top two lines of the red and light colored seed entries of the climbing bean trials. IBYAN 1984.

LOCATION		LINE	YIELD	LINE	YIELD	LSD.05
		Small, red-seeded lines, warm climate n =12				
Palmira B	COL	ZAV 8359	4631	ACV 8351	4588	559
Popayan B	COL	ACV 8340	3325	ACV 8349	3087	1333
San Andrés	SALV	Rojo 70	3457	ZAV 8344	3049	611
Chipata	ZAMBIA	ZAV 8344	1884	ACV 8311	1704	648
Lae	PAPUA NG	ACV 8311	2099	ZAV 8344	1876	177
		Light color - seeded lines, warm climate n=12				
Palmira B	COL	ZAV 8313	5066	ZAV 8352	4459	627
Chipata	ZAMBIA	ZAV 8308	1984	ZAV 8332	1711	437
Mbala	ZAMBIA	ZAV 8305	919	ZAV 8332	820	154
Lae	PAPUA NG	VRB 81012	795	ZAV 8305	632	88
		Light color seeded lines, medium/cool/climates n=12				
Popayan	COL	I. Llanogrande	3450	I. Viboral	3340	644
Sta. Catalina	ECU	E 605	1206	F 849	1120	281
Peña del Panal	MEX	R. de Castilla	1794	Cacahuate	1471	417
Chapingo	MEX	ZAV 8399	1889	ZAV 8394	1573	383
Cajabamba	PERU	ZAV 8382	1051	ZAV 8394	976	447
Chipata	ZAMBIA	ZAV 8378	920	ZAV 8399	793	273
Mbala	ZAMBIA	ZAV 8394	664	ZAV 8398	646	165

Table 34. Average yield (kg/ha) of the black and red-seeded beans tested in CIAT-Palmira. IBYAN 1984. Semester B.

SMALL, BLACK-SEEDED LINES			SMALL, RED-SEEDED LINES		
Rank order	Identification	Yield	Rank order	Identification	Yield
	Experimental lines				
1	NAG 15	3501	1	RAB 59	3197
2	NAG 55	3493	2	RAB 141	3156
3	NAG 42	3439	3	RAB 71	3003
5	NAG 44	3175	5	RAB 79	2930
	CHECKS				
4	BAT 271	3232	4	A 21	2964
6	Jamapa	3100	12	Zamorano 2	1867
Mean (n=12)		3017			2743
LSD.05		514			548
CV		10.1			11.8%

Table 35. Average yield (kg/ha) of the medium-sized, red-mottled beans tested in CIAT-Palmira and CIAT-Popayan, IBYAN 1984. Semester B.

Rank order	PALMIRA Identification	PALMIRA Yield	Rank order	POPAYAN Identification	POPAYAN Yield
	Experimental lines				
2	PVA 1258	2341	1	PVA 901	2479
3	PVA 875	2300	2	PVA 1258	2218
4	PVA 1360 B	2274	3	A 476	1898
5	A 471	2201	5	A 471	1686
	CHECKS				
1	BAT 1297	2830	4	BAT 1297	1758
9	Pompadour Mocana	1846	11	Pompadour Mocana	828
Mean (n=12)		2047			1517
LSD.05		354			826
CV		10.2%			32.1%

Table 36. Average yield (kg/ha) of the large-sized, red-mottled beans tested in CIAT-Palmira and CIAT-Popayan. IBYAN 1984. Semester B.

Rank order	PALMIRA Identification	PALMIRA Yield	Rank order	POPAYAN Identification	POPAYAN Yield
	Experimental lines				
1	MCD 257	2198	1	PVA 359	1671
3	PVA 1180	1916	2	MCD 257	1485
4	PVA 791	1859	3	MCD 252	1115
5	PVA 702	1727	4	MCD 251	1115
	CHECKS				
2	Calima	2009	6	Calima	879
Mean (n=12)		1681			922
LSD.05		358			672
CV		12.6%			43.1%

Table 37. Average yield (kg/ha) of a group of lines developed for the Mexican highlands tested in CIAT-Palmira and CIAT-Popayan. IBYAN 1984. Semester B.

Rank order	PALMIRA Identification	PALMIRA Yield	Rank order	POPAYAN Identification	POPAYAN Yield
	Experimental lines				
1	A 445	3447	1	A 445	3662
2	PVMX 1597	2737	2	A 429	3095
3	PVMX 1590	2717	3	A 411	3009
	CHECKS				
12	G 2858	2250	6	G 2858	2843
Mean (n=12)		2614			2772
LSD.05		505			585
CV		11.4%			12.5%

Table 38. Average yield (kg/ha) of the cream-seeded beans tested in CIAT-Palmira and CIAT-Popayan. IBYAN 1984. Semester B.

Rank order	PALMIRA Identification	PALMIRA Yield	Rank order	POPAYAN Identification	POPAYAN Yield
	Experimental lines				
1	PVBZ 1782	2983	1	PVBZ 1782	2901
2	PVBZ 1894	2946	2	PVBZ 1896	2688
3	PVBZ 1730	2838	4	PVBZ 1790	2468
	CHECKS				
4	Carioca	2832	3	Carioca	2476
6	IPA 7419	2625	10	IPA 7419	2084
Mean (n=12)		2662			2289
LSD.05		592			1020
CV		13.1%			26.3

Table 39. Average yield (kg/ha) of the black-seeded climbing beans tested in CIAT-Palmira and CIAT-Popayan. IBYAN 1984. Semester B.

Rank order	PALMIRA Identification	PALMIRA Yield	Rank order	POPAYAN Identification	POPAYAN Yield
	Experimental lines				
1	VNA 81017	2139	2	VNA 81004	3964
2	V 8360	2137	3	VNA 81017	3539
3	V 8367	2089	4	VNA 81003	3357
4	VNA 81009	2068	5	VNA 81009	3129
5	V 8364	2039	6	V 8367	3115
	CHECKS				
10	G 6040	700	1	G 6040	4474
Mean (n=10)		1639			3337
LSD.05		711			628
CV		25%			10%

Table 40. Average yield (kg/ha) of the small, red-seeded climbing beans tested in CIAT-Palmira and CIAT-Popayan. IBYAN 1984. Semester B.

Rank order	PALMIRA Identification	PALMIRA Yield	Rank order	POPAYAN Identification	POPAYAN Yield
	Experimental lines				
1	ZAV 8359	4631	1	ACV 8340	3325
2	ACV 8351	4588	2	AVC 8349	3087
3	ZAV 8344	4201	3	ACV 8363	3086
4	ACV 8368	4075	4	ACV 8343	2998
5	ACV 8363	4033	5	ACV 8351	2904
	CHECKS				
12	Rojo 70	2723	7	Rojo 70	2574
Mean (n=12)		3742			2624
LSD.05		559			1333
CV		8%			30%

Table 41. Average yield (kg/ha) of light-color climbing beans for warm climates tested in CIAT-Palmira. IBYAN 1984. Semester B.

Rank order	Identification	Yield
	Experimental lines	
1	ZAV 8313	5066
2	ZAV 8352	4459
3	V 8336	4322
4	ZAV 8332	4131
5	ZAV 8358	4044
	CHECKS	
7	P 589	3778
Mean (n=12)		3915
LSD.05		627
CV		9%

Table 42. Average yield (kg/ha) of light color climbing beans for medium/cool climates tested in CIAT-Popayan. IBYAN 1984. Semester B.

Rank order	Identification	Yield
	Experimental lines	
1	ZAV 8398	2729
2	ZAV 8399	2677
3	ZAV 8385	2638
4	ZAV 8376	2470
	CHECKS	
7	ICA Viboral	2348
9	ICA Llanogrande	2176
Mean (n=12)		2307
LSD.05		760
CV		19%

Table 43. Average yield (kg/ha) of the black-seeded, erect (type IIa) lines tested in Palmira and Popayan. 1985 IBYAN. Semester A

PALMIRA			POPAYAN		
Rank order	Identification	Yield	Rank order	Identification	Yield
	Experimental lines				
2	NAG 12	2303	1	NAG 12	4788
3	NAG 16	2249	2	NAG 13	4767
	Checks				
1	BAT 271	2907	3	Jamapa	4663
4	BAT 1554	2199	9	BAT 527	3891
11	Jamapa	1768	11	BAT 527	3662
Mean (n=14)		2025			3997
LSD.05		377			784
CV		11.1%			11.7

Table 44. Average yield (kg/ha) of the black-seeded, non erect (types IIb and III) beans tested in CIAT-Palmira and CIAT-Popayan. IBYAN 1985. Semester A.

PALMIRA			POPAYAN		
Rank order	Identification	Yield	Rank order	Identification	Yield
	Experimental lines				
3	NAG 46	2442	1	XAN 151	4600
4	NAG 70	2430	2	NAG 81	4457
	Checks				
1	BAT 271	3790	3	Jamapa	4454
2	BAT 304	2594	12	BAT 304	3684
15	Jamapa	1602	16	BAT 527	3301
Mean (n=16)		2190			3984
LSD.05		570			805
CV		15.6%			12.1%

Table 45. Average yield (kg/ha) of the small red-seeded lines, Zamorano type[a], tested in Palmira and Popayan. IBYAN 1985. Semester A.

PALMIRA			POPAYAN		
Rank order	Identification	Yield	Rank order	Identification	Yield
	Experimental lines				
1	RAB 128	2795	1	RAB 58	4556
2	RAB 74	2489	2	RAB 72	4562
3	RAB 58	2470	3	RAB 73	4401
4	RAB 102	2465	4	RAB 102	4367
	Checks				
16	Zamorano	1114	15	Zamorano	3389
Mean (n=16)		2126			3917
LSD.05		352			780
CV		9.9%			11.9%

[a] Light red, shiny

Table 46. Average yield (kg/ha) of the small shiny red-seeded lines tested in Palmira and Popayan. IBYAN 1985. Semester A.

PALMIRA			POPAYAN		
Rank order	Identification	Yield	Rank order	Identification	Yield
	Experimental lines				
1	RAB 143	2248	1	RAB 123	4708
2	RAB 59	2237	2	RAB 59	4576
3	RAB 155	2090	3	RAB 106	4458
4	RAB 43	2030	4	RAB 124	4415
	Checks				
14	BAT 795	1347	5	BAT 795	4277
16	Zamorano	944	10	Zamorano	3892
Mean (n=16)		1748			4031
LSD.05		621			644
CV		21.3%			9.6%

Table 47. Average yield (kg/ha) of the small opaque red-seeded lines tested in Palmira and Popayan. IBYAN 1985. Semester A.

PALMIRA			POPAYAN		
Rank order	Identification	Yield	Rank order	Identification	Yield
	Experimental lines				
1	RAO 15	2893	2	RAO 11	4068
2	RAO 16	2718	4	RAO 22	3613
3	RAO 17	2514	5	RAO 16	3524
	Checks				
6	BAT 1155	2330	1	A 21	4075
7	A 21	2299	3	BAT 795	3664
Mean (n=14)		2098			3347
LSD.05		560			671
CV		15.9%			11.7%

Table 48. Average yield (kg/ha) of the red-mottled lines tested in Palmira, Colombia. 1985 IBYAN. Semester A.

Red kidney types warm climate			Red-mottled, med/large warm climate			Red-mottled, med/large medium climate			Red-mottled, small warm climate		
Line	Yield	%	Line	Yield	%	Line	Yield	%	Line	Yield	%
BAT 1297	2424	100	BAT 1297	2318	100	BAT 1297	2664	100	BAT 1297	2796	100
PVA 1145	1778	73	PVA 774	1936	84	PVA 1025	2032	76	PAI 43	2946	105
PVA 1117	1757	72	PVA 772	1834	79	PVA 386	1854	70	PAI 37	2865	102
PVA 1435	1749	72	PVA 1216	1828	79	PVA 508	1730	65	PAI 97	2850	102
PVA 1453	1726	71	PVA 475	1808	78	PAD 14	1723	65	PAI 105	2760	99
PVA 1095	1716	71	PVA 288	1806	78	PAD 13	1718	64	DOR 303	2732	98
Calima	1681	69	Calima	1688	73	Tundama	631	24	Calima	1549	55
Mean (n=20)	1611		(n=20)	1662		(n=18)	1643		(n=18)	2322	
LSD.05	211			261			299			425	
CV	7.8%			9.5%			11.0%			11.0%	

Table 49. Average yield (kg/ha) of a group of lines developed for the Mexican highlands tested in Palmira and Popayan. IBYAN 1985. Semester A.

PALMIRA			POPAYAN		
Rank order	Identification	Yield	Rank order	Identification	Yield
	Experimental lines				
1	ZAV 8306	2345	1	ZAV 8306	5086
2	BAT 1764	2323	2	ZAV 8314	4814
3	ZAV 8314	2294	4	MAM 11	4607
4	MAM 7	2286	5	MAM 7	4540
5	BAT 1763	2259	6	BAT 1764	4462
	Checks				
13	Canario 107	1436	3	Ojo de Cabra	4739
16	Ojo de Cabra	1087	15	Canario 107	2501
Mean (n=16)		1895			3916
LSD.05		300			621
CV		9.5			9.5%

Table 50. Average yield (kg/ha) of small shiny red seeded climbing beans for warm climates tested in CIAT-Palmira. IBYAN 1985. Semester A.

Rank order	Identification	Yield
	Experimental lines	
1	ACV 8326	4378
2	ACV 8363	4311
3	ACV 8329	4307
4	ACV 8311	4267
	Checks	
15	Comp. Alajuela	1381
16	Rojo 70	782
Mean (n=14)		3297
LSD.05		672
CV		12.1%

III. EVALUATION AND IMPROVEMENT OF AGRONOMIC PRACTICES

A. On-Farm Research

On-farm research achievements in the Bean Program in 1985 may be divided into: methodology adaptation; training; network establishment, technology development on-farm and technology adaptation to specific areas.

During the year from September 1984 - August 1985, 98 trials were planted by CIAT-ICA in the four work areas in Colombia (Table 1), and 126 trials were planted from August to December 1985 to initiate the 1985B planting. The increase in the number of trials planted in 1985B over 1984B reflects: (a) a greater number of trials under direct farmer management or in verification (extensive farmer participation); (b) the inclusion in the program of ICA activities previously planned separately; and (c) the return to planting in El Carmen in second semester (at present in October) due to the advance of 1 to 2 months each year in the planting date.

Methodology Adaptation

In the previous CIAT Bean Program Annual Report, results were presented to show the low or non-existent correlation between yields on the experimental station and farmers' fields of groups of 10 elite lines. Selection in La Selva experimental station for the relatively infertile area, San Vicente, is counterproductive. More good lines than bad are eliminated by further screening on the station. Even for the El Carmen municipality which has mean yields equal to or higher than the experimental station, some of the best lines for farms were eliminated by further selection on-station. In 1985, preliminary results became available from two years' work on other types of trials comparing station and farms, namely trials of advanced lines in Antioquia and of various agronomic practices in southern Nariño.

A low selection intensity of 50% in La Selva was reasonably efficient as preliminary screening of 43 advanced lines (F8 to 12), obtaining 9 of the 10 best for San Vicente and 7 for El Carmen (only two were common to both locations). More intense selection eliminated some of the best lines for farms. Selection on farms was more reliable in identifying the best lines for the next year on farms, despite considerable year to year variation. The selection of 132 F7 lines in La Selva on the basis of yield was of no use for El Carmen. The proportion of high yielding lines recovered was never greater than the selection intensity. F7 selections in farms of El Carmen in 1984B met with some success in El Carmen in 1985B. In particular, the two best F7 lines which were promoted to variety trials took third and fourth place among 24 lines. Together with two high-yielding promotions from the group of advanced lines, these were found to have acceptable seed type with a group of 16 farmers in El Carmen, and have now entered farm trials under farmer design and management.

In southern Nariño, copies of farm trials in Ipiales have been planted on Obonuco experimental station each year from 1982B to 1985B.

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Table 1. Number and type of trials planted on farms in different regions of Colombia 1984B & 1985A.

Type of trial	Eastern Antioquia (San Vicente) 1984B	Southern Nariño (Ipiales) 1984B	Central Nariño (Funes) 1984B	Northern Nariño (El Tambo) 1984B	Eastern Antioquia (El Carmen) 1985A
Variety					
Parents, segregating generations or advanced lines	3[a]	1	1	4	5
Bean varieties	4[a]	4[a]	4	3	3
Maize varieties	-	-	-	2	-
Exploratory trials	-	-	7[b]	3	6[d]
Determination of economic levels					
Variety x cultural practices	4	-	-	-	-
Variety x planting arrangement	-	3[a]	-	-	-
Seed and soil treatment	-	2	-	c	-
Fertilizer	-	3[a]	3	-	-
Intensification of cropping cycle	-	3[a]	-	-	-
Variety x Rhizobium inoculation	-	-	-	2	-
Verification	4	13[a]	-	-	-
Farmer-managed	-	11	-	-	-
TOTAL	15	40	15	14	14

a Copy of trial planted on nearby experimental station for comparison.
b Four in bean sole crop, three in bean/maize row intercrop.
c Included in another type of trial.
d 1 Carmen (relay), 3 in Marinilla (sole crop).

In the first year, the field proved highly atypical of the station conditions and the results were not used for station-farm comparisons. Results are now available from the subsequent two years and have led to these examples of differences between station and farms:

(a) The results from Obonuco suggested that neither beans nor maize would respond to nitrogen, whereas on farms there was a response in maize. The station results suggested that there would be no response to P in beans, but possibly in maize, whereas on farms the reverse was true: there was a response in beans but not in maize (Table 2).

(b) Station data supported the application of fertilizer below the seed at planting, instead of side-dressed at ridging up, as most farmers do. However, on-farms, application at planting was damaging in two dry years and markedly reduced bean yields.

(c) In trials of variety x planting arrangement, station data over-estimated the benefits of planting 2 maize and 2 bean seeds every 0.5m instead of 4 maize and 2 beans every 1m. However they underestimated the benefit on farms of planting 4 maize and 4 bean seeds every 1m. In the same trial, the three varieties were in a different order of mean yield on farms and on-station.

Work on methodologies for technology adaptation on-farm continued in Ipiales, Funes, El Tambo, San Vicente and El Carmen. It is expected, after four years work is completed with the harvests due in the first semester of 1986, that a detailed analysis can be undertaken of the experiences with the different strategies used in each area.

Table 2. Comparison of yields on station and farms.

Fertilizer applied kg/ha	Exp. Stn. Obonuco mean of 2 trials		Farms Ipiales mean of six trials	
	Beans	Maize	Beans	Maize
13 N[a]	866	2523	672	1837
39 N	898	2869	592	2282
65 N	844	2684	623	2836
11.3 P[a]	888	2544	572	2273
34 P	860	2618	611	2378
56.7 P	859	2916	705	2304
LSD (10%)	130	702	76	240

[a] Mean use by farmers in Ipiales.

Training

The year 1985 was important for the expansion of training activities in OFR. The second seven-week specialization in OFR was attended by 14 professionals from Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, the Dominican Republic, Colombia and Ecuador.

The first in-country course on OFR was initiated in Peru, with the presence of 25 researchers and extensionists from 11 different regional centres. In the first phase, during two weeks in February, participants carried out a survey of bean production in Chota, a major bean producing area in the mountains of the Cajamarca department. The survey was analyzed by the group, then problems and solutions were discussed. The solutions were screened for their ease of research, ease of adoption and potential benefit, in order to design farm trials with the most promising technology. Between phases, participants carried out these procedures in their own areas. In the second phase, of six days in October, participants planted in Chota the trials planned by the group. The diagnosis and trial plans were then presented by each participant for his or her own area and discussed by the group. Participants will now plant the trials planned for their own areas, supported by visits from INIPA and CIAT personnel, and return with data for the third and final phase in August 1986. The response of participants was excellent in that 24 out of 25 carried out the whole process of diagnosis and planning (the other resigned from INIPA). As a by-product, a total of 813 farmer questionnaires on beans have been executed in the three major ecological regions of Peru.

In Costa Rica a regional two-week course for Central America was organized by CIAT with CIMMYT and CATIE support. The course was of a new model with a special emphasis in on-farm variety testing. There were 11 participants active in the Pacifico Sur region of Costa Rica, and two each from Guatemala, El Salvador, Honduras and Nicaragua. The stages of diagnosis, screening of solutions, design of trials, planting, harvest and analysis were all included but in a more abbreviated form than usual. The course will be followed up for the Costa Rican participants by a second phase in June 1986 in which they present the results of the diagnosis conducted and the trials they have planned.

Considerable progress has been made this year with training materials, including different models of written "exploratory surveys" (developed by the Bean Economics section) and documents, slide sets and reading lists covering the most important parts of the OFR courses. These are now in the process of revision, based on the comments of course participants.

Network Establishment

A number of activities in which the program has participated have served to draw together institutions involved in OFR. There has been an active interchange of ideas and training materials with CIMMYT personnel. In addition to collaborating with CATIE on the OFR course conducted in Costa Rica, CIAT and CIMMYT OFR staff are working together

with (INIFAP) the Instituto Nacional de Investigaciones Forestales y Agropecuarias in Chiapas, Mexico. CIAT is initiating OFR support in beans to an on-going OFR project on maize between the other two institutions.

CIAT has also collaborated with a number of other institutions, especially CIMMYT and IDRC, which are supporting a new project in OFR planned by ICA, Colombia.

Technology Development On-Farm

Two activities conducted with ICA in farmers' fields in Colombia are exploring the necessity of moving some types of technology development off-station. Apart from the testing of large numbers of advanced lines on-farm, selection in segregating generations on-farm has also been continued in background studies. In a different line of work, to support the Bean Microbiology section, research on the advantage of inoculation with Rhizobium has been expanded to Ipiales, having commenced in El Tambo in 1984B. Soils and bean plants are being studied in all three work areas of Nariño in order to determine the effectiveness of native strains.

Technology Adaptation to Specific Areas

The identification of technologies for specific areas is not the principal reason for the program's involvement in OFR. The intensive work with ICA in Colombia over the last three years is, however, producing results which confirm the effectiveness and speed of OFR in identifying technologies suitable for farmers and initiating their adoption.

In 1985, two varieties were released by ICA as a direct result of recommendations derived by ICA-CIAT on-farm research. Ecuador 605 was released as Frijolica 0-3.2 for cold climates (2400-2850 masl), especially in southern Nariño, and La Selva 1 was released as Frijolica LS-3.3 for moderate cool climates (1700-2600 masl), especially in eastern Antioquia. Both lines had proved stable across a wide range of environments and management conditions within their target areas, as have been described in previous annual reports. In the case of Frijolica 0-3.2, ICA's decision to release the variety was influenced by farmers' adoption before its release. After the second year of trials, in June 1984, 20 farmers requested seed from ICA, others saved trial borders. Apart from those involved in trials, at least 40 farmers planted Ecuador 605 on a semi-commercial or commercial scale in 1984/85 and it is estimated that at least 60 had sold seed by July 1985, reporting little or no price discount (see Economics section of this report for further details). Two field days in June and August 1985 distributed seed samples of 1 kg to a further 160 farmers after release. Commercial plantings were damaged in some areas by a severe frost in October 1985 immediately after planting, but it is still believed that the spread of the variety Frijolica 0-3.2 will proceed rapidly.

Frijolica 0-3.2 is only part of a flow of elite lines from Obonuco station to Ipiales, facilitated by four variety trials per

year and, since 1983B, by on-farm nurseries of advanced lines. Thus (Table 3), some lines or varieties reached verification and were found unsuitable for promotion in the area (Llanogrande and 32980-1-41), another (Potosi 1) did not reach verification because it was no more tolerant of root rots than Frijolica 0-3.2 and was susceptible to anthracnose, while another (TIB 30-42, an early anthracnose resistant line) is in verification and is expected to pass to farmer-managed trials in 1986.

The flow of technologies from Obonuco station to Ipiales has not been confined to varieties. Table 4 shows the progress of a number of other promising technologies. Foliar application of benomyl is now included farmer-managed trials after two years in verification (in the first year there were doubts about its profitability which were resolved in the second year). Increasing bean density by planting at 0.5m in the row was agronomically and economically promising but received poor evaluations from farmers in the verification stage. A revised technological alternative (3 maize, 3 beans every 0.8m) was apparently acceptable when tested in small-plot trials in 1984/5 and is now in verification. Increased fertilizer doses and a change in maize variety are also in verification for the first time in 1985/86.

Groups of verification trials have been planted in all the other work areas in 1985B and a number of technologies are expected to be ready for farmer-managed trials and/or demonstration in 1986. It has proved difficult to identify materials clearly superior to Nima in El Tambo without losing seed quality or those for Funes which yield a similar amount to Argentino but which have seed of higher consumer preference and value. In 1984B, the series 25 EP (medium and large

Table 3. Movement of promising lines from year to year in the Ipiales district, Colombia.

	Number of trials with the line included					
	Before 1981	1981-2	1982-3	1983-4	1984-5	1985-6
ICA Llanogrande	30 in eastern Antioquia	2	10V[a]			
Frijolica 0-3.2		2	14	32V	40VM	47VM
32980-1-41		2	4	8	16V	5
Potosi 1			1	8	12	
TIB 30-42				4	12	25V
V 8001-47					1	8

[a] V: Included in verification trials

M: Included in farmer-managed trials

seeds only) was planted in El Tambo on three farms as well as the VEF (two reps on one farm). This was repeated in 1985B on three farms each for EP and VEF in both El Tambo and Funes. From this major effort it is hoped to speed up the identification of materials suitable for farms of the drier, less fertile parts of the Colombian medium altitudes (1000-2200m), an area of great importance in bean production which is not well represented by present experimental stations of CIAT or ICA.

Table 4. Movement of other technologies from year to year in farm trials in the Ipiales district, Colombia.

Technology	Number of trials in which included				
	Before 1982	1982-3	1983-4	1984-5	1985-6
Addition of benomyl to farmer disease control	Successful in eastern Antioquia	6	12V	12V	8M
2 maize, 2 bean seeds every 0.5m	Successful in eastern Antioquia	6	12V	4	
3 maize, 3 bean seeds every 0.8m				4	15V
Increased use of fertilizers		4	4	4	14V
MB 521 maize		OBSN[a]	4	4	15V
Pool 7 maize				4	4

[a] V: Included in verification trials

M: Included in farmer-managed trials

OBSN: Observation in non-replicated plots

B. Economics

Economics research in 1985 focused on production studies, marketing studies, and training. Production studies identify farm level constraints, evaluate new technologies as solutions to these constraints and assess the adoption of new technologies. Marketing studies are crucial in Latin America because most beans are produced for the market, making consumer acceptability, price and ease of market entry critical factors in farmers' adoption of new varieties. Much of the research on these issues is conducted in collaboration with national programs, and strengthening their research capacity through training and joint projects is a major objective.

Production Studies

A variety of production studies were conducted in 1985 (Table 1). Rapid appraisals, exploratory surveys and cost studies identify constraints by generating information on farmer production problems, resources, and objectives. New technologies are evaluated through analysis of profitability and also by direct feedback from farmer users of new technologies under trial. Adoption surveys measure the spread and impact of technologies after release by national programs. While each type of study has its particular focus, any study may serve multiple objectives. For example, an adoption survey can be used to define continuing production constraints.

Rapid appraisals

Jointly with an EMBRAPA-CNPAF economist and in collaboration with various state research institutes, informal interviews were conducted with farmers in major bean regions in Espiritu Santo, Goias, Minas Gerais and Santa Caterina (Brazil) to obtain an initial impression of the acceptability and adoption of recently released improved bean varieties. Major contrasts seem to exist between states in adoption of new varieties, and possible means for understanding the reasons for these differences are being explored in collaboration with CNPAF.

A rapid appraisal in Honduras confirmed that market access has been an important obstacle to the use of the new variety, Acacias 4, and further studies are being planned in collaboration with SRN.

Exploratory studies

In order to orient the design of INIPA on-farm trials of new bean technology, 140 farmers were surveyed in Chota, Peru, as part of a course in on-farm research. The results, analyzed in collaboration with an INIPA economist, show that varietal improvement is likely to be the most promising strategy in the short run (Table 2). Beans are primarily a subsistence crop in this highland zone, as well as being secondary to maize and potatoes. Consequently, capital is a severely limiting constraint on many possible intensifications of management. Assessment of the opportunities for fomenting the commercialization of beans is almost a precondition to considering many changes in cultural practices. INIPA personnel trained in this course subsequently conducted exploratory surveys in their regions of responsibility, thereby

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Table 1. Production research activities with CIAT bean economics involvement, 1985

Activity	Objective	Collaborative projects 1985
Rapid appraisal	Obtain initial view of production situation to orient future research.	Brazil Honduras
Exploratory survey	Characterize bean production system and problems. Identify constraints.	Peru Guatemala Dominican Republic Colombia Argentina
Cost studies	Derive cost data	Costa Rica Colombia Guatemala
Farmer evaluations	Obtain farmer opinions of trial technologies.	Colombia Guatemala
Adoption studies	Measure adoption. Identify constraints. Assess socio-economic impact.	Argentina Costa Rica Guatemala

Table 2. Principal problems, some potential solutions and limiting resources identified in exploratory study, Chota, Peru, 1985.

Problems	Potential solutions	Limiting resource
Drought	Improved varieties	-
Foliar disease	Improved varieties	-
	Fungicides	Capital
Low density	Plant in furrows	Labor
	Plant more seed	Seed
Poor seed quality	Chemical treatment	Capital
	Seed selection	Labor
Fertility	Chemical fertilizers	Capital

generating information on bean production systems throughout Peru. These data are still being analyzed.

In Guatemala, bean production in Peten has risen rapidly so that it is now the second most important bean producing department. To improve understanding of bean production in Peten, in collaboration with ICTA, an exploratory survey was conducted. It found little use of improved varieties, but the most common local cultivars originate from the southeast, suggesting that improved varieties originally selected in the southeast (eg.Tamazulapa), should have a high probability of being adapted in Peten. As a result, on-farm trials of improved bean varieties are being initiated in Peten.

An exploratory survey, yet to be fully analyzed, was also conducted in 1985 with the collaboration of CESDA and CENDA in three bean production regions in the Dominican Republic. A study characterizing Argentine bean production systems was carried out by an EEAOC economist as a by-product of an adoption study.

As part of a course in on-farm research, an exploratory survey was conducted in San Vicente, Antioquia, Colombia. It found that the strong tendency for bean farmers to shift out of relay cropping to climbing beans in monoculture, observed in a 1984 exploratory survey in nearby Marinilla, is also true in a more marginal area. A special study of alternative bean cropping systems in Antioquia found that climbing bean monoculture on artificial support is far more profitable than maize-bean relay. Bean yields go up as density is increased, and it is possible to take two bean crops annually. Thus, on-farm research in eastern Antioquia should include research on the increasingly important monoculture system as well as on the traditional maize-bean relay.

Cost studies

Several studies of costs of production were undertaken over a wide variety of production systems from traditional shifting cultivation to input-intensive climbing beans on artificial support (Table 3). Returns tended to be high in Colombia due to a strong bean price in early 1985. For example, the highly preferred Cargamanto bean of Antioquia was valued at $1.29/kg, compared to $0.14/kg for black beans in Guatemala.

The cost studies were conducted for a number of purposes. In Antioquia the objective was to better understand the recent tendency to shift away from maize-bean relay to climbing beans in monoculture. Clearly, the monoculture system generates higher returns to all factors for those who have sufficient capital to switch to this system. In Caldas, Colombia, costs and returns to farmers growing the new variety BAT 1297 were studied in collaboration with FEDECAFE. It was found that at then prevailing prices, BAT 1297 was highly profitable for farmers, especially when intercropped with coffee and when agrochemicals were utilized. The cost study in Costa Rica, a by-product of an adoption survey done in collaboration with the University of Costa Rica, found that the traditional broadcast system (tapado) is less profitable than the newer more intensive planted system except where the cost of land is low.

Farmer evaluations

While statistical and economic analysis of trial results help identify promising new technologies, the inclusion of farmers as active participants in the evaluation process as soon as possible is vital, because their evaluation criteria may differ from those of economists or breeders.

In collaboration with ICA, on-farm trials have been conducted in southern Nariño, Colombia, since 1982 testing the line E-605. In 1985, interviews were conducted with 38 farmers with experience in growing the new line, since released as Frijolica 0-3.2. Farmers reported an average yield gain of 100 kg/ha with the new variety, and this datum was confirmed by crop cuttings taken in commercial plots. Besides yield, farmers commented favorably on the new line's earliness (2-3 weeks earlier than traditional cultivars) and disease resistance. Farmers are cultivating Frijolica 0-3.2 with the same management practices as they have utilized with local varieties. The new line

Table 3. Costs and returns of commercial bean production in selected Latin American production systems, 1985

Location	System	Labor (days/ha)	Agrochemicals ($/ha)	Total costs[a] ($/ha)	Yields (kg/ha)	Net returns[b] ($/ha)	Net return to capital (%)	Net return to labor ($/day)
Antioquia, Colombia	Climbing beans relayed with maize	110	265	680	1212	370	54	3.36
Antioquia, Colombia	Climbing beans on trellis	124	475	1041	1952	1470	141	11.85
Peten, Guatemala	Shifting cultivation Slash and broadcast	34	0	46	699	54	117	1.59
Caldas, Colombia	Bush beans[c] intercropped with coffee	40	35	327	801	445	136	11.13
San Isidro, Costa Rica	Bush beans[d] monoculture	60	78	276	929	416	151	6.93

a Opportunity costs. Excludes land.
b Net returns to owned factors.
c BAT 1297
d Talamanca (ICA 10103).

has encountered no difficulties in market access, though when sold without mixing with the local variety, the practice of most farmers, there was an average price discount of 6.5% compared to the price of traditional varieties.

In the department of Caldas, Colombia, FEDECAFE has been promoting the cultivation of BAT 1297 intercropped with coffee that is being pruned. This novel system permits farmers to obtain a harvest while their coffee is out of production. Interviews were conducted with 44 commercial growers of BAT 1297 to obtain farmer opinions of the new line. Some 76% of the farmers reported they obtained improved yields with the new line; 20% noted improved disease resistance and 86% planned to continue growing BAT 1297. However, only 14% of those satisfied with the new line's productivity would grow it for on-farm consumption, thus indicating the importance of market access for BAT 1297 (see discussion on marketing below). This finding contradicts previous conceptions that the line might have a role in subsistence production in the coffee zone.

Adoption studies

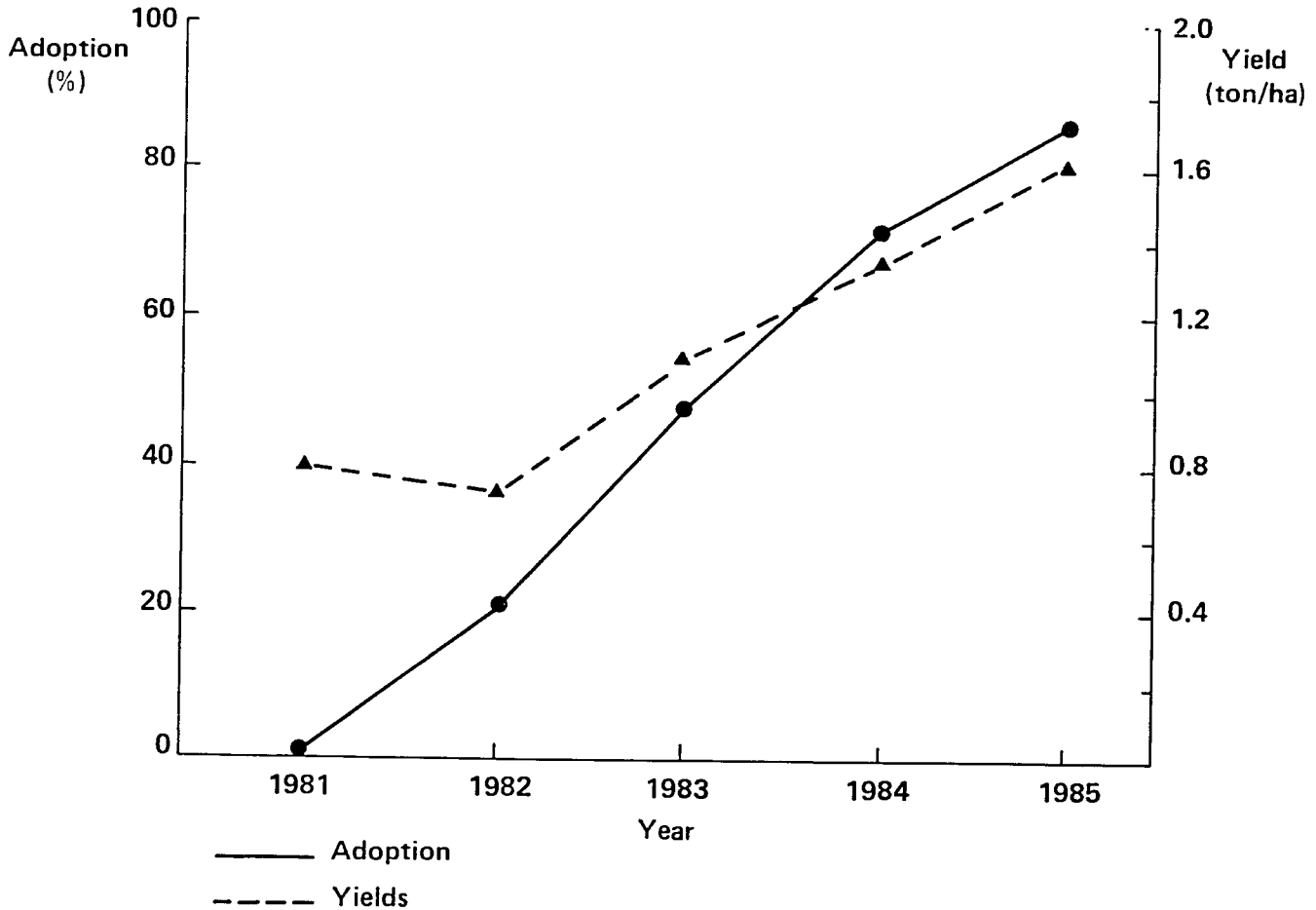
In 1985, an EEAOC economist analyzed the results of a survey of a 15% sample of Argentine bean farmers to measure the adoption of new black bean varieties (DOR 41, BAT 448, BAT 304). Adoption has been rapid, rising from no commercial use of new varieties in 1981, to an estimated 85% in 1985 (Figure 1). Parallel with this rapid adoption, available published data show a steep climb in black bean yields. While not all of this yield increase can be attributed to the improved varieties, survey farmers reported an average yield increase of some 292 kg/ha with the new varieties as compared to traditional black varieties.

The net benefits to farmers of replacing traditional varieties with improved ones, is estimated at US$2.5 million for 1985. Based on the full costs of INTA and EEAOC bean research from 1976 - 1985, net benefits accrued through 1985 earned a 40.1% internal rate of return to investment in Argentine bean research.

Because black bean consumption in Argentina is practically nil, benefits to Argentina are captured by producers. Up to 40,000 tons of black beans were exported by Argentina to Mexico in 1985, while substantial quantities of black beans are believed to have entered Brazil through unrecorded channels. The impact of improved Argentine bean productivity on ultimate bean consumers in Mexico and Brazil, as well as on bean farmers in these countries, is yet to be assessed.

In Costa Rica, interviews on varietal adoption were carried out with 160 farmers in the South (Perez Zeledon and Buenos Aires) and 120 farmers in the North (Upala- Los Chiles). These two regions contribute slightly more than half of the Costa Rican bean production. In the South in 1985, 52% of farmers grew the new varieties, Talamanca (ICA 10103) or Brunca (BAT 304), on 67% of the black bean area, while in the north 43% of farmers cultivated the new varieties on 63% of their area.

Figure 1. Adoption of improved Black Bean Varieties and Black Bean Yields, Argentina 1981-85.



Source: Survey (adoption); Michigan Bean Digest (yields).

Farmers growing Talamanca cited yield and upright architecture as its most positive features, while those using Brunca mentioned yield and earliness most often. The most frequently noted problem with Talamanca is anthracnose (29% of farmers in the north), while many farmers found fault with Brunca's prostrate architecture. Nevertheless, over 90% of the farmers adopting the new varieties plan to continue planting them. Talamanca is the more frequently grown of the two varieties while Brunca is in an earlier stage of diffusion and may yet achieve greater spread than it already has.

Across various regions and crop cycles, farmers report higher yields with the new varieties both when beans are planted with digging stick (espequeado), and also in the broadcast tapado system (Table 4). In espequeado the improved varieties outyield the locals by an average of 46.1% or 307 kg/ha, while in tapado they outyield the local varieties 23.1% or 108 kg/ha. The clear superiority of the new varieties in espequeado is such that in the South 83% of the area in this system is now planted with improved varieties. In contrast, in tapado improved varieties account for 54% of area cultivated.

A survey of adoption of new varieties in Guatemala was also conducted in 1985, and analysis of these data is just beginning.

Marketing studies

Since most beans in Latin America reach the consumer through the market, consumer preferences, market structure and demand can all be important influences conditioning the chances of success of new varieties.

Table 4. Farmer yields with improved and local black bean varieties, by system and season, Costa Rica.

System	Region	Cycle	Yield Improved (Kg/ha)	Yield Local (Kg/ha)
Planted or Espequeado	South	1982B	662	575
	South	1983A	977	616
	South	1984B	1129	848
	North	1984/85	1124	625
	Average		973	666
Broadcast or Tapado	South	1981B	435	319
	South	1982B	543	403
	South	1984B	584	589
	North	1984/85	738	555
	Average		575	467

Source: Chapman et al; Ballestero; CIAT survey data.

Dominican Republic

Promising varieties have been subject to stringent selection criteria with respect to color and grain type which have led to much high yielding material being eliminated as unacceptable to consumers in the Dominican Republic. These grain type criteria, however, were based on informal notions, and not on a systematic assessment of market requirements and consumer preferences.

Interviews with nearly 100 bean traders and some 60 housewives in 1985 made clear that grain types other than that of the traditionally preferred Pompadour class are accepted in the market. Not only do Dominican consumers regularly purchase white beans and black beans, but non-Pompadour types are easily accepted. At the moment, the most preferred bean type is an imported Pinto, which is esteemed both for its quality and lower price.

Because Dominican housewives in general neither soak beans before cooking nor utilize pressure cookers, freshness and associated short cooking time are the principle components of quality. Consumers judge freshness largely by color, accepting only beans that are mottled with white spots. Darker spots are associated with old beans that are hard to cook. Evaluations of promising CESDA-CENDA lines by bean traders and housewives indicate the importance of size and color (Table 5), and such evaluations of market acceptability can be taken into account in varietal release decisions.

Colombia - hedonic model

Because the price offered in the market for grain types of new varieties is a major factor in their profitability for farmers, the determinants of price differences among grain types continue to be studied intensively. A hedonic price model in which price is regressed on grain characteristics - size, color and form - was estimated from combined Cali data from 1983 when bean prices were fairly normal, and 1984 when real prices were higher. The model gives satisfactory predictions of observed price differentials between commercial varieties in the two periods, with a mean absolute deviation of 3.7 between predicted and actual percentage price discounts.

Observed price differentials between commercial varieties were less in the high priced market of 1984 than in 1983, and similarly the model indicates that price discounts for new lines are less in a tight market (Table 6). Narrowing price differentials are consistent both with a greater inelasticity of demand for less preferred beans so that their price varies more with a supply change than that of preferred beans, and also with a substitution effect out of preferred beans as prices rise.

Thus, theory and empirical evidence are consistent with the common sense observation that consumers are less fastidious about bean quality characteristics when prices are generally high. The hedonic model now permits an estimation of price discounts for new grain types under varying market conditions.

Colombia - BAT 1297

BAT 1297 has consistently obtained superior yields in regional trials conducted with FEDECAFE and its performance in commercial production was also confirmed this year. However, despite an acceptable color, the variety's small seed size was expected to lead to a substantial price discount compared to other commercial varieties, and perhaps even prevent commercial acceptability.

Table 5. Consumer and bean trader evaluations of acceptability of grain types of promising CESDA-CENTA/CIAT lines, Dominican Republic, 1985.

Acceptability	Line	Color	Size (g/100 seeds)
Very good	PC 50[a]	Bright red, white spots	42.7
Very good	PAD 43	Bright red, white spots	46.0
Very good	ZAA 84001	Bright red, white spots	49.0
Very good	ZAA 84066	Red, white spots	50.0
Acceptable	DOR 198	Dark red, white spots	48.0
Acceptable	MCD 251	Purple, pink spots	40.0
Acceptable	BAT 1412	Red, yellow spots	41.5
Acceptable	ZAA 84095	Red, yellow spots	53.0
Poor	RIZ 30	Red, yellow spots	27.0
Poor	PAT 8	Redish coffee, yellow spots	28.0
Very poor	PAT 11	Pale red, yellow spots	30.0
Very poor	PAD 41	Red maroon, yellow spots	43.0
Very poor	PAT 9	Pale red, yellow spots	32.0
Bad	PAT 6	Pale red, yellow spots	27.0

[a] Local check (selection of cv. Pompadour)

Table 6. Hedonic model estimated price discount (%) for new lines in comparison to commercial varieties in differing market conditions. Cali, Colombia.

New variety	Discount (%) with weak prices	Discount (%) with high prices	Commercial comparison
BAT 1297	21.7	12.4	Rojo Americano
Frijolica 0-3.2	6.7	1.8	Mortiño
ICA L-23	10.3	5.9	Calima
Frijolica LS 3.3	4.2	2.5	Cargamanto

In a test market program the supermarket chain MERCALDAS sold BAT 1297 in Manizales at prices 20-35% lower than the cheapest alternative bean in the market. In the study period of July 1985, BAT 1297 was the biggest selling bean, taking a 37% market share. This suggests that a low priced bean can penetrate the market, even when it does not meet traditional concepts of market requirements. Obviously, the viability of such a strategy depends on the relative proportions of productivity increase versus price discount. In this particular case, the cost of production study indicated that even at the lower end of the price range tried in the test marketing, BAT 1297 would be quite profitable for most growers.

Training

Training in economics emphasizes learning by doing through collaborative projects. Visiting economists from Argentina, Costa Rica, Mexico and Peru received such training at CIAT, Palmira. Training in survey techniques, survey analysis and economic analysis of trial results formed a major part of courses in on-farm research in Costa Rica, Colombia and Peru, while these subjects were presented in less detail in production courses in El Salvador, Honduras, Peru and Costa Rica.

IV. SCIENTIFIC TRAINING AND NETWORK ACTIVITIES

A. Training

Introduction

Training of technicians in the evaluation and testing of new advanced lines at headquarters continued as the principle objective of the scientific training section. Considerable progress has been made recently and in collaboration with national institutions in the search of improved germplasm. In the initial stages of this search, for example, with respect to the collection of new germplasm, CIAT has the greater responsibility. But some intermediate stages of the process are being carried out successfully directly in the countries, by national technicians who have been trained at CIAT.

The evaluation and testing of this promising germplasm from the intermediate stage of the process under local conditions facilitates the rapid advance of selected lines. On the other hand before the release of a new variety, the advanced lines should be tested directly on farmers' fields in their cultivation systems. For this reason, considerable emphasis is now being given to training in on-farm research and crop systems. For the first time, CIAT collaborated directly in the countries with courses oriented toward these topics. These courses were carried out in Peru and Costa Rica. The support given to 200 professionals (Table 1) through nine courses carried out in Argentina, Chile, Costa Rica, Peru, Honduras and Colombia demonstrate the continued tendency to support training activities directly in the countries. This situation is directly related to the release of new varieties in the countries since one of the principle focuses of the courses constitutes the presentation and recognition of the agronomic characteristics of these new varieties and their extension. On the other hand the interchange of experiences of the participants in these activities facilitates a redefinition of problems, priorities and methodologies. A specific case with respect to priorities is the slow movement in several countries among farmers of the seeds of new varieties. The redefinition of the high priority of this problem indicates the urgent need to program activities to promote seed production.

With respect to methodological aspects of training, the following has been done recently:

(a) Improve mechanisms so that participants can rapidly focus on their objectives and activities of training (see Figure 1). The application of the "focused and unfocused" methodology in the course has improved the satisfaction and academic levels of the participants to procure a rapid adjustment between the expectations of the participants and the organizers.

(b) More stringent course requirements and a better academic level as the courses acquire a "pass-fail" nature rather than a "participatory" character.

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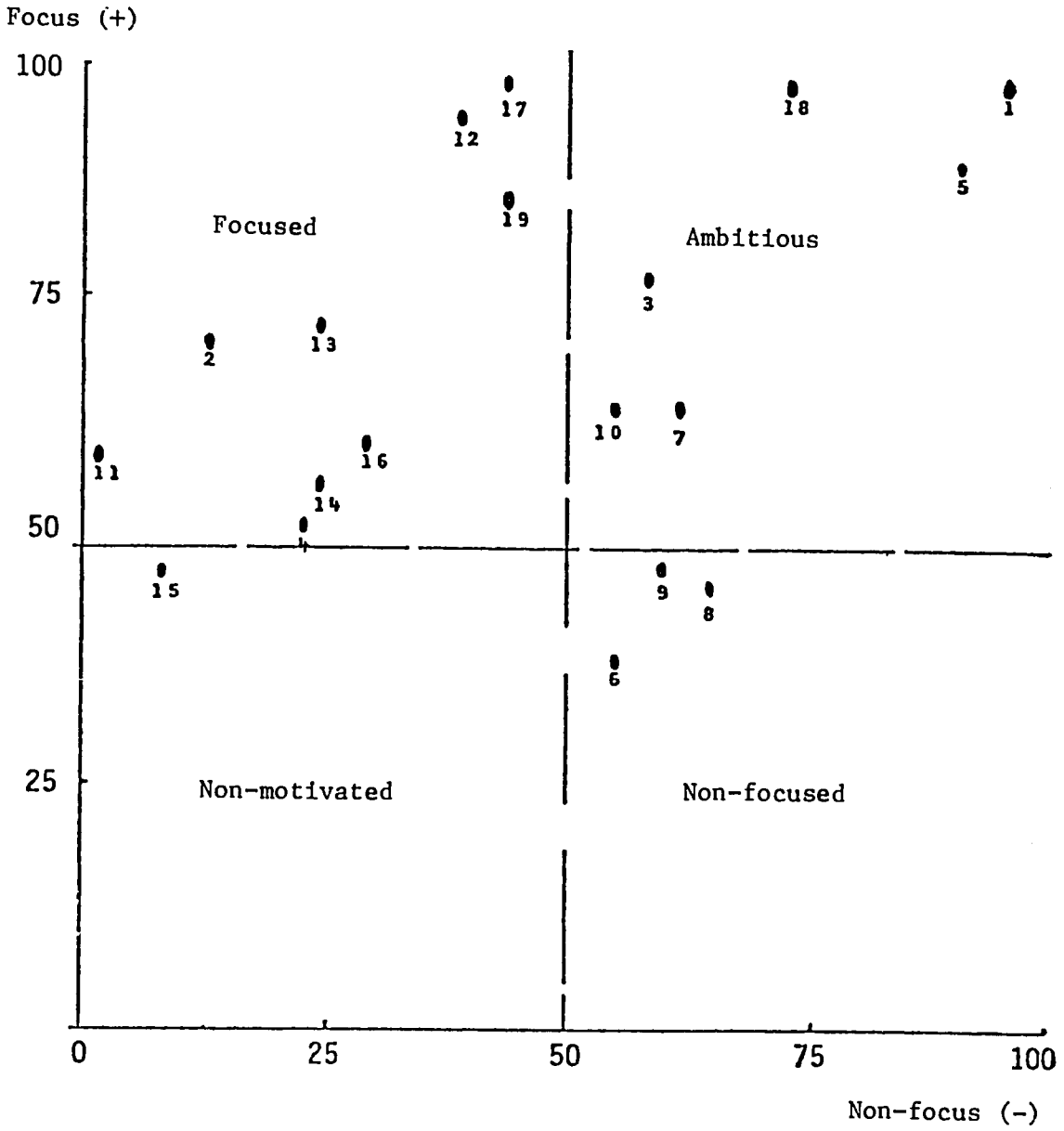
Table 1. Nature and emphasis of the courses carried out in 1985. (The course on On-Farm Research in Peru has three phases of which phases I and II were carried out in 1985.) The course for Non-formal Seed Production was carried out in collaboration with the CIAT Seed Unit.

COUNTRY	NATURE AND ENPHASIS OF THE COURSE	COLLABORATING INSTITUTION	NO. OF PARTICIPANTS
1. Argentina	National : production	Est. Obispo Colombres	20
2. Colombia	National : non-formal seed production	ICA	14
3. Costa Rica	International : production	MAG, U de CR, CNP, ONS	32
4. Costa Rica	International : on-farm research	CATIE, CIMMYT	18
5. Chile	International : production	INIA	22
6. El Salvador	National : production	CENTA	28
7. Honduras	National : production	Sec. Recursos Naturales	21
8. Peru	National : on-farm research phase I-II	INIPA	25
9. Peru	National : production	INIPA	20
		SUB-TOTAL	200
10. Colombia	International : XII intensive phase		21
		TOTAL	221



Graph 1. Gradient of "focus and non-focus" of the participants in the XII Multidisciplinary Intensive Phase. This is measured on the first day of the course. In the "focus" cuadrant are found those individuals whose expectations are similar to the objectives established for the course. Each number represents an individual. The application of this methodology should facilitate the movement of ambitious, unmotivated or nonfocused individuals into the "focused" cuadrant.

(c) A substantial increase in the follow-up and support of the course participants. This has been achieved through the programming of training activities in "phases" which are carried out on different dates, with each phase having a specific program of activities, a program which is reviewed, evaluated and adjusted in the following phase.

(d) Have complete or advanced editions or revisions of the audiotutorial units.

(e) Have a complete training manual for beans.

Achievements

The efforts of the bean scientific training section during 1985 has facilitated the following activities at CIAT headquarters as well as in the countries:

- Increase the contribution to the development of the scientific leadership in the national institutions. The support for research projects has been increased pursuant to academic degrees such as Ph.D. and M.S. (Table 2).

- Continue the decentralization of training activities through greater support and greater number of courses in countries.
  In 1985 (Figure 2) more courses were hosted in the countries (9), participants (200). Off CIAT headquarters, three international courses were carried out, one in Chile and two in Costa Rica. This has been feasible through the availability of a great number of trained professionals and also through the availability of training materials such as audiotutorials. Figure 2 and Table 1 present cuantitative evidence of the number of participants in the course, their countries and the number and location of these courses.

- Continue the training of national technicians who could advance the search for new varieties in their respective countries.

- Reinforce the network of crop researchers and their channels of communication.

Training in CIAT

Table 2 indicates the number and quantity of man/months corresponding to professionals trained by countries and by training category. A total of 59 professionals came to headquarters for their training. The countries which received principle attention were: Guatemala (six researchers for 22.6 M/M), U.S.A. (three researchers for 21.5 M/M) and Peru (five researchers for 18.1 M/M).

Table 3 describes the training by discipline and training category. Greater emphasis was placed on the following disciplines: breeding and farming systems. Four visiting researchers did their theses for their Ph.D. and six for their M. S.

Table 2. No. of professionals trained at CIAT and man/months, by training category in their country of origen, during 1985.

Program: Beans	Training category: Visiting research associate				Visiting research						Student		Intensive multidisciplinary course		Sub-totals	
	PHD Thesis		No. Thesis		M.S. Thesis		Specialization		Specialization plus intensive multidisciplinary course							
	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months
Latin America and the Caribbean																
Argentina							1	(2.2)							1	(2.2)
Bolivia									1	(4.3)					1	(4.3)
Brazil							1	(0.8)					2	(2.2)	3	(3.0)
Chile					2	(5.9)									2	(5.9)
Colombia							2	(3.0)					3	(3.3)	5	(6.3)
Costa Rica							2	(2.5)	1	(1.2)					3	(3.7)
Cuba							1	(3.1)							1	(3.1)
Ecuador							1	(1.5)	1	(2.7)					2	(4.2)
El Salvador					2	(9.4)			2	(5.4)					4	(14.8)
Guatemala					1	(6.2)	2	(3.4)	2	(8.0)	1	(5.0)			6	(22.6)
Honduras							1	(1.5)	1	(5.2)			1	(1.1)	3	(7.8)
Mexico							2	(2.8)	3	(8.6)			3	(3.3)	8	(14.7)
Nicaragua									2	(7.5)					2	(7.5)
Peru							4	(12.9)	1	(5.2)					5	(18.1)
Dominican Republic							1	(1.3)							1	(1.3)

(Continued)

Table 2 - (Continuation)

Program: Beans	Training category															
	Visiting research associate						Visiting research						Student		Intensive multidisciplinary course			
	PHD Thesis		No. Thesis		M.S. Thesis		Specialization		Specialization plus intensive multidisciplinary course								Sub-totals	
	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months
Other countries																		
Asia																		
Turkey							1	(3.3)									1	(3.3)
Africa and Oceania																		
Burundi							1	(0.8)									1	(0.8)
Rwanda							1	(3.7)									1	(3.7)
Uganda							1	(4.0)									1	(4.0)
Developed countries																		
Germany	1	(12.0)															1	(12.0)
Belgium			1	(12.0)													1	(12.0)
Canada					1	(2.9)											1	(2.9)
U.S.A.	2	(18.8)					1	(2.7)									3	(21.5)
Holland							1	(12.0)									1	(12.0)
United Kingdom	1	(4.5)																
Total for program	4	(35.3)	1	(12.0)	6	(24.4)	24	(61.5)	14	(48.1)	1	(5.0)	9	(9.9)	59	(196.2)		

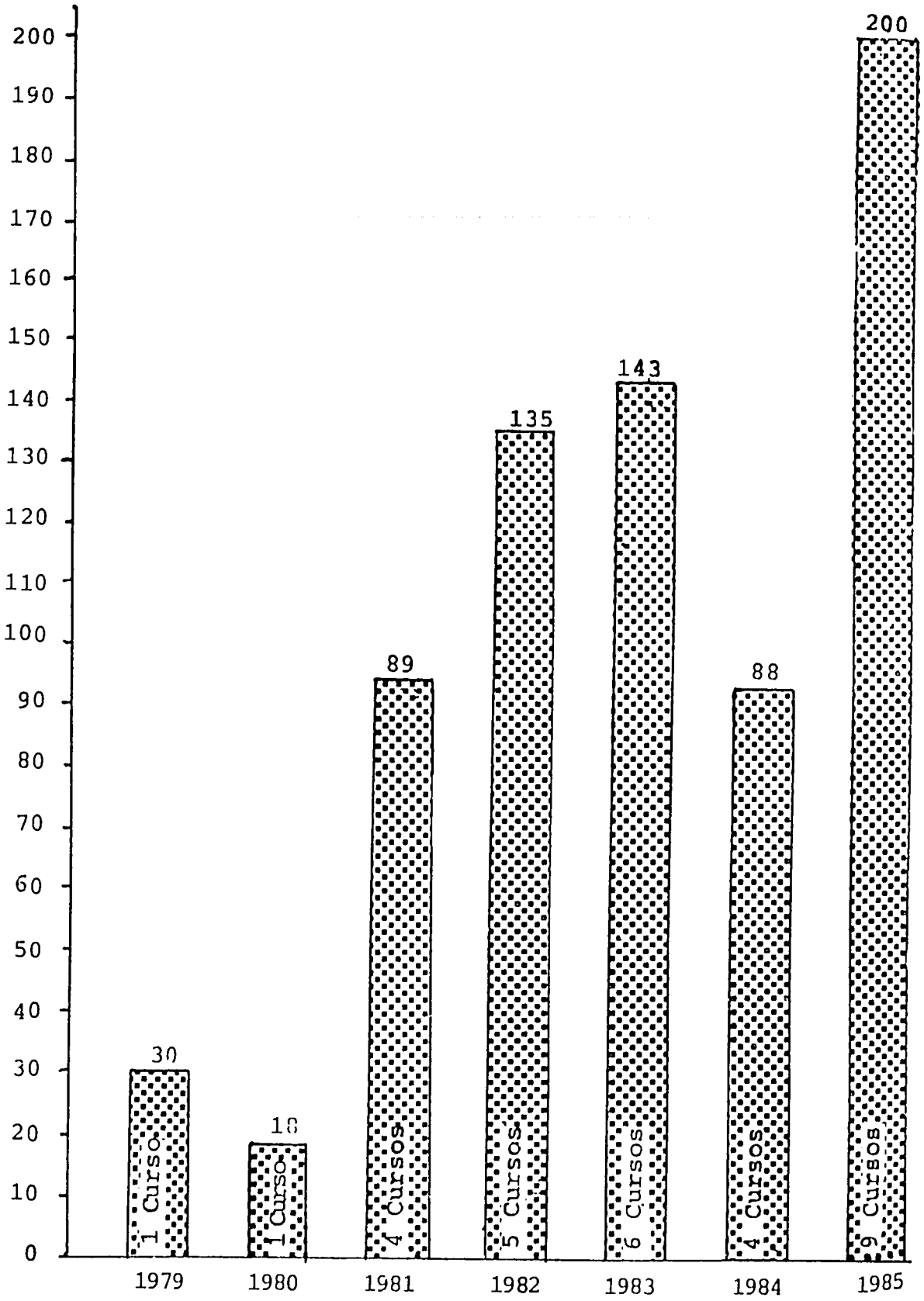


Figure 2. No. of professionals trained in in-country courses.

Table 3. Professionals trained at CIAT by program or unit, discipline during 1985.

	Training category											
	Visiting research associate				Visiting research				Student		Intensive multidisciplinary course		
Program: Beans	PHD Thesis		No. Thesis		M.S. Thesis		Specialization		Specialization plus intensive multidisciplinary course				Sub-totals	
	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months	No.	Months
Disciplines:														
Agronomy					1	(3.0)	3	(9.2)	1	(1.2)			5	(13.4)
Economy					1	(2.9)	5	(19.5)					6	(22.4)
Farming systems					2	(5.9)	7	(10.3)	6	(15.8)			15	(32.0)
Physiology	1	(4.5)							1	(5.2)			2	(9.7)
Fitomejoramiento	1	(12.0)	1	(12.0)	2	(12.6)	4	(8.5)	3	(13.3)	1	(5.0)	12	(63.4)
Phytopathology							4	(12.1)	2	(8.3)			6	(20.4)
Soil microbiology	1	(10.9)											1	(10.9)
Seed production	1	(7.9)							1	(4.3)	9	(9.9)	9 (9.9) 2	(12.2)
Virology							1	(1.9)					1	(1.9)
Total Program	4	(35.3)	1	(12.0)	6	(24.4)	24	(61.5)	14	(48.1)	1	(5.0)	9 (9.9) 59	(196.2)

The XII Intensive Multidisciplinary Research course for Bean Production was carried out with 21 participants.

Table 4 summarizes the participants trained in 1985, their countries and institutions.

In-country Courses

Some 200 professionals participated in the courses which were carried out in Argentina, Colombia, Costa Rica, Chile, El Salvador, Honduras and Peru.

Workshops

From the 18-27 of November, a workshop was carried out on bean breeding with emphasis on tolerance to drought with the participation of seven brazilian researchers. In addition, seven researchers collaborated in the presentation of the internal seminars. In addition, several workshops were carried out not only in Latin America but in Africa as well.

Table 4. List of course participants

Latin America and the Caribbean			
Argentina			
Garguiulo	Carlos Arturo	Estex Agrin Obp Colombres	Economics
Bolivia			
Lenaz	Lucio	Inst Inv. Agr. El Vallecito	Seeds
Brazil			
Braga	Luis Osmar	Un. Fed. de Pelotas	Production
Resende	Humberto	Emater-Mg	Production
Felix Da	Costa Antonio	Emp. Pernambucana Agrop.	Phytopathology
Chile			
Tapia F	Francisco A	Inst Inv Agropecuarias	Farming systems
Tapia F	Francisco	INIA Chile	Farming systems
Colombia			
Arcila G	Maria Belen	ICA Colombia	Farming systems
Franco	Tito Livio	CIAT Colombia	Production
Melo	Marco Antonio	ICA Colombia	Farming systems
Ochoa C	Ivan Erick	CIAT Colombia	Production
Rodriguez	Carlos E.	ICA Colombia	Production

Costa Rica

Ballestero	Maureen	Ministerio Planificación	Economics
Elizondo	Dagoberto	Min Agric. Gan C. Rica	Agronomy
Ledesma A	Eduardo	Consejo Nal de Prod. C.Rica	Farming systems

Cuba

Garcia A	Evelio Juan	Subest Exp de Granos	Breeding

Ecuador

Ceballos N.	M. Edmundo	INIAP Ecuador	Farming systems
Mora	Nelson A	INIAP Ecuador	Farming systems

LATIN AMERICA AND THE CARIBBEAN

El Salvador

Bruno G	Ovidio	Minagricultura	Agronomy
De Deras	Haydee	Minagricultura	Farming systems
Garcia	Carlos Mario	Centa	Breeding
Parada H	Francisco E	Minagricultura	Farming systems

Guatemala

Guzman	Marcial E	ICTA	Phytopathology
Mendoza M	Andres	ICTA	Virology
Rodriguez	Rafael	ICTA	Breeding
Rodriguez	Rafael Raul	ICTA	Breeding
Rosales G.	Gabriel	Digesa Guatemala	Farming systems
Velasquez	Marcelo Ruben	ICTA	Farming systems

Honduras

Espinel F	Dinnie	Esc Agrc. Panam Honds	Production
Guevara	Carlos A.	Secretaria Rec. Naturales	Breeding
Rivera M.	Victor E.	Secretaria Rec. Naturales	Farming systems

Mexico

Aceves R	José de Jesús	Campo Agr. Ex Altos Jalisco	Phytopathology
Aguilera M	Jose Luis	INIA	Production
Chuela	Margarito	INIA	Production
Fernandez	Mario	INIA	Production
Hernandez	Alberto	INIA	Agronomy
Nuñez	Abelardo	INIA	Breeding
Rodriguez	José Raúl	INIA	Breeding
Salinas	Gilberto E	U. Autonm Nuevo Leon Mex	Farming systems

Nicaragua

Corrales	Sergio	Midinra. Region I. Esteli	Physiology
Jimenez G	Mario Fco	Midinra. IV Region Z VII	Farming systems

Peru			
Arbulu	Pedro A	INIA Peru	Economics
Cardama V	Italo Orlando	CIPA XVI - INIPA	Agronomy
Maldonado	Segundo Dario	CIPA- X . Morobamba	Phytopathology
Mestanza	Carlos A.	INIPA Peru (Cipa XVIII)	Agronomy
Valladolid	Angel Rodolfo	Est Exp. Chincha INIPA	Breeding
Dom. Republic			
Herrera	Miguel	SEA-CESDA	Farming systems
AFRICA			
Burundi			
Nzimenya	Isidorf	Isabu	Breeding
Rwanda			
Bonaventure	Ukiriho	Isar Ins des Sciences Agr	Breeding
Uganda			
Opio Asinasi	Fina	Kawanda	Phytopathology
ASIA			
Turkey			
Isik	Muzaffer	Agric Research Institute	Phytopathology
DEVELOPED COUNTRIES			
Germany			
Panse	Axel	U Friedrich Wilhelm	Breeding
Belgium			
Schmit	Veronique	U de Gembloux	Breeding
Canada			
Anderson	Marina	University of Alberta	Economics
U. S. A.			
Barkdoll	Anne	Un. Florida USA	Soil microbiology
Starbird	Ellen Hall	Fletcher School of Law	Economics
Wilson	Dale	Univ. de Ohio USA	Seeds

Holland			
Van Herpen	Catharina	Un Wageningen Holanda	Economics
United Kingdom			
Woodfin	Richard Mark	University of Bath	Physiology

B. Central America

The Bean Project for Central America and the Caribbean including tropical Mexico and Panama continued to generate technology in 1985 for national programs. Emphasis was placed on training and on the strengthening of close collaboration among the participating countries IICA and ICTA, continued to provide logistic support for the project facilitating the efficiency of the three scientists in the project.

Highlights of 1985

During 1985, the collaborative action taken by the national programs to resolve problems was outstanding. This was due to the training received by the national scientists in previous years which permitted the formation of strong multidisciplinary teams in nearly all the countries in the area, such teams having comparative advantages for the generation of technology for specific problems of the region. Leadership in the research on golden mosaic (partially financed by the Central American Project) was taken by Guatemala in collaboration with Mexico, El Salvador and the Dominican Republic; Apion by Guatemala and Honduras; slugs by Honduras in collaboration with the Escuela Agricola Panamericana; web blight by Costa Rica in collaboration with the Dominican Republic and Guatemala; common bacterial blight by Cuba and Nicaragua; rust by the Dominican Republic and Cuba; and on-farm trials by Costa Rica, Honduras and the Dominican Republic.

Scientific exchange activities through visits by scientists from national and other programs increased substantially during the year. This also occurred with respect to the number of courses carried out at the regional or country level on topics which covered: the use of micro computers; on-farm research; varietal description; and bean production with emphasis in on-farm trials. This facilitated the training of 154 technicians in the region. In addition, with respect to the special projects being carried out by each country, in-service training of 1-3 months was given to several of the members of the national programs. Meetings among the national programs were promoted to review the results of the research carried out and the programming of the same.

Also noteworthy in 1985 was the consolidation of a continuous flow through the regional nurseries, of lines selected from segregating populations in the specific projects in each country.

On-farm trials were increased in each country, particularly in the Dominican Republic, Honduras, Costa Rica and El Salvador. Greater emphasis has also been placed on on-farm trials. In the courses on production. All of this has resulted in the identification of promising materials superior to those which are presently in use; e.g. Guatemala produced two new varieties for the highland zones- ICTA Parramos and ICTA Quinakche; the Dominican Republic- Quisqueya; and Honduras is the process of releasing Arauli and Catrachita. For diversification reasons, the following countries adopted germplasm; Costa Rica adopted the black-seeded BAT 76 and Negro Huasteco;

Haiti-ICTA-Tamazulapa; and Cuba Negro Huasteco, Brunca, Quetzal and CENTA Tazumal.

Large quantities of seed of these varieties were delivered to each country to collaborate in their rapid diffusion.

Economic studies on the adoption of new improved varieties in Guatemala and Costa Rica (See section II. 2 Economics) indicated that they have been enthusiastically adopted by farmers and their influence is already being noted in these countries' economies. Guatemala is now self-sufficient in beans and it is expected that this country will be an exporter of black beans in the region. (See Table 1). For the first time Costa Rica will not import beans this year: when this project was initiated, Costa Rica imported 40% of its bean consumption needs.

Research Activities

Apion

The strategies used in previous years in the breeding program to incorporate resistance to this insect were based on:

(1) Utilization of genes previously identified, principally from Mexico 1290 and APN 18;

(2) Search for transgressive segregation from crosses carried out among lines with some tolerance; and

(3) Identification of new sources of resistance in germplasm of Mexican origen.

In 1985, populations were evaluated for the first two strategies, which offered promising results. The entry G 13614 collected by the name of "Celaya" showed good resistance, color and acceptable grain size, good climbing ability and a moderate adaptation to Central American conditions. The F2 and F3 populations derived from G 13614 show good adaptation, especially in the relay system in El Salvador.

Bean golden mosaic virus

Substantial progress was made on this viral disease of beans in increasing the levels of resistance which had been previously obtained. The resistance sources A 429, DOR 302 and DOR 303, DOR 303, have better resistance than the tolerant black variety released in 1979. In particular, A 429 was useful in the development of small red types for Central America, and several commercial types could be recovered.

At the beginning of the project, the improvement of the Pompadour types was blocked by the genetic linkage of the grain color with susceptibility to the BCMV. Now that lines with resistance to BCMV have been obtained with the Pompadour grain type, progress is expected to be much greater in the development of BGMV resistent genotypes.

TABLE 1. Imports, exports of beans in Guatemala, 1972-82.

YEAR	IMPORTS (T)	EXPORTS (T)
1972/1973	1,623	86
1973/1974	1,302	13
1974/1975	390	0
1975/1976	7,242	9
1976/1977	961	0
1977/1978	2	59
1978/1979	6,575	208
1979/1980	21	943
1980/1981	351	530
1981/1982	0	0
1982/1983	0	0
1983/1984	0	0

In general, materials which were more resistant to BGMV were obtained in all the grain types consumed in Central America and the Caribbean as well as on the Pacific coast and the Mexican Caribbean area.

The BGMV nurseries included: F2 populations of black-seeded segregating for beans tolerant to drought; F3 reds and mottled reds; resistant; black seeded families tolerant to common bacterial blight; lines from Brazil, Canary-colored lines from Mexico, Flor de Mayo and Bayo types; and the Adaptation Nurseries for black-seeded, small reds and red-mottled, and Mexican types.

It was shown that the materials tolerant to the virus can yield almost 100% of their capacity if the vector is controlled with insecticides, especially when plant growth first starts. This integrated control was economical and easily applied by the small farmers in the southeastern region of Guatemala.

Web blight

F2 populations were evaluated in Costa Rica representing the first group of segregating populations which combined the best parents identified in the International Web Blight Nursery. These crosses were specifically planned to search for those combinations which would

provide transgressive segregation. First, the selection was carried out among the populations to identify those entries which might provide transgressive segregation, and then within the promising populations. Some of the best combinations were: Acacias 4 x MUS 6; BAT 450 x Turrialba 1;, BAT 1636 x S630-B; MUS 6 x A 40; DOR 60 x PAI 113, PAI 113 x A 40; MUS 13 x Talamanca and MUS 1.4 x Brunca.

It is noteworthy and fortunate the sources of resistance to common bacterial blight continued to produce progeny which were highly promising with resistance to web blight.

During 1985, 29 segregating F_4 populations, three F_2 populations and 45 F_2 populations of specific crosses for web blight of which 25 populations were selected for their adaptation and resistance. Of 63 black colored lines in the Common Bacterial Blight project 37 were selected for their resistance to web blight. In addition, of 57 F5 lines backcrossed in the same project, 26 were outstanding for their resistance which was superior to the tolerant check Porrillo Sintetico.

At the same time, the VEF, VA and VPN nurseries for red and black-seeded beans were evaluated, as well as the VIM. With the objective of searching for new sources of resistance, 920 entries from the CIAT germplasm bank were planted, of which 30 showed resistance. Of the 109 "criollo" materials which were collected in the "tapado" system or for their tolerance to heat, only Turrialba Vaina Blanca, Chimbolo Rojo, Frijol Guaria, Cuarenteno Rojo and Cuarenteno Negro were outstanding.

In general, the progress which has been made is highly significant and there are lines of various grain colors and sizes with sufficient tolerance to be produced economically in a system of integrated control.

The search continued for a better disease control system through the use of cultural practices and chemical control. It was observed that the application of a fungicide, in addition to the association with corn and the use of a tolerant bean variety produced high yields under severe disease conditions. On the other hand, the following fungicides were once again superior to Benomyl (1.2 g/l) and therefore reduced the cost of web blight control: Duter (1.2 g/l); Brestan 60 (0.6 g/l) and Supertin (2 cc/l). However, the results indicated the action of Benomyl should be studied.

Common bacterial blight

Black-seeded bean lines were developed at CIAT through a thesis project using the backcrossing method, and these were tested not only for their resistance to common bacterial blight but also to BGMV and web blight. In Guatemala, several of these proved to have resistance to golden mosaic comparable to that of the tolerant varieties, and in Costa Rica many were resistant to web blight. Based on these results,

a project is on-going for backcrosses oriented to production of red and red-mottled lines to obtain materials with multiple resistance to the limiting factors on production in the region.

Slug control

In collaboration with the Escuela Agricola Panamericana, the Secretariat of Natural Resources of Honduras and CENTA in El Salvador, several baits have been tried in the form of pellets which give good slug control of this pest. An inexpensive and efficient method of pelletization has been developed using cornmeal as a base (11 lb Sevin, or 11 lb Dipterex or 120 g Lannate), and an inhibitor to prevent fermentation (10 g of sodium benzoate). This mixture is pelletized using an inexpensive meat grinder. The process included drying which can be done with solar energy in an open-air patio or with gas or diesal dryers.

Nurseries

In past years, the vertical transfer of technology from CIAT and the horizontal transfer of technology among the national programs were considered separately. However, the national programs of the countries in the project have matured scientifically and with self-financing have developed technology within the region which can be useful to other countries in the area. This technology has been achieved through specific projects which make use of the comparative advantages offered by each national program. This has facilitated a constant and systematic flow of materials stemming not only from the activities of CIAT in Cali, Colombia but also between programs with assistance from CIAT scientists in the region. The breeding parents are selected by the breeders of the national programs together with the project breeder. The crosses are carried out in CIAT, and then the F2 or segregating materials return to the region to the country responsible for that particular project. This system can be summarized as follows: VA-VPN-VCA-VINAR-VICAR - ON-FARM TRIALS. The F2 and the VA or VEF as well as the IBYAN nurseries constitute the vertical transfer of technology from CIAT to the region. The VPN's are the national preliminary nurseries and the VINAR's are the national yield and adaptation nurseries. At the regional level are the VCA's, nurseries made up of the best segregating materials from the specific projects, and the VICAR which are the yield and adaptation nurseries made up of the improved varieties or advanced lines from the national programs. All these nurseries are organized collaboratively with the participating countries. Finally, based on the best materials the On-farm Trials are done.

Adaptation nurseries

Adaptation nurseries (VA's) with red and black-seeded beans were distributed as follows: small reds to Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala and Cuba; and blackseeded to Guatemala, Costa Rica, Cuba and Mexico. The mottled red VA was sent to Cuba, the Dominican Republic, Haiti, Panama, Puerto Rico, Guadalupe and Guatemala. In January 1985, participants from the countries met in

IICA, Costa Rica to share and discuss the results of the VA/84. This was only the second time that the national programs received their summaries on time and thus were able to make their selections.

In November 1985, the participants from all the countries in the region attended a field workshop for Central America to evaluate the VA's and the VPN's. It concluded with a meeting in Costa Rica where plans were made for 1986. The elements included in this plan are: selection of parents in Central America among native varieties and/or introduced germplasm; hybridization and reproduction up to the F3 in CIAT; selection in Central America in the national programs according to the specific project involved; formation of a Central American VA (VCA) especially composed of materials selected in the region in each project and proposed by the national programs. The CIAT breeding program can also participate with entries to this VCA. This will substantially improve the horizontal transfer among the countries in the project.

VPN's

With the improved materials from the VA/84, each country formed a National Preliminary Yield Nursery to be evaluated in more than one site per country. On the basis of these and other promising results, the national programs formed their national yield nurseries (VINAR) which were tested in several sites in each country. These VINAR have different names according to the national program involved e.g. Ensayos Ecologicos in Cuba, and Pruebas Regionales in El Salvador, etc.

VICAR's

These nurseries continued to produce the best advanced lines or new varieties for testing. Some 66 nurseries were distributed, 34 red-seeded and 32 black-seeded to Costa Rica, El Salvador, Nicaragua, Guatemala, Honduras, Dominican Republic, Cuba, Beliz, and Puerto Rico. In the black-seeded VICAR the following were outstanding: HT 7719, ICTA Precoz 2, ICTA Precoz 6, Talamanca and ICTA Tamazulapa. In the red-seeded VICAR the only outstanding entries were RAB 58, RAB 59, RAB 203, RAB 204, RAB 50, and RAB 208.

On-farm trials

In the Dominican Republic black-seeded materials were tested which could replace Venezuela 44. Outstanding were Talamanca, XAN 93 and BAT 240. In addition, in the red-mottled seeds, the line BAT 1412 which was named Quisqueya was superior to Pompadour. PC 50 was also selected as a variety after evaluation in on-farm trials.

In Guatemala, work was carried out on the Pacific coast and in Peten, new regions for this type of trial. On the Pacific coast the following varieties were noteworthy: ICTA Quetzal and ICTA Tamazulapa, lines ICTA 81-31, ICTA L 883-2 and BAT 450 in the black-seeded beans. In the small reds, RAB 58m RAB 70, RAB 203 and RAB 204 were outstanding.

In Peten, 40 experimental lots were established with ICTA Tamazulapa and the diffusion of this variety was studied in the region by means of seed sold in 5 and 10 lb. bags.

In Honduras, where research efforts were concentrated in on-farm trials this year, it was observed that the lines RAB 39 (Araulí), RAB 205 (Catrachita) and RAB 50 were superior to the traditional varieties-Zamorano, Danli 46 and Desarrural. RAB 39 has been evaluated in first and second season plantings on more than 20 farms and RAB 205 in five locations in second season plantings. At the same time, agronomic studies were carried out with the same lines including distances and planting densities, fertilization and weed control.

In Costa Rica, there are some black-seeded lines which are superior to Talamanca, particularly with respect to their resistance to anthracnosis, the principal weakness of this variety. Outstanding were BAT 76, ICTA 883-2 and Negro Huasteco. BAT 76 as well as Negro Huasteco have been adopted by the farmers, and at present are being multiplied for basic and registered seed for their rapid diffusion in the near future.

In El Salvador, on-farm trials showed the superiority of lines RAB 204 and RAB 203 as well as of some special climbing lines for relay planting with maize: RCV 83-11, ACV 83-68, and ZAV 83-44. Nevertheless, the diffusion of these improved materials is not being done due to the lack of research at the on-farm level, which is partially impeded by the lack of economic resources and the existing political problems.

Seed multiplication

During the year, seed of the new lines BAT 1412 and DOR 198 was multiplied and delivered to the Dominican Republic, of Negro Huasteco and Brunca to Cuba, in addition to the seed quantities delivered to the regional nurseries.

Training

This year in agreement with the wishes of the national programs training was substantially increased through regional courses, in-country courses, workshops and meetings. Candidates participated from Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Cuba, the Dominican Republic and Haiti. Some 154 national technicians were trained and greater emphasis was given to on-farm research to assist in the transfer of the technology to the farmer. Regional courses were carried out in Costa Rica, one each on Bean Production, On-Farm Research, and the use of Microcomputers in Bean Research. In addition, a regional course was given on varietal description in Guatemala and courses were given in El Salvador and Honduras. Fifteen technicians attended a multidisciplinary course at CIAT and stayed on there to receive in-service training in the different disciplines according to the needs of each national program.

Two candidates for M.Sc. degrees from El Salvador finished their studies and returned to strengthen the national program CENTA. At present and M.Sc. candidate from Guatemala is finishing research for his thesis in CIAT.

The project sponsored visits by technicians from national programs to other programs in the region for training in the evaluation of material in the project, to learn new techniques or to standardize the screening systems. In addition, two technicians from Cuba visited the Mexican program in Sinaloa to study and to transfer the techniques of direct harvesting which is a bottleneck of bean production in this country. At the same time, national technicians travelled to other countries to assist in the evaluation of materials or as course instructors.

The project collaborated and participated in several regional workshops. In Guatemala together with INCAP, technicians in the region were brought together to standardize the evaluation methods of the physical and chemical properties of beans. In collaboration with ICTA, the International Workshop on Golden Mosaic was carried out which was attended not only by representatives from the countries in the project but also scientists from CIAT, the University of Puerto Rico, Costa Rica and others in the U.S.A.

In January 1985, a workshop on the adaptation nurseries was held with the national breeders to review the data from the VA/84 and to select the most outstanding materials for the VPN's of 1985. This workshop was followed by a field workshop in November on the VA's and the VPN's held in November on a working visit to the national programs of Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica which was attended by personnel from these countries as well as from the Dominican Republic, Cuba, Panama and Mexico and from CIAT. The workshop concluded with a meeting in IICA, Costa Rica where the participants made decisions with respect to these nurseries for 1986. A noteworthy event, was the design of a uniform flow of materials to all the countries and the inclusion of a regional VA to be known as VIDAC composed of the best materials from the specific projects.

Coordination meeting

Coincidental with the annual meeting of the PCCMCA was the coordination meeting of the project. Two participants per country were invited. This meeting reviewed the vertical transfer of technology from CIAT to the region, and the horizontal transfer among the countries and through the specific projects. At the same time, the materials and nurseries necessary for each country were programmed as well as the courses, visits, workshops and other project activities throughout the year. The active participation of each representative was solicited with respect to decision-making on the generation of technology as well as the training activities of the project and the distribution of "firefighting" funds for each country.

The project breeder accepted a position in CIAT-Palmira as of July of this year. This position has not yet been filled. In addi-

tion, in November a postdoctoral in phytopathology began his activities in Costa Rica to collaborate in research on web blight.

Future plans

The national programs together with the breeder have planned the needs of each country with respect to specific crosses at the local and regional level. The collaborative network is strong and well-coordinated, which facilitates greater continuity in the flow of adapted materials.

Training activities will continue to give increasing emphasis to courses in on-farm research to accelerate the process of the transfer of materials and agronomic practices from the national programs to the farmer and feedback to the researcher. A workshop will study the progress in research on web blight in the Dominican Republic as well as in Costa Rica, and the field workshops on the VA's will continue. The project will sponsor mutual visits by national scientists and CIAT personnel in the region.

The coordination meeting of the project will be carried out in March at the PCCMCA meeting in El Salvador. In this meeting, the research and training activities will be planned as well as the partial financing of the specific projects in each country.

The annual meetings of the national programs will be increased and reinforced in order to better coordinate the national programs' activities in research, extension, credit, marketing, etc. bearing upon the process of adoption of new materials by the farmers.

C. Brazil

Germplasm flow to Brazil

During 1985 advanced breeding lines entered Brazil (Table 1). Most were requested by Brazilian breeders during the breeder workshop held in November 1984 at CIAT.

Table 1. The best advanced breeding lines entering Brazil.

Materials	Origin	Number of lines
1. 84 EP	Agronomy	62
2. 84 VEF	Agronomy	134
3. 83/84 Adaptation Nursery Red	Breeding I	17
4. 84 Adaptation Nursery (Black)	Breeding I	170
5. 84 Adaptation Nursery Red	Breeding I	30
6. 84/85 IBGMV	Breeding II	192
7. Observation Nursery[a] (Cream + Carioca)	Breeding II	325
8. Adaptation Nursery[a] (Cream + Carioca)	Breeding II	515
9. Resistence Sources for[b]:	Phytopathology	
a. Gene I		17
b. CBB		13
c. Rust		10
d. Empoasca		20
e. Web blight		29
f. Web blight (red seeded)		15
g. Rhizobium (N-fixation)		24
h. Cold climate		4
i. Anthracnose		9
j. Ascochyta		17
Total entries		1407

[a] Special request from IPA

[b] Special request from CNPAF breeders and pathologists

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These lines entered Brazil via CENARGEN, where one envelope with 60 seeds was kept for lab testing and the remaining four envelopes went to CNPAF and were planted in April in CAM in a three row plot. Fourteen days after germination, a pathologist, virologist, and nematologist of CENARGEN inspected the field for the presence of unknown diseases that came in the seeds.

After CENARGEN approval, one set of the adaptation and one set of the observation nurseries from the Breeding II section were shipped to IPA where they were planted in May 1985.

The nurseries in Goiania and IPA (Belem do Sao Francisco-PE) were evaluated jointly by IPA, CNPAF and CIAT scientists in July/August 1985.

The same set of materials from CAM was also sent to IAPAR, IRATI/PR for adaptation and anthracnose evaluation. These were evaluated by the CNPAF and CIAT scientists during the first week of December 1985.

Joint Breeding Project CNPAF-CIAT

The F2 and F3 populations of crosses made at CIAT, will be shipped through CENARGEN in December 1985. These crosses, totaling 1,009, are:

1. Drought tolerance
   10 multiple crosses
   Basic parents are: Carioca, BAT 258, IPA 74-19 and BAT 477.

2. Anthracnose resistance. The anthracnose crosses are made according to seed color. A total of 31 crosses were requested as follows: 5 simple crosses for black-seeded; 3 simple crosses for red/purple; 3 simple crosses for Carioca type; 20 multiple crosses for all colors. For black-seeded types the sources of resistance are: Mexico 222, G 3807. 310.026.1.4, 310.152.2.6, 310.157.25.3 CF 810456, AB 136, PI 207262, A 253, CF 810457, BAT 1386,A 483, A 295, A 338, G 0811, G 02331, G 02333, G 05653, Prinkor, K2, G 07148 and A 368.
   Red/Purple: sources of resistance are:
   BAT 1354, A 210, and BAT 1387.
   Carioca type : Sources of resistance are:
   A 482, A 321, 310.151.29.2, 310.039.5.2, 310.D99.18.2, A 193, Evolutie, To, Tu and Ancash 66.

3. Angular leaf spot

   Approximately 20 crosses. Three simple crosses; 7 double crosses for red and pink seed color; 6 double crosses for Carioca and cream seeded; 4 multiple crosses. Sources of resistance are: Mexico 279, Compuesta Chimaltenango 2, Jalo EEP 558, Diacol Nima, CF 810454, CF 810456, CF 810457, 310458, BAT 76, A 237, G 3884, G 3997, BAT 1554, A 75, A 154, Rico Pardo 896, G 5653, A 295, A 296, A 240, BAT 6, A 51, and A 211.

4. Rust
A total of 20 multiple crosses. Sources of resistance are: CF 4000, CF 810454, CF 810456, CF 810457, BAT 93, BAT 308, BAT 256, BAT 67, BAT 76, EMP 81, Redlands Pioneer, Cuilapa 72, Cocacho, Mexico 309, and Mexico 235.

5. Common bacterial blight
Ten simple crosses, six multiple disease resistance and nine multiple crosses involving eight parents are requested. Sources of resistance are: XAN 159, XAN 160, XAN 161, XAN 40, XAN 87, XAN 112, XAN 116 and XAN 125.

EPR (Ensaio Preliminar de Rendimento) of the NBEN (National Bean Evaluation Network).

EPR 1982-84 Results:

The first series of the EPR conducted during the period of 1982-84 was concluded in September 1984. Results were still coming in during 1984. A summary of EPR trials executed during 1982-84 is presented in Table 2.

Thirty-six EPR trial results were reported of which 33 could be evaluated statistically, which gives a 49% return. Many losses occurred in institutions with poor infra-structure especially in the Central West. In order to increase the return of data, fewer numbers of trials should be shipped to those problem areas and the scientists should be expected to put more effort into conducting the experiments.

During the period of 1982 through 1984 angular leaf spot (ALS) was the only important disease. The 10 best materials over locations for red, black and cream groups, respectively, are given in Tables 3, 4, and 5.

Table 2. No of trials and types carried out in 1982-84.

	Number of trials	
Seed color	Shipped	Data received
Black	14	14
Cream and Carioca type	36	17
Red/purple	17	05
Total	67	36

Table 3. The 10 best red/purple advanced breeding lines, common and local checks tested in EPR during 1982-1985 over five locations (yield in kg/ha).

Identification	LOCATION					Mean
	Ilha Solt. 1984	Bourados 1985	Emgopa 1983/84	Emgopa 1984	CNPAF 1984	
			Advanced Breeding Lines			
1. BAT 1458	2309	1800	1107	1710	2817	1787
2. LPM 10092	1053	2000	1120	2055	2333	1712
3. BAT 614	1510	1903	1083	1550	2283	1665
4. LPM 30068	929	1443	1613	2077	2158	1644
5. LPM 10033	946	1727	1612	1467	2183	1587
6. XAN 57	903	1767	1093	1465	2483	1542
7. BAT 696	1446	1567	1435	1578	1692	1539
8. XAN 37	1364	1610	1152	995	2533	1530
9. LPM 10348	1161	1253	1285	1725	1858	1456
10. BAT 1510	1371	1537	1168	1292	1908	1455
$\bar{X}_{10}$	1299	1661	1267	1591	2225	1592
			Common Checks			
1. Jalo EEP	1624	1827	1175	790	2107	1504
2. Carioca	1122	1570	1212	1555	1950	1481
3. IPA 7419	1515	1550	1542	1280	1317	1440
4. Cornell 49242	1295	1737	1010	990	1567	1319
5. Rosinha G-2	1051	1155	715	740	900	912
$\bar{X}_5$	1321	1568	1131	1071	1568	1331
			Local Checks			
1. T. local 1	1195	1590	1328	1638	992	
2. T. local 3	1212	1130	1443	1347	1228	
3. T. local 4	1494	1483	993	1013	1233	
4. T. local 2	1410	1660	1087	885	808	
$\bar{X}_4$	1328	1466	1213	1221	1060	

Table 4. The 10 best black advanced-breeding lines, and local checks tested in EPR during 1982-1984 over 14 locations (yield in kg/ha).

Identification	Ilhsol 1984	CNPAF 1984	EMCAPA 1984	CAMPOS 1984	UFVMG 1984	EMGOPA 83/84	OSORIO 1983	OSORIO 83/84	OSORIO 1984	CAMPOS 83/84	CAMPOS 82/83	CAMPOS 1983	EMGOPA 1983	CNPFAF 1983	MEAN
Advanced Breeding Lines															
1. PV 99 N		2694	1717	1214	1274	2735	817	1423	1800	608	1728	1798	1659	2106	1659
2. EMP 84	1440	2541	1600	1321	1823	1988	517	1642	1667	783	1835	1483	1655	2398	1635
3. ICTA QUETZAL	1508	2722	1483	1261	1295	2142	1067	983	1717	900	1717	1758	1572	2636	1625
4. BAT 429	1370	2725	1500	1541	1633	2402	967	1442	1583	692	1297	1592	1317	2540	1614
5. BAT 431	1018	2894	1625	1122	2122	2063	633	1251	1717	783	1429	1311	1780	2689	1602
6. ICA PIJAO	1580	1642	1850	1220	1347	1397	1267	1821	1650	617	1545	1564	1538	2833	1562
7. BAT 1554	1223	2172	1617	1339	1163	1805	917	1525	2083	437	1113	1551	1551	2790	1522
8. BAT 1647	815	2914	950	1023	1439	1643	950	1872	1883	1095	1441	1454	1454	2206	1508
9. BAT 67	1050	2094	1667	1018	1668	2137	667	1850	1733	692	1491	1579	1579	2029	1507
10. MD 64	737	2103	967	1016	1755	1943	817	1925	1283	842	2263	1316	1316	2546	1501
$\bar{Y}_{10}$	1193	2450	1518	1208	1553	2026	862	1573	1712	745	1586	1541	1542	2477	1774
Common Checks															
1. Cornell 49242	1102	1947	1483	1292	1467	1845	1200	1682	1800	675	1192	1293	1453	1836	1447
2. Jalo EEP 558	1163	1795	1750	1264	1572	1957	1583	1356	1417	583	534	1408	1348	2166	1421
3. Carioca	953	1763	1267	1390	1397	1912	733	1326	1450	755	1887	1406	1605	1873	1408
4. Rico Pardo 86	1063	2147	1700	1471	1460	1885	617	1234	250	180	250	1831	1714	2059	1404
5. Rio Tibagi	1362	1665	1367	1218	1678	2062	567	1302	1267	532	1350	1197	1274	2401	1374
6. Rosinha G-2	728	1012	950	1355	847	140	617	877	1117	375	2104	1482	1198	1373	1012
$\bar{X}_5$	1062	1722	1420	1332	1404	1634	886	1296	1517	517	1220	1436	1432	1951	1344
Local Checks															
1. T. Local 2	1005	1972	1758	1229	1400	1777	1033	1218	1667	797	1238	1512	1725	1926	
2. T. Local 4	997	2026	1567	955	1174	2065	950	1494	1483	825	1222	1611	1650	2034	
3. T. Local (RT)	1062	2305	1408	1396	1168	1332	733	1152	1533	1088					
4. T. Local (M)	843	1844	1742	1013	1387	1913	817	1116	1417	793					
$\bar{Y}_4$	977	2037	1619	1148	1282	1772	883	1245	1525	876	1230	1562	1688	1980	

Table 5. The 10 best cream advanced-breeding lines, their common checks tested in EPR during 1982-1984 over five locations (yield in kg/ha).

Local Identification	Ilhas 1984	Irece 83/84S	Irece 83/84C	Caruar 1984	UFBA 1984	CNPAF 83/84	EMEPA 1984	DOURAB 1984	UFVICO 1984	IPIRA 1984	BODOMS 1984	TERENO 1984	LINHA 1983	CNPAF 1983	MEAN
							Advanced Breeding Lines								
1. IPA L 1055	953	1889	1610	1411	1114	3433	633	2413	1918	667	1352	942	1580	3693	1686
2. A 294	1104	1349	1868	2016	1182	2903	427	2063	1317	867	1205	678	2123	2815	1565
3. IPA 1	1214	1304	1748	1812	1342	3117	632	2400	2034	117	969	842	1345	3017	1564
4. BAT 731	1307	1530	1404	1728	1307	2542	537	1720	1662	367	899	896	2187	3243	1524
5. A 281	1427	1374	1220	1596	1366	2320	933	2487	1439	433	1061	781	1473	3182	1507
6. A 245	1085	1563	1757	1625	610	2550	670	2300	1484	967	1083	806	1867	2700	1505
7. A 295	1216	1673	1730	1979	552	2725	778	2107	1648	133	1272	712	1783	2727	1503
8. IPA L 5400	1448	1428	1778	1734	1470	1942	375	1837	1803	283	636	839	1642	3423	1474
9. EMP 117	1012	1475	1816	1985	982	2742	494	2080	1123	417	901	528	1610	3107	1448
10. A 286	948	1272	1384	1505	884	2208	637	1817	1883	283	940	801	1749	3232	1403
$\bar{X}_{10}$	1171	1485	1632	1739	1081	2648	612	2132	1631	453	1032	783	1736	3114	1518
							Common Checks								
1. JALO EEP 558	772	1270	1947	1877	720	2142	700	1910	1178	1133	1450	592	1648	2725	1433
2. CARIOCA	1238	1357	1101	1782	396	2637	552	2003	1216	1233	559	814	1544	2558	1356
3. RIO PARDO 896	741	929	1140	1770	1169	2142	593	2007	1668	1417	839	462	1572	2375	1345
4. IPA 74-19	1145	1425	1700	1237	1004	1525	540	1680	1478	1067	677	812	1278	2602	1305
5. PARANA 1	1706	1392	1213	1711	774	1530	347	1693	1515	917	435	905	1720	2372	1300
6. APOANA	875	1511	1576	1557	647	1410	682	1917	1102	883	520	559	1333	2783	1240
7. CORNELL 49242	671	1254	1844	1655	212	1850	452	1600	1066	1233	909	420	1747	2243	1225
8. ROSINHA 6-2	1009	1340	1408	1108	597	1447	738	1653	884	467	232	963	1240	2098	1085
$\bar{X}_8$	1020	1310	1491	1587	690	1843	576	1808	1263	1044	703	691	1510	2470	1287

(Continued)

Table 5. (Continued)

Local identification	Ilhas 1984	Irece 83/84S	Irece 83/84C	Caruar 1984	UFBA 1984	CNPAF 83/84	EMEPA 1984	DOURAB 1984	UFVICO 1984	IPIRA 1984	BODCMS 1984	TERENO 1984	LINHA 1983	CNPAF 1983	MEAN
							Local Checks								
1. T. LOCAL 4		1613	1855	1400	1198	1850	490	2130	1595	1417	396	1033	1538	2240	
2. T. LOCAL 2	851	1252	1441	1293	856	1700	557	2173	1465	1183	854	663	1998	1557	
3. T. LOCAL 5	1329	927		1489	832	2250	613	2293	1436		309	1317	1537	2227	
4. T. LOCAL 1		1168	1517	1140	972	1317	675	1813	1126	817	422	809	1642	1877	
5. T. LOCAL 3			1772	1517	888	1617	365	2250	1126		207	901			
$\bar{X}_5$	436	992	1317	1368	949	1747	540	2132	1350	1139	438	945	1679	1975	

In general where ALS pressure was severe, the common check variety, Jalo EEP 558, with growth habit I and resistant to ALS, gave the highest yields and in many cases outyielded Carioca or Rio Tibaji.

In the red-seeded group only few advanced breeding lines were better than their common check or local check, e.g., BAT 1458, LM 10092 and BAT 614; however, their seed color still differs slightly from the commercial varieties.

In the black and cream-seeded groups many advanced breeding lines were better than the local checks. In the black-seeded group, BAT 429, BAT 431, BAT 1554, BAT 67, and BAT 1647 outperformed the local checks and common checks. Only BAT 67 is resistant to Anthracnose (Table 4).

In the cream-seeded group, I 1055 (released in 1985 as IPA 6), A 294, IPA 1, BAT 731, and A 281 performed better than the standard check IPA 74-19 or Carioca over 14 locations (Table 5). Most of these materials are now in the state trials in the northeast.

The summary of the outstanding lines over locations and years in the first series of EPR (1982-1984) is shown in Table 6.

EPR 1984-1985 Partial Results

During the period of September 1984 to December 1985, a total of 81 EPR trials were shipped. The results received so far from this second series of EPR are presented in Tables 7-11.

In the red-seeded group ESAL 502 and ESAL 503, RAO 23, DOR 191, and LM 10348 are the outstanding lines compared to the common and local checks (Table 7).

In the black-seeded group, LM 21132, LM 21124, W 22-34 and NAG 37 performed well in the southeast of Brazil (Table 8). In the centralwest different lines appeared outstanding although they were tested in the same locations (Table 9). Distinct constraints were present during different semesters of the same year. In both regions the best lines of the group outperformed the checks Rio Tibaji or Carioca.

In the cream-seeded group, IPA lines performed well in the northeast (Table 11) but few appeared within the 10 best in the centralwest (Table 10).

The preliminary results of 1984-1985 show large location versus variety interactions. This suggests that advanced breeding lines for the northeast differ from those for the centralwest.

It is proposed to have a CAM for cream seeded lines, especially for the northeast of Brazil, in order to increase the testing efficiency.

Table 6. Frequency of advanced breeding lines found within the best 10 lines of the EPR 1982 - 1984.

10 x	9 x	8 x	7 x	6 x	5 x	4 x
Black seeded :		(14 experiments)				
	ICTA Quetzal	BAT 431	BAT 67	A 226		
		EMP 84	BAT 429	A 227		
			PV 99 N	MD 64		
Cream seeded :		(17 experiments)				
IPA 1	IPA 6	IPA L 6097	BAT 731	EMP 117		
	A 286	IPA L 5400	A 295	A 358		
	A 281	A 294	A 245	A 255		
				A 62		
Red seeded: (5 experiments)						
					BAT 362	LM 10092
					LPM 10033	A 482
						LPM 10348
						BAT 1458
						BAT 614
						BAT 1510

Table: 7. The 10 best red advanced breeding lines, common and local checks tested in EPR in the Central West of Brazil (1984-1985). (Yield in kg/ha).

CNPAF 84/85		CNPAF 85.1		CNPAF 85.2		EMGOPA 84/85		ESAL 85	
				Advanced Breeding Lines					
1. DOR 191	1268	LM 10348-0	1422	LM 10348-0	1597	ESAL 502	1845	LM 10069-0	900
2. LM 30013-0	1113	DOR 191	1400	ESAL 503	1563	ESAL 9503	1673	LM 10061-0	853
3. ESAL 502	1035	ESAL 503	1383	ESAL 502	1533	LM 30013-0	1573	LM 10092-0	585
4. RAO 18	952	82 PVBZ 1736	1290	RAO 23	1514	LM 10065-0	1572	LM 10076-0	572
5. LM 10348-0B	923	LM 10348-0	1270	82 PVBZ 1736	1216	RAO 23	1533	82 VAR 112	545
6. ESAL 503	918	82 PVBZ 1838	1270	DOR 191	1214	82 PVBZ 1838	1460	LM 10088-0	503
7. BAT 41	907	ESAL 502	1265	LM 10348-0	1175	LM 10060-0	1407	ESAL 503	501
8. RAO 23	883	RAO 23	1095	82 PVBZ 1838	1160	LM 10009-0	1377	LM 30380-0	485
9. LM 10415-0	840	LM 10092-0	1052	ROXAO EEP	1156	LM 10348-0A	1363	LM 10102-0	470
10. LM 10348-0A	837	LM 30330	1012	LM 10013-0	1130	LM 10092-0	1343	LM 10062-0	469
$\overline{X}_{10}$	968		1247		1326		1515		588
Average of breeding lines (n=41)	615		919		936		1196		375
				Common Checks					
1. IPA 74-19	830	IPA 74-19	585	IPA 74-19	868	IPA 74-19	1470	IPA 74-19	418
2. CARIOCA	768	CARIOCA	973	CARIOCA	1008	CARIOCA	1202	CARIOCA	543
3. CORNELL 49242	908	CORNELL 49242	1628	CORNELL 49242	1120	CORNELL 49242	1040	CORNELL 49242	449
4. JALO EEP 558	1048	JALO EEP 558	1568	JALO EEP 558	1528	JALO EEP 558	1125	JALO EEP 558	416
$\overline{X}_4$	664		1189		1131		1129		457

(continued)

Table:7. (Continued)

CNPAF 84/85		CNPAF 85.1		CNPAF 85.2		EMGOPA 84/85		ESAL 85	
				Local Checks					
1. LM 10056-0	290	LM 10056-0	808	LM 10056-0	603	CNF 101	617	ESAL 547	528
2. LM 10017-0	633	LM 10017-0	832	LM 10017-0	434	ROSINHA	837	RIO VERMELHO	410
3. LM 30598-0	500	LM 30598-0	792	LM 30548-0	482	ROXO ANP	1277	ESAL 543	185
4. LM 10104-0	793	LM 10104-0	1258	LM 10104-0	391	AMARELO ANP	1427	ESAL 550	169
$\overline{X}_4$	554		923		478		1040		323
MEAN (n=47)									
LSD (5%)			299		334		774		253
CV (%)			16.2		18.7		23.0		34.2

Table 8. The 10 best black advanced breeding lines, common and local checks tested in EPR in the southeast of Brazil (1984-1985). (Yield in kg/ha).

IPAGRO/OSORIO 84/85		PASFUN 1984		EMPASC/CHAPECO 84		PESAGRO/CAMPOS 85	
			Advanced breeding lines				
1. LM 21132	2534	LM 30074	1370	LM 21132	2823	LM 00574	2258
2. LM 21124	2522	82 B VAN 39	1312	LM 30074	2786	RICO 1735	2090
3. W 22-34	2498	LM 30547	1303	LM 20355	2779	LM 20816	2087
4. NAG 37	2466	RICO 1735	1301	A 230	2741	LM 21124	2058
5. 82 B VAN 38	2413	LM 20357	1288	NAG 37	2668	LM 21132	2017
6. LM 20785	2407	LM 21135	1227	82 B VAN 74	2646	L 10259	1971
7. LM 21135	2370	LM 20363	1220	LM 20785	2626	NAG 24	1987
8. W 22-55	2364	LM 10364	1220	LM 21124	2625	LM 10377	1985
9. NAG 24	2317	LM 20781	1200	LM 210089	2587	LM 10363	1965
10. LM 30074	2296	A 230	1187	NAG 24	2577	LM 10426	1964
$\bar{X}_{10}$	2419		1263		2686		2040
Average of breeding lines (n=72):	2007		897		687		1718

(Continued)

Table 8. (Continued)

IPAGRO/OSORIO 84/85		PASFUN 1984		EMPASC/CHAPECO 84		PESAGRO/CAMPOS 85	
			Common Checks				
1. RIO TIBAGI	1815	RIO TIBAGI	910	CARIOCA	2945	RIO TIBAGI	1796
2. CARIOCA	2298	CARIOCA	746	RIO TIBAGI	2175	CARIOCA	1577
3. CORNELL 49242	1923	CORNELL 49242	992	CORNELL 49242	2115	CORNELL 49242	1300
4. JALO EEP 558	2608	JALO EEP 558	1230	JALO EEP 558	2053	JALO EEP 558	1731
$\overline{X}_6$	1911		969		2327		1601
			Local Checks				
1.	2079	RIO TIBAGI	1221	RIO TIBAGI	2378		1778
2.	2083			EMPASC 201	2209		1881
3.	1603			IGUACU	1950		1368
4.	1906			TURRIALBA 4	1926		1745
$\overline{X}_4$	1918		1221		2116		1693
MEAN (n=81)							
LSD (5%)	489		689		135		620
CV (%)	12.4		24.6		10.1		18.5

Table 9. The 10 best black advanced breeding lines, common and local checks tested in EPR in the Central West of Brazil (1984-1985). (Yield in kg/ha).

CNPAF 84/85		CNPAF 84/85.3		CNPAF/85		EMGOPA 84/85		PONTE NOVA 85	
				Advanced Breeding Lines					
1. CNF 352	2492	LM 20816	2167	LM 20816	1574	LM 21124	2160	LM 30074	2357
2. 82 B VAN 38	2070	LM 20720	2146	LM 20720	1573	LM 21132	2012	LM 10363	2312
3. RICO 1735	2063	LM 20363	2130	LM 21124	1559	LM 10401	1918	LM 30030	2288
4. NAG 23	2058	LM 30036	2103	A 211	1506	LM 30030	1905	LM 21135	2255
5. NAG 15	2000	LM 30074	2102	A 212	1504	82 B VAN 39	1847	W 22-2	2125
6. LM 21132	1998	RICO 1735	2062	LM 10363	1485	CNF 352	1812	82 B VAN 38	2095
7. LM 30016	1923	LM 21132	2055	DOR 218	1483	LM 30063	1778	IPA 74-19	2088
8. LM 30074	1914	LM 30016	2020	CNF 351	1461	LM 30016	1760	LM 00189	2072
9. LM 10363	1895	LM 210089	2017	MILIONARIO	1449	LM 20720	1732	W 22-50	2058
10. LM 30036	1832	W 22-8	1978	NAG 24	1447	LM 30074	1698	NAG 25	2025
$\bar{X}_{10}$	2031		2078		1504		1862		2168
Average of breeding lines (n=72):	1449		1609		1184		1442		1575
				Common Checks					
1. RIO TIBAGI	1192	RIO TIBAGI	1317	RIO TIBAGI	851	RIO TIBAGI	1495	RIO TIBAGI	1790
2. CARIOCA	1208	CARIOCA	949	CARIOCA	914	CARIOCA	1447	CARIOCA	1695
3. CORNELL 49242	1308	CORNELL 49242	1542	CORNELL 49242	1128	CORNELL 49242	1128	CORNELL 49242	2055
4. JALO EEP 2127	2127	JALO EEP 558	1653	JALO EEP 558	1166	JALO EEP 558	1150	JALO EEP 558	1917
$\bar{X}_6$	1459		1365		1013		1305		1417

(Continued)

Table 9. (Continued)

CNPAF 84/85		CNPAF 84/85.3		CNPAF/85		EMGOPA 84/85		PONTE NOVA 85	
				Local Checks					
1. IPA 74-19	588	LM 21059-0	1610	LM 21059-0		MORUNA 80	1007		1548
2. JALO EEP 558	688	LM 20620-0	1496	LM 206-20-0		CNF 178	1673		2008
3. CARIOCA	1155	LM 20950-0	1562	LM 20950-0		XAN 25	735		1783
4. RIO TIBAGI	792	LM 00217-0	1481	LM 00217-0		EMP 84	1692		1253
$\overline{X}_4$	805		1537				1277		1648
MEAN (n=81)									
LSD (5%0	681		493		338		752		937
CV (%)	24.3		15.8		14.8		18.8		18.8

Table 10. The 10 best cream advanced-breeding lines, common and local checks tested in EPR in the Central West of Brazil (1984-19
1984-85 (yield in kg/ha).

CNPAF 84/85		CNPAF 85.1		CNPAF 85.2		RIO BRANCO 85		ESAL 84/85		ESAL 84/85.2	
Advanced Breeding Lines											
1. 82 PVBZ 1783	999	ESAL 504	2126	82 PVBZ 1901	1723	ESAL 509	1590	1. A 254	1538	82 PVMX 1648	527
2. A 323	751	ESAL 505	2078	ESAL 507	1652	82 PVBZ 1843	1369	2. LM 21387	1275	ESAL 501	500
3. ESAL 508	741	LM 21322	1916	A 156	1648	82 PVBZ 1770	1328	3. L 13497	1232	A 295	475
4. A 344	740	82 PVMX 1638	1825	L 11076	1637	A 274	1292	4. ESAL 506	1223	ESAL 506	447
5. ESAL 501	735	LM 10402-0	1720	82 PVBZ 1843	1500	L 11086	1245	5. 82 PVMX 1529	1221	A 266	433
6. ESAL 505	733	82 PVMX 1637	1719	A 274	1495	82 PVMX 1638	1239	6. LM 21322-0	1218	ESAL 504	403
7. A 317	732	ESAL 507	1692	L 10238	1443	L 11093	1228	7. A 344	1205	ESAL 208	402
8. 82 PVBZ 1901	731	A 251	1666	L 11093	1438	LM 10027-1	1221	8. LM 21473-0	1202	LM 30877-0	402
9. ESAL 506	703	82 PVBZ 1824	1652	LM 30079-0	1422	LM 10033-0	1216	9. L 10257	1179	82 PVBZ 1843	397
10. A 318	694	82 PVBZ 1718	1646	82 PVMX 1546	1420	LM 21317-0	1215	10. A 295	1176	LM 30995-0	395
$\bar{X}_{10}$	756		1804		1538		1294	X_{10}	1247		438
Average of breeding lines (n=89):	505		1177		1069		938		835		270
Common Checks											
1. IPA 74-19	383	IPA 74-19	1193	IPA 74-19	987	MUL.V.ROXA	1270	1. IPA 74-19	757	IPA 74-19	474
2. CARIOCA	614	CARIOCA	1040	CARIOCA	925	PARANA 1	1259	2. CARIOCA	865	CARIOCA	376
3. PARANA-1	500	PARANA-1	875	PARANA-1	1108	IPA 74-19	1229	3. PARANA-1	1257	PARANA-1	307
4. AROANA	574	AROANA	999	AROANA	927	CARIOCA	1227	4. AROANA	628	AROANA	487
5. MUL. V. ROXA	548	MUL. V. ROXA	1236	MUL. V. ROXA	533	CORNELL 49242	1011	5. MUL.V.ROXA	778	MUL.V.ROXA	401
6. JALO EEP 558	654	JALO EEP 558	1324	JALO EEP 558	1297	JALO EEP 558	875	6. JALO EEP 558	813	JALO EEP 558	239
7. CORNELL 49242	567	CORNELL 49242	1691	CORNELL 49242	983	AROANA	712	7. CORNELL 49242	850	CORNELL 49242	323
$\bar{X}_7$	549		1194		966		1083	X_7	850		372

(Continued)

Table 10. (Continued)

CNPAF 84/85		CNPAF 85.1		CNPAF 85.2		RIO BRANCO 85		ESAL 84/85		ESAL 84/85.2	
					Local Checks						
1. LM 10416-0	435	LM 10416-0	593	LM 10416-0	845	PINTADO	665	1. PINTADO	665	PINTADO	660
2. LM 10413-0	522	LM 10413-0	291	LM 10413-0	1488	ESAL 547	770	2. ESAL 547	770	ESAL 547	645
3. LM 21307-0	640	LM 21307-0	842	LM 21307-0	952	ESAL 546	931	3. ESAL 546	931	ESAL 546	446
4. LM 10350-0	476	LM 10350-0	427	LM 10350-0	1072	ESAL 535	566	4. ESAL 535	566	ESAL 549	347
$\overline{X}_4$	518		538		1089		732		733		567
MEAN (n=100)											
LSD (5%)	251		513		644				363		218
CV (%)	25.2		22.7		30.9				22.3		38.8

Table 11. The 10 best cream advanced breeding lines, common and local checks tested in EPR in the northeast of Brazil (1984-1985). (Yield in kg/ha)

IRECON 85		POCO VERDE CON.85		IRESOI 85		POCO VERDE SOL.85	
			Advanced Breeding Lines				
1. A 300	1156	ESAL 504	1667	L 11152	948	BAT 841	2392
2. L 11077	1124	82 PVBZ	1718	1327 L 11133	916	A 295	2364
3. L 11090	1118	82 PVMX	1648	1273 ESAL 505	905	L 10081	2273
4. L 11086	1117	A 251	1256	LM 21307	898	LM 21303-0	2217
5. L 11130	1106	A 295	1214	LM 21307	848	ISAL 504	2204
6. LM 21317-0	1085	L 10238	1200	L 11090	836	82 PVBZ 1718	2187
7. L 11076	1071	LM 21525	1177	L 11093	834	82 PVBZ 1824	2171
8. LM 21306-0	1068	82 PVBZ 1901	1163	L 10111	803	L 10110	2130
9. L 10323	1068	L 10238	1161	82 PVMX 1637	786	L 10146	2110
10. L 11732	1048	L 12155	1153	A 251	782	ESAL 507	2103
$\bar{X}_{10}$	1096		1259		856		2215
Average of breeding lines (n=89):	767		875		512		1666
			Common Checks				
1. IPA 7419	1010	JALO EEP 558	1114	IPA 7419	812	JALO EEP 558	2017
2. CARIOCA	1024	AROANA	901	CARIOCA	419	AROANA	1783
3. PARANA-1	976	MUL. V. ROXA	900	PARANA-1	765	MUL.V.ROXA	1509
4. AROANA	1025	PARANA 1	831	AROANA	1037	PARANA 1	1491
5. MUL.V.ROXA	659	CORNELL 49242	761	MUL.V.ROXA	607	CORNELL 49242	1404
6. JALO EEP 558	804	CARIOCA	734	JALO EEP 558	631	CARIOCA	1130
7. CORNELL 49242	979	IPA 74-19	411	CORNELL 49242	380	IPA 74-19	959
$\bar{X}_7$	925		807		664		1470

(Continued)

Table 11. (Continued)

IRECON 85	POCO VERDE CON.85		IRESOl 85		POCO VERDE SOL.85
		Local Checks			
1. AGENORZINHO	680	1613	EPABA-1	693	2043
2. EPABA-1	674	1564	EPABA-1	637	1815
3. AGENORZINHO	513	1415	AGENORZINHO-1	979	1718
4. EPABA-1	643	1097	AGENORZINHO-2	657	1680
$\overline{X}_4$	628	1422		742	1814
Mean (n=100)					
LSD (5%)	379			280	
CV (%)	24.7			26.9	

CAM at IAPAR-IRATI/PR, 1985

In September 1985, 1,848 lines from CAM were tested at IRATI/PR. All CIAT entries that produced seed in CAM-Goiania (advanced breeding lines EP, VEF and Anthracnose source lines) were included. Due to drought conditions, Anthracnose did not occur although the nursery was inoculated twice. Adaptation and bacterial blight incidence were evaluated.

Introduction nurseries conducted by IPA - Belem-Sao Francisco

Out of the 804 materiales introduced from Breeding II (see previous section on germplasm flow to Brazil) planted at Belem-Sao Francisco, 76 were selected because the majority were susceptible to Fusarium. These 76 advanced breeding lines will be tested again at the Belem Sao Francisco station along with 185 advanced breeding lines from crosses made at CIAT.

The results of the adaptation and disease nurseries in CAM-Capivara Goiania, IPA-Belem Sao Francisco, anthracnose and adaptation nurseries at IAPAR-Irati/PR, will be compiled and distributed to all collaborators and be made available to all interested parties.

Segregating populations that entered Brazil prior to the joint breeding Project.

Two hundred ninety crosses in F2 and F3 (175 and 115) entered Brazil in early 1984 and were distributed to the corresponding scientists and they have evaluated at least two generations. The best of these lines will enter the EPL (Ensaio Preliminar de Linhagens) and be tested in at least two locations.

Anthracnose project. The 150 populations of F2 and F3 generations produced 486 advanced lines which are now being field tested under inoculation at Capivara.

Angular leaf spot project. The 30 populations of F2 and F3 generations produced 151 lines and are also being field tested at this time.

Common bacterial blight project. The 33 populations produced 531 advanced breeding lines.

Drought stress project. Eleven crosses were sent to CNPAF and their scientists have selected 45 advanced breeding lines. Crosses using BAT 477 and BAT 85 gave the best progenies.

High yield potential project. The 123 crosses produced 612 lines. At the moment, only 111 lines will be tested further in the preliminary yield trials.

Low soil phosphorus. During the first semester of 1985 the F5 and F6 generations of the low soil P project could not be evaluated

because the P-stress was too high. In the second semester only seven populations were selected and single plant selections were made. Some 114 lines are now in progeny testing.

Ensaio Estadual de EMGOPA

Tables 12 and 13 show the results of the state trials conducted by EMGOPA in six locations in the principal bean growing areas of the state of Goias.

The 20 black-seeded materials tested showed non-significant yield differences in all locations. Most of them were also susceptible to anthracnose and ALS. Only BAT 67, A 227, A 237, RAI 72 and RAI 76 possess anthracnose resistance (Table 12).

In the 20 colored materials tested, EMGOPA Ouro (A 295) was the most stable cultivar over all locations (Table 13), followed by LM 30068, XAN 57 and BAT 363.

Introduction nurseries conducted by CNPCO in 1984

In 1983 CNPCO received one set of EPR cream seed. The results of the nursery are shown in Table 14 and 15 for Poco Verde and Nossa Senhora das Dolores sites, respectively. The Carioca seed types performed well at both sites e.g. A 247, A 252.

Table 12. Mean production (kg/ha) of 20 lines/cultivars of black beans, obtained in the "dry" season, in six towns of the state of Goias, 1985.

Line/cultivar	Goiania	Anapolis	Pirenopolis	Santa Isabel	Itapuranga	COOPA/DF	Mean
SPB 1	1368a*	1325a	1223ab	1227abc	1527ab	1750ab	1403
ICA COL 10103	1454a	1177a	1441a	807abc	1617ab	1781ab	1379
BAT 1647	1225a	1254a	923abc	847abc	1729a	1979ab	1326
Ouro	971a	1257a	695bc	1008abc	1671ab	2081a	1294
BAT 451	1117a	1241a	1095abc	1244ab	1579ab	1427ab	1284
Carioca	1303a	1244a	1255ab	694bc	1256ab	1885ab	1273
BAT 67	1190a	1417a	654bc	1083abc	1613ab	1661ab	1270
FMP 84	910a	1452a	816abc	1312a	1427ab	1219b	1189
FT 83 160	894a	1278a	959abc	899abc	1291ab	1708ab	1171
A 227	1151a	1296a	695bc	899abc	1367ab	1604ab	1169
CNF 178	1093a	1377a	673bc	1045abc	1373ab	1448ab	1168
Rico 23	1195a	1294a	728abc	625c	1461ab	1583ab	1148
A 237	1017a	1454a	735abc	1105abc	1185ab	1281ab	1129
FT 83 195	1161a	1193a	715abc	849abc	1209ab	1604ab	1122
Rio Tibagi	867a	1216a	1074abc	651bc	1222ab	1656ab	1114
RAI 72	849a	1411a	396c	1212abc	1253ab	1531ab	1109
Porrillo Sintetico	1277a	1228a	871abc	671bc	1141ab	1437ab	1104
CNF 120	827a	1409a	646bc	793abc	1366ab	1552ab	1099
Preto Caruaru	1052a	1339a	925abc	719abc	1071b	1463ab	1095
RAI 76	854a	1332a	723abc	891abc	1271ab	1500ab	1095
Mean	1089	1310	862	933	1382	1605	
C.V.(%)	22,3	14,1	27,3	21,3	15,3	15,3	

* Means of the same column, followed by the same letters do not differ significantly between themselves, at the level of 5% probability, by Tukey's test.

Table 13. Mean production (kg/ha) of 20 lines/cultivars of colored beans, obtained in the "dry" season, in six towns of the state of Goias, 1985.

LINE/CULTIVAR	Goiania	Anapolis	Pirenopolis	Santa Isabel	Itapuranga	COOPA/DF	Mean
EMGOPA 201-Ouro	1336abc*	1588abc	947ab	815abc	1678a	2219a	1430
LN 30068	1403abc	1809a	1070ab	798abc	1603ab	1552abcde	1372
XAN 57	1554ab	1486abc	848ab	529abc	1680a	1833abc	1321
BAT 363	1480abc	1619abc	575ab	1065a	1317abc	1729abcd	1297
Ayso	1361abc	1429abc	688ab	857abc	1417ab	1698abcde	1252
Carioca	1237abc	1370abc	1006ab	727abc	1289abc	1854ab	1247
Roxao RG	1610a	1566abc	845ab	457bc	1393ab	1594abcde	1244
LM 10089	1225abc	1359abc	1145a	668abc	1163abc	1875ab	1239
XAN 37	1373abc	1448abc	471ab	620abc	1569ab	1906ab	1231
LM 10348	1126abc	1692ab	949ab	655abc	1507ab	1312abcde	1207
IPA 7419	1205abc	1447abc	913ab	638abc	1257abc	1750abcd	1202
Parana 1	1235abc	1455abc	889ab	682abc	1185abc	1521abcde	1161
Ricopardo 896	1231abc	1540abc	647ab	617abc	1863abc	1510abcde	1151
Vermelho	932bc	1444abc	725ab	371c	1567ab	1635abcde	1112
Rosinha	865c	1348abc	879ab	993ab	1142bc	1031bcde	1043
A 395	1277abc	1382abc	317b	593abc	1317abc	1323abcde	1034
CNF 13	1029abc	1067c	972ab	696abc	1285abc	865de	985
CNF 05	997abc	1231abc	422ab	925abc	1378abc	917cde	978
Rosado	1027abc	1182bc	439ab	754abc	895c	1458abcde	959
CNF 10	915bc	1072c	339ab	674abc	1337abc	781e	853
Mean	1221	1430	754	707	1367	1518	
C.V.(%)	17,0	13,2	32,2	27,1	12,3	19,7	

* Means of the same column, followed by the same letters do not differ significantly between themselves, at the 5 % level of probability, by Tukey's test.

Table 14. Yield, 100 grain weight and days to flowering of the 20 best lines planted by CNPCO in Poco Verde in 1984.

Identification	Days to Flowering	100 grain weight (g)	Yield kg/ha
1. A 247	40	21	970
2. BAT 336	41	20	937
3. A 358	41	20	920
4. IPA CV 7019	40	20	837
5. A 246	40	23	743
6. EMP 117	41	19	727
7. A 353	41	18	690
8. A 354	41	18	680
9. IPA CV 7310	42	24	677
10. A 357	43	17	676
11. A 286	41	15	670
12. A 322	31	27	603
13. A 268	41	23	603
14. VERMELHO	37	35	583
15. A 249	41	20	583
16. CENA 164	41	19	577
17. A 357	35	24	573
18. A 281	43	17	573
19. IPA CV 9245	45	17	550
20. AROANA 80	41	23	550

Table 15. Yield, number of pods per plant and ALS reaction of the 20 best lines planted by CNPCO in Nosso Senhora das Dolores in 1984.

Identification	ALS Reaction[a]	Pods/ Plant	Yield kg/ha
1. A 252	0	5.1	1323
2. Rico Pardo 896	2	8.6	931
3. A 296	0	7.0	925
4. CNF 0167	3	5.2	919
5. CNF 0168	3	5.5	885
6. IPA CV 9245	1	5.5	883
7. JALO EEP 558	0	7.7	882
8. A 290	2	4.9	759
9. IPA CV 7310	0	3.3	735
10. A 339	1	3.3	700
11. A 338	0	6.1	695
12. A 340	0	4.5	694
13. A 247	3	4.2	632
14. IPA 1	1	4.5	616
15. A 282	2	4.1	593
16. A 364	1	2.5	585
17. IPA CV 4131	3	5.3	552
18. VERMELHO	3	5.9	533
19. A 391	1	6.2	515
10. A 242	3	4.1	515

[a] ALS Reaction: 0 - No Symptoms
1 - Light
2 - Moderate
3 - Severe

D. Peru

Introduction

The CIAT regional project to promote research and crop extension of beans in Peru has been operating for two-and-a-half years. Last year, the project continued to support the development of this crop in the 16 regional centers or CIPA's of INIPA. Working priorities have been given to beans together with nine other edible legume species which are managed in the Peruvian national program.

Genetic improvement of bean varieties has been given maximum promotion since to date this technology is considered to be the most efficient for the immediate increase of the productivity of this crop in the three agroecological regions in the country.

On the coast, the project's efforts have been concentrated in studies on the use and efficient management of irrigation water and genetic tolerance or resistance to BCMV, to rust and to nematodes.

In the Sierra region, taking advantage of the advanced bean lines which have been developed with disease resistance, a procedure was established to evaluate this new technology in other areas of the Peruvian Sierra.

In the Selva region (the tropical rain forest) the project opted for the training of scientific personnel in specific areas of bean production to most efficiently advance the projects in this region of the country.

Main Results and Research Advances

With respect to the genetic improvement of bean varieties, INIPA has managed to officially deliver to farmers, six new commercial varieties of beans, an event which has not occurred in the country for more than 10 years. Of these varieties (Table 1), three have been developed to promote bean production in the Sierra, particularly in the production zones located in the departments of Cajamarca and Cuzco. Of the other three varieties for the Coast, two (Blanco Chancay and Bayo Florida at least maintained bean production in the department of Lambayeque, while similar varieties are being developed with resistance to BCMV and to rust. The variety Blanco Chinchano which is resistant to BCMV is one of the first varieties to increase the area under bean production in the Valle de Chincha where 1,800 ha were planted in 1974 and at present only 500 ha are planted.

Other highly promising experimental varieties that are being intensively evaluated in the Valle de Chincha are: CIFAC 1277 and CIFAC 1288 (Table 2).

These bean lines are first to be developed with resistance to BCMV and to rust with good adaptation in the Valle de Chincha since their experimental yield (1.9 t/ha) is equal to that of the regional variety Canario Divex 8120 which is presently planted commercially.

Table 1. Commercial varieties of beans released officially by INIPA in 1985.

Variety	Grain type		Zones recommended for planting	Production system	Outstanding characteristics
	Color	Size (g.)			
Blanco Salkantay	Big white	65.0	Cuzco	Assoc. with maize	High productivity
Rojo Mollepata	Big red	65.0	Cuzco	Monoculture	High productivity Tol. halo blight
Blanco Chinchano	Small white	20.0	Central Coast	Monoculture	High productivity resist. BCMV
Gloriabamba	Medium Bayo	35.0	Cajamarca	Association with maize	High productivity very early maturing resist. anthracnose
Blanco Chancay	Big white	42.0	Lambayeque	Monoculture	High productivity
Bayo Florida	Big Bayo	43.0	Lambayeque	Monoculture	High productivity

Table 2. Experimental yield of bean lines with resistance to BCMV and rust.

Code	Identification	Grain color	Grain size (g)	Yield (t/ha.)[a]
CIFAC 1277	CC 7332-4-2-1-3-CM(10-C)-M-M	Yellow	43.0	1.9
CIFAC 1288	CC 6002-14-3-CM(8A)-4-1-2-CM(20B)	bayo	24.0	1.9
FR 2716	Canario Divex 8120 (Local Variety)	Yellow	45.0	1.9

(a) Planting date: March 4, 1985

Of these lines, CIFAC 1277 with a yellow grain type will be evaluated next year with farmers on semicommercial lots to validate its release as a new commercial variety for the Valle de Chincha.

Another significant advance for the future development of other productive zones of beans in the Sierra has been the establishment of the first network experiments such as the Uniform Yield Trial for Climbing Beans for the Sierra/1985 (Table 3) and the Uniform Yield Trial for Bush Beans for the Sierra/1985 (Table 4). In both trials the best advanced lines have been included from the regional programs of Cuzco and Cajamarca which have high productivity and resistance to several diseases in the zone. These experiments have already been distributed for planting in the 10 CIPA's or regional centers in the country.

Table 3. Selected lines forming the Uniform Yield Trial for Climbing Beans for the Sierra/1985, INIPA-Peru.

Code	Identification	Grain type: Color	Grain type: Size
CAFEM-1	G 10889	White	medium
CAFIM-1	Gloriabamba	Bayo	medium
CAFAM-1	Puebla 444	Yellow	medium
CAFEM-2	Cajamarca 64-1	White	medium
CAFOG-30	GC-64-54-82	Cream/purple	big
CAFEN-1	Blanco Salkantay	White	big
CAFYG-20	GC-61-50-82	Bayo	big
CAFOG-31	VEF 83-1368	Yellow/brown	big
CAFOG-32	VEF 83-1342	Cream/red	big
CAFAG-1	VEF 83-1364	Yellow	big
CAFEO-1	(Pendiente)	White	medium
CAFEB-1 (LOCAL CHECK)	(Pendiente)	White	small

Table 4. Lines selected to form the Uniform Yield Trial for Bush Beans for the Sierra/1985, INIPA-Peru.

Code	Identification	Grain Type	
		Color	Size
CAFRG-1	Royal Red x Montcalm	Red	Big
CAFOG-2	Cargabillo x BAT 1386	Red/cream	Big
CAFOG-3	G 4432 x G-3710	Pink	Big
CAFIG-4	G 6592 x G-72	Bayo	Big
CAFOG-5	G 6592 x A 487	Guinda	Big
CAFOG-6	G 4452 x BAT 1582	Guinda/cream	Big
CAFOG-7	BAT 1276 x G 12666	Pink	Big
CAFYG-8	Perú 69 x G 6415	Bayo	Big
CAFOG-9	G 14307 x BAT 1386	Guinda	Big
CAFOG-10 (LOCAL CHECK)	G 6592 x A 487	Guinda	Big

Adaptation to drought

On the coast of Peru due to the semi-desert type characteristics and soils with a high sand content, irrigation water must be used as efficiently as possible. This has resulted in studies which began in 1984 in the Valle de Chincha of bean lines for their tolerance to drought. These are evaluated providing only one irrigation prior to planting plus a supplementary irrigation at flowering.

To date, six lines have been selected for their performance (Table 5) due to their good adaptation and their superior yield when compared with the regional variety. These lines will be evaluated next year in uniform yield trials.

Table 5. Bean lines selected for their performance in drought tolerance trials, Valle de Chincha, Peru, 1984-85.

Line	Type of grain		Growth habit
	Color	Size (g)	
A 59	Brown	28.0	II
San Cristóbal 83	Mottled red	32.0	III
BAT 1393	Bayo	49.0	I
G 4523	Mottled red	45.0	I
V 8025	Black	24.0	III
G 4495	Black	25.0	II

Resistance to Nematodes

The damage caused by the nematode *Meloidogyne sp.* on the coast of Peru (together with root rots) is one of the biggest factors which has contributed to the reduction in the area planted to beans at present. Of the studies being carried out in the Valle de Chincha, one deals with the genetic resistance to these nematodes. As can be observed in Table 6, five lines have demonstrated resistance and have been selected for further evaluations. Some of these lines such as P.I. 313 709 (medium sized yellow grain) and Nema Snap are being crossed with regional varieties from the coast.

Training Advances

Training of scientific personnel in the national grain legume program of INIPA continues to be promoted to the maximum not only through special courses on beans at CIAT but also in courses carried out in the country. Last year, four scientists visited CIAT of which three work in the humid tropics of Peru. Over the short term, this has led to more efficient management of the bean projects in these zones.

Of the courses organized by CIAT-INIPA in 1985, the III Intensive Postgraduate Course in Research and Bean Production was carried out in Huanuco. In the Cajamarca region phases 1 and 2 were held of the I Intensive Postgraduate Course in On-Farm Bean Research. The courses trained 45 scientists.

Conclusions

With more productive varieties being developed in 1985 and which will also be obtained in 1986, it is highly probable that over the next few years there will be significant increases in bean production, this change being initiated in the production zones of Cajamarca, Cuzco and the central coast of Peru.

Table 6. Bean lines selected for their resistance reaction to nematodes in the Valle de Chincha, Peru, 1985.

Line	Identification	Grain type		Presence of galls on roots[a]
		Color	Size	
G 6278	Manoa Wonder	brown	medium	1.0
G 2587	P. I. 313 709	yellow	medium	1.0
G 3736	Alabama-1	black	small	1.0
A 211	-	black	small	1.0
FR 2811	Nema Snap	white	medium	1.0
FR 2716	Canario Divex 8120 (Check)	yellow	medium	2.6

[a] Reaction to nematodes: 1 = without galls;
5 = many galls.

E. Africa

Introduction

Three regions are now distinguished in Africa with respect to bean research: The Great Lakes region (Rwanda, Burundi and the Kivu province of Zaire); Eastern Africa (Ethiopia, Kenya, Somalia and Uganda); and Southern Africa - comprising the SADCC group of countries (Southern Africa Development Coordination Conference) (Tanzania, Malawi, Mozambique, Zambia, Swaziland and Zimbabwe being the most important for beans).

The germplasm improvement strategy involving the CIAT breeding program and African regional and national programs continued as outlined in the 1984 annual report for eastern Africa. Information on breeding and advanced line nurseries grown in Africa was used to plan crosses. The number of crosses made for national programs in Africa is shown in Table 1. The crosses aim to incorporate the specific resistance factors listed in the 1984 CIAT Bean Program Annual Report into African-adapted backgrounds, both local germplasm and materials introduced from CIAT. Most crosses were for the Great Lakes, where a strong regional program already operates.

Table 1. Crosses made at CIAT for Africa

Region	Country	No. of crosses
Great Lakes	Rwanda	174
	Burundi	45
Eastern Africa	Kenya	27
	Uganda	11
Southern Africa	Malawi	8
	Tanzania	51
	Zimbabwe	6
	Others	45
	Total	367

Products of the crosses were supplied in the form of bulked F2 and F4 populations, early generation progenies and families and advanced lines of the VEF, EP and IBYAN international nurseries. The numbers of these different sets of materials supplied for national programs in Africa are summarized in Table 2. National programs are encouraged to return superior materials they have selected in segregating populations to CIAT for inclusion as VEF candidates. Third country quarantine facilities have been established at NVRS, Wellesbourne, England to enable this transfer.

Information generated in Africa serves in the identification of the major constraints to bean production and of superior breeding materials. Such information is vital to the development of an effective and efficient breeding program, including the choice of parents and the planning of selection and testing strategy.

Great Lakes

Introduction

The objectives of the Great Lakes Regional Project in central Africa, funded by the Swiss government (SDC), are to strengthen both national reseach capacity and intraregional cooperation for the development of improved bean production technology to increase bean production in the region. The project works with three national institutions: l'Institut des Sciences Agronomiques du Burundi (ISABU), l'Institut des Sciences Agronomiques du Rwanda (ISAR), and l'Institut National des Etudes et Recherches Agricoles (INERA) of Zaire. Collaboration with development projects, especially in on-farm research, has also become an important project strategy. The Agro-Pastoral Project (GTZ) and Project Agricole de Kibuye (SDC), have been particularly helpful in this regard.

The report which follows represents the work of three national reserch institutions working with the CIAT regional team in the great lakes region. Each of the collaborating institutions will prepare a separate annual report covering the work of the national program in more detail. This report should be read as a syntheses of regional activities of which each national effort is a part and should not be interpreted as a report on the work of CIAT in isolation.

Both the regional project and the national programs were reinforced by additional staffing this year. The regional project was reinforced by the arrival of the project agronomist. All regional project positions are now filled. New national program staff assignments include the addition of a full time legume pathologist at INERA, half time bean pathologists at both ISABU and ISAR and a full time bean breeder/agronomist at ISAR. Additional technical staff were also assigned to the legume program at ISAR and ISABU. Increased national program staffing and CIAT support for their activities is increasing the region's capacity to develop competent and effective bean research programs.

Agreements of cooperation have now been signed and ratified with both the Burundian and Rwandan governments. The government agreement with Zaire is still in process.

Summary of 1985 Key Activities

Key activities during the September 1984 through the August 1985 agricultural year included continued emphasis on intraregional cooperation and expanded on-station and on-farm research activities. All project research was carried out in close collaboration with one or more of the national programs in continued reinforcement of national programs.

Intraregional cooperation was intensified this year through several activities, such as: (1) the continuation of the regional advanced varietal trial containing the most promising varieties of each of the national programs; (2) the initiation of the regional cooperative disease resistance nursery (the PRER, Pepiniere Regional de Evaluation de Resistance); and (3) the first regional seminar on bean production and research held in Bujumbura, Burundi, May 20-25, 1985, followed by a meeting of national coordinators at Mulungu, Zaire, October 29-31, 1985.

On-station research activities in breeding and pathology were expanded at all three national programs this year. Data from varietal cooking time studies are showing large cooking time differences among national program varieties, which have important implications relative to consumer acceptability.

On-farm research was expanded into Burundi and Zaire this year. An extended network of on-farm research was developed in Rwanda in cooperation with rural development and extension projects. Linking projects with the capacity to do varietal testing and extension with ISAR research is a key element in developing an efficient on-farm testing and extension system. On-farm research currently includes: (1) diagnostic research, including exploratory trials and bean production/consumption surveys; and (2) varietal trials, where varieties are rated for farmer acceptability, for yield and for other agronomic factors.

Training and Regional Information Exchange

One scientist each from ISABU and ISAR spent a four-month training period at CIAT in Colombia this year. In addition, two other scientists from Burundi and Zaire attended the CIAT International Trials Workshop in November 1984. The project also sponsored a visit by two ISABU scientists to the three principal ISAR research stations to evaluate the regional advanced variety trial and other nurseries.

The first regional symposium on bean production and research in the Great Lakes Region was held by ISABU in cooperation with the regional project May 20-25, at Bujumbura, Burundi. The primary purpose of the meeting was to bring together bean researchers and seed production and extension officers to share information on production

problems, past and current research and current seed production and extension activities. Approximately 50 persons attended the seminar, including bean researchers from the three national programs, and extension or seed production officers from ministries of agriculture and projects. A total of 37 presentations were made over three days, with two and a half days reserved for visits to three of ISABU's research stations, a rural development project (SRD Kirimiro) and farmers' fields. Regional meetings such as this promise to turn into an annual forum for bean scientists in the region to discuss research problems and to promote further avenues of cooperation.

In addition, a regional on-farm research orientation workshop was held in Kigali, under ISAR auspice, from November 4-9. Some 35 Senior research administrators, researchers, project directors and university and ministry representatives from the three countries took part. The workshop resulted in the formulation of strong recommendations to place increased emphasis on on-farm research and to promote training and education in this field. As part of the continuing inter-center collaboration in OFR, CIMMYT, CIAT, IITA and CIP all played active roles in assisting ISAR in holding this workshop.

Varietal Development and Pathology Research

Increased national program staffing combined with CIAT support is increasing the capacity within the region to undertake effective varietal development and pathology research activities. Current breeding/pathology strategies to increase bean productivity remain cultivar improvement and the development of cultural techniques for disease and insect control that are compatible with farmer requirements. These strategies are based on diagnostic on-farm research.

Currently, national varietal selection programs are emphasizing yield breeding (selection for general adaptation), incorporation of disease resistance, tolerance to drought (earliness) and tolerance to poor soil fertility.

Varietal Introductions

Introduced germplasm continues to show much promise in the Great Lakes region either for eventual release as varieties or as donor varieties for crosses with local germplasm. The quantity of germplasm introduced into the region this year has increased with improved national program capacity for varietal evaluation (Table 1). Nearly double the number of advanced lines were introduced to the region in 1985 as compared to 1984. Varietal selection activities have especially increased at INERA during 1985. In 1984, only three IBYAN international trials and 48 advanced lines were introduced for evaluation by INERA.

Introduced germplasm now forms a large percentage of the varieties in the region's advanced bush bean trials (Table 2). Climbing bean introductions also continue to show much promise in on-station yield trials. This is especially apparent in Rwanda where

Table 1: Germplasm originating at CIAT introduced and evaluated in the Great Lakes region in 1985.

Location		IBYAN yield trials	Advanced[b] lines	Segregating populations
ISABU	(Burundi)			
	1985 A[a]	3	884	95
	1985 B	1	330	30
ISAR	(Rwanda)			
	1985 A	3	771	112
	1985 B	3	1275	386
INERA	Zaire			
	1985 A	2	390	28
	1985 B	2	283	0
	TOTAL	14	3933	651

[a] 1985A: January harvest, 1985B: June harvest

[b] Germplasm accessions from Latin America or breeding lines developed at CIAT.

Table 2. Varieties selected for advanced national program yield trials in 1986.

ISABU ESSAI DEFINITIVE		ISAR ESSAIS MULTILOCATION			
Variety	Origin	Variety	Origin	Variety	Origin
BAT 1375	CIAT	Rubona 5	Colombia	Kibobo	Rwanda
AROANA	Brazil	Ikinimba	Rwanda	Mtekerabasilimu	Rwanda
A 410	CIAT	Inyumba	Rwanda	Mbangarumbise	Rwanda
BAT 1386	CIAT	G 2816	Mexico	G 12470	Peru
PVA 779	CIAT	G 11060	Mexico	XAN 76	CIAT
HM 5-1	ISABU	G 13671	Mexico	A 197	CIAT
HM 21-7	ISABU	PVA 563	CIAT	Kilyumukwe	Rwanda
BAT 1426	CIAT	PVA 1272	CIAT	A 483	CIAT
HM 5-5	ISABU	PVA 555	CIAT	A 484	CIAT
PVA 1186	CIAT	Kirundo	Burundi	Bayitungirubwiza	Rwanda
M 75	ISABU	A 370	CIAT	A 490	CIAT
INERA		ESSAI COMPARATIVE			
Rubona 5	Colombia	D6	Unknown	MCD 230	CIAT
Kilyumukwe	Rwanda	Nakaja	Zaire	PVA 880	CIAT
Kirundo	Burundi	Mukinga	Zaire	PVA 781	CIAT
Mutiki 2	Rwanda	BAT 1297	CIAT	PVA 702	CIAT
Urubonono	Burundi	PVA 555	CIAT	PVA 702	CIAT
Inyumba	Rwanda	PVA 901	CIAT	PVA 359	CIAT
Ikinimba	Rwanda	Mungu	Zaire	Nainde Kyondo	Zaire

more emphasis is being placed on climbing beans (Table 3). The large numer of introductions of advanced lines is in fact testing national program capacities for effective evaluation, especially as many varieties from previous introductions are returned in ongoing varietal development.

Many varieties and breeding lines are also introduced to national programs primarily as sources of disease resistance. Sources with resistance to anthracnose (Colletotrichum lindemuthianum), angular leaf spot (Isariopsis griseola), Aschochyta and BCMV are required most urgently. Best adapted sources (originating from introductions such as the BALSIT, IBAT and crossing blocks) are evaluated further in cooperation with national programs in the region's disease resistance nursery, PRER, over a number of seasons and various agroecological zones in Rwanda, Burundi and Zaire. In this way, the stability of resistance is measured over time and region. For example, the best sources of resistance to Isariopsis at Rubona were then planted in two

Table 3. Multilocation yield trials of climbing beans in monoculture.

Variety	Origin	M.A.[a]	Location			Avg	Observation
			H.A.[a]	(north)	Crest[a]		
1. G 858		CIAT	1899	2837	1351	2029	Late
2. G 2333		CIAT	1616	2973	1423	2004	Early
3. G 811		CIAT	1674	2955	982	1870	Average
4. Mixture ISAR 85		ISAR	1615	2708	928	1750	Variable
5. C 8		Rwanda	1610	2274	910	1598	Average
6. Urunyumba 3		Rwanda	1449	2162	685	1432	Early
7. Gisenyi 6		Rwanda	1557	1904	1059	1507	Early
8. Ica Viboral		CIAT	860	2311	1011	1394	Late
9. Cajamarca		Peru	1066	2047	1077	1397	Late
Local mixture			1498	773			

[a] M. A. = Mid altitude, H. A. = high altitude, Crest= Zaire-Nile Crest.

additional locations in the second season of the PRER. Reactions of the cultivars to Isariopsis are presented in Table 4. In general, reactions to angular leaf spot in Rwanda and Zaire were similar under high disease pressure. However, two lines, VCA 81018 and XAN 122, were relatively resistant in one location but very susceptible at the other, indicating possible pathotype differences within the region.

Best adapted and most stable resistant lines are used as parents in the crossing programs at CIAT and by the countries in the Great Lakes region. These lines are also retained in the PRER for continued evaluation of stability. A list of lines currently used as parents is given in Table 5. Changes have occurred in listings since last season either because lines were found to be more susceptible than first indicated, or their yields were too low. Although new sources were added many good sources of resistance were ommited due to poor adaptation and due to ample availability of better resistance sources particularly for anthracnose.

Intraregional germplasm exchange

Germplasm exchange among the region's national programs is important in increasing the efficiency of the national varietal development programs. This occurs through informal exchanges and the regional advanced variety trial. In 1985, there were several informal germplasm exchanges among the three national programs of the region. An example is the introduction to Burundi and Zaire of 25 climbing bean varieties from Rwanda and the transfer of 23 segregating populations from the ISABU breeding program to Rwanda and Zaire.

The regional advanced variety yield trial was planted in both seasons in 1985 and for the first time also included varieties from INERA (Table 6). The trial's primary objectives are intraregional varietal exchange and evaluation of the most promising varieties over a wide range of ecological conditions within the region. The trial has generated much enthusiasm for intraregional cooperation. Four to six of the most promising varieties of each national program were included in the trial. The same trial design was used as reported in the 1984 CIAT Bean Program Annual report. The four varieties which stood out as high yielding over several sites are: Kirundo and Urubonobono from ISABU and Ikinimba and Rubona 5 from ISAR. It is of concern, however, that three of these four varieties, except Kirundo, had questionable farmer acceptability in on-farm trials.

Regional management of segregating generations

Though many varietal introductions show promise as high yielding varieties, local management of segregating populations offers clear advantages of increased variability for the breeding programs of the region. These programs are now developing their technical capabilities sufficiently to place more emphasis on local management of segregating populations. At present, introduced or locally collected varietal accessions still form the largest proportion of the varietal development programs, but all three national programs are working with segregating populations to some extent, especially ISABU and ISAR. Most crosses managed in the region are currently made at

Table 4. Reactions to angular leaf spot of a selection of lines in two locations each in Rwanda and Zaire.

Identification	Rubona (Rw)		Mulungu (Z)	
	A	B	A	B
A 116	-	1	-	3
A 222	2	3	-	2
A 240	2	3	-	2
A 381	2	3	-	2
BAT 1510	2	-	-	2
Caraota 260	3	3	-	4
Cuva 168-N	3	2	-	4
G 5173	2	2	-	2
I116	2	2	-	3
Matambre negro	2	2	-	3
VCA 81018	2	3	-	6
XAN 58	1	3	-	2
XAN 122	7	6	-	3
Local control	4	4	-	5

Table 5. Best sources of resistance to major pathogens in the Great Lakes region

Ascochyta phaseolorum	*Colletotrichum lindemuthianum*	*Mycovellosiella phaseolina*	*Phaeoisariopsis griseola*	*Pseudomonas syringae* p. v. *phaseolicola*	*Xanthomonas campestris* p. v. *phaseoli*	BCMV
A 345	A 240	A 212	A 381	G 76	BAT 1220	V 8354
A 182	A 252	A 281	A 222	G 89	G 790	ACV 8334
A 116	A 336	A 222	A 345	G 790	Red Koto	ACV 8347
A 185	A 345	BAT 1428	A 152	G 3710		BAN 6
BAT 795	A 140	BAT 160	A 339	G 5477		ZAV 83012
BAT 1225	A 182	BAT 1628	A 163	G 6384		XAN 156
BAT 477	A 262	BAT 1261	A 116	G 6415		ZAV 83057
BAT 1297	A 116	BAT 1375	A 240	G 6416		ZAV 83059
V 8354	A 411	BAT 1297	BAT 76	G 11254		BAN 9
V 8010	A 483	G 3439	BAT 1510	G 14016		CC7556-22-2-1-6
PVA 1406	A 484	V 8336	BAT 431	G 14645		cm (20A)F7
ACV 8334	BAT 431	PVA 1111	G 6071	V 7945		G 3359
VRA 81018	BAT 76	EMP 86	G 5971	BAT 590		BAT 1297
VRA 81022	BAT 1225	ANP 6	G 4129	BAT 1220		PVA 1184
Caraota 260	G 5971	Equador 299	G 5173	EMP 70		PVA 1216
G 5971	G 4129	XAN 90	G 6074			PVA 518
G 35182	G 5173	XAN 156	G 6719			PVA 668
ZAV 83059	G 6074	ENT 141	V 7920			PVA 1428
ZAV 83091	G 35182	PAN 10	ACV 8334			VCB 81012
BAN 6	G 8519	G 6719	Caraota 260			VA 83/841225
	ZAV 83009		XAN 58			PVA 2289
	ZAV 83012		BAN 6			BAT 1373
	ZAV 83041					BAT 1387
	ZAV 83059					
	ZAV 83058					
	ZAV 83091					
	V 8354					
	V 8010					
	V 7920					
	V 8043					
	PVA 1145					
	ACV 8334					
	ACV 8347					
	VRA 81018					
	VRA 81009					
	VCA 81012					
	EMP 90					
	BAN 6					

Table 6. Performance of the four best varieties and local mixture: Great Lakes Regional Advanced Variety Trial 1985A.

Rwerere (Rwanda)	kg/ha	Kisozi (Burundi)	kg/ha	Mulungu (Zaire)	kg/ha
Rubona 5	1944	Urubonobono	1088	Urubonobono	1520
Calima	1371	Inyumba	917	Nain de Kyondo	1420
Inyumba	1675	Ikinimba	862	Ikinimba	955
Kirundc	1606	Kirundo	852	Rubona 5	890
Local mixture	1269	L. mixture	562	L. mixture	655
LSP .05	404		334		315

Rubona (Rwanda)	kg/ha	Karama (Rwanda)	kg/ha	Moso (Burundi)	kg/ha
Urubonobono	1288	Kilyumukwe	1965	Urubonobono	3013
Kirundo	988	Kirundo	1745	Rubona 5	2490
Calima	888	Ikinimba	1670	Ikinimba	2330
Munyu	875	Urubonobono	1570	Mutiki 2	2328
Local mixture	658	L. mixture	1000	L. mixture	2255
LSD.05	NS		326		536

CIAT (Table 1) since CIAT can efficiently provide segregating populations of crosses requested by the national programs. In parallel, though, both ISABU and ISAR are developing their own crossing programs. In 1985, ISAR produced 82 new F_2 populations. Also at ISAR, 224 advanced lines from their breeding program (from crosses made at CIAT or ISAR) entered first level yield trials (essai triage) in competition with introduced and locally collected varieties. Additionally, 14 locally developed lines entered advanced variety trials at ISAR. Most of these 14 lines have Rubona 5 (ICA Palmar), an introduction from Colombia, as one of the parents.

In addition to multiple character selection, subprograms are now being initiated within the region with the objective of specific character improvement. As Ascochyta is an important disease in the region at 1600 a msl and above, both ISABU and ISAR have begun selection programs for the development of increased levels of resistance to Ascochyta based on interspecific crosses (P. coccineus P. vulgaris) received from CIAT in collaboration with the University of Gembloux. These populations are proving difficult to manage because of late maturity and the requirement of a large number of intercrosses among resistant progeny or backcrosses to P. vulgaris to obtain Ascochyta resistant P. vulgaris selections.

Some P. vulgaris accessions have useful intermediate levels of resistance to Ascochyta. But these accessions are either not well adapted or have a small black grain type which is marginally acceptable in this region. Emphasis is now being redirected towards crosses among P. vulgaris accessions with the objective of increasing levels of Ascochyta resistance through selection for transgressive resistant segregants. A second subprogram, for BCMV resistance, was initiated this year at ISAR. More than 100 F_2 populations and segregating lines were screened for resistance at Rubona. BCMV is an important disease in the region and is a major problem during seed multiplication. In addition, climbing beans in general appear to be very susceptible in comparison to bush beans; BCMV is much more pronounced. BCMV susceptibility of climbers may be an important limitation to extending climbing bean culture in the region. One or more necrotic strains are predominant in the region and the I gene resistance which confers immunity in most of Latin America induces systematic necrosis in varieties if infected with necrotic BCMV strains present in the region.

As most of CIAT germplasm has the I gene, this represents a major limitation to the use of this germplasm within the region. High levels of resistance to these necrotic strains are available but are currently restricted to breeding lines that are poorly adapted in the region. The objective of this subprogram is to transfer resistance to locally adapted germplasm which can subsequently be used in multiple factor crosses in the development of new resistant varieties for the region.

Cultural and Chemical Control of Diseases and Pests

To broaden present disease control strategies, alternative methods complementary to resistance are being studied by national programs in cooperation with regional staff. These methods are particularly important in controlling Ascochyta and beanfly where high levels of resistance are not available over the short term and control methods are urgently required.

In 1985, trials were conducted on methods of improving seed selection, the effectiveness of removing infected leaves and highly diseased seedlings on yield area disease development, as well as on the use of selective chemical seed treatments to control beanfly while searching for resistance/tolerance to the pest in P. vulgaris and P. coccineus. Significant increases in yield were observed only in the trial studying the effectiveness of inoculum reduction by removing primary infection sources (Table 7). Removing older infected leaves in particular augmented yield. Chemical seed treatment with Aldrin to control beanfly resulted in marked reductions in infection and improved vigor of bean plants. However, the chemical control is too toxic for use by farmers.

Further research will concentrate on combining cultural disease control methods, and on searching for better insecticides with low toxicity to humans for control of beanfly.

Seed Multiplication

Improvement of seed quality was a high priority for the national programs of Burundi and Rwanda in 1985. Commencement of spraying with phytosanitary products, negative selection of plants and selection of fertile fields has already resulted in a marked improvement in seed sanitation and quality.

Nutrition and Bean Quality Research

One of the objectives of nutritional and bean quality research in the Great Lakes region is to identify important culinary characteristics with genetic variability which influence consumer acceptance of new varieties and to develop screening methods to evaluate these characteristics in advanced lines in the varietal development program. Another objective is to document dietary patterns, bean preparation methods and varietal preferences in various areas throughout the region. Major activities undertaken to meet these objectives include: (1) a bean consumption and preference survey; (2) on-farm sensory evaluation of varietal trial materials; (3) a study to determine the relative influence of variety and environment on cooking time and protein content; and (4) a laboratory screening program of cooking time, water absorption and hard seed for materials in advanced variety trials based at ISAR Rubona. The first two activities are discussed under on-farm research.

Table 7. Effect of removing diseased leaves and seedlings on disease development and bean yield.

Treatments	Total foliar diseases (Mean % surface area infected) R7	R8-9	Yield (kg/ha)
Control	38 a	38 a	393 a
Removal of diseased leaves	36 a	24 ab	657 b
Removal of diseased seedlings	29 a	18 b	500 a
Removal of diseased leaves and seedlings	33 a	16 b	562 b

Varietal/environmental influence on cooking time and protein content

The cooking time of beans in the Great Lakes region is important due to the shortage of firewood caused by the high population density and deforestation for cultivation. Beans are the staple protein source in the region and are prepared on an average of three times per week. Since the fuel requirement for bean preparation is higher than for any other common foodstuff in the diet, bean cooking time to a large extent determines firewood needs. Prior research indicates that environmental effects are important in determining total protein content. However, the relative importance of varietal versus environmental factors influencing bean cooking time have not been well documented.

Activities undertaken to identify a varietal influence on nutritional or culinary quality include: (1) a varietal/environmental influence study on cooking time and protein content; (2) laboratory screening of cooking time of regional trial materials; and (3) a comparison between laboratory screening and sensory evaluation of cooking time of on-farm varietal trial materials.

a. Varietal/environmental influence study on cooking time and protein content

The purpose of this study is to document how cooking time and protein content are influenced by location, variety and season. This

trial will provide information to evaluate the feasibility of developing faster cooking or higher protein bean varieties and to determine the necessary sampling scheme for laboratory screening of quality characteristics. Ten varieties were planted in Rwanda in three locations of differing altitudes over three seasons. Cooking time was estimated using the bar-drop method (CIAT Bean Program Annual Report, 1982).

Results indicate that seasonal effects were insignificant (Table 8). However, highly significant differences in both cooking time and protein content were observed among all three locations. The highest altitude had the fastest cooking time and intermediate protein content. Highly significant varietal differences were observed in cooking time, but not in protein content. Two out of the 10 varieties, Rubona 5 (a red and cream mottled bean) and Kibobo (a black seeded variety) cooked significantly longer than the other varieties (Table 9). Calima was the fastest cooking variety. The range in the cooking time index among varieties was 12 minutes.

Table 8. Analysis of variance in varietal versus environmental influence study of cooking time and protein content over three seasons and three locations.

Independent factors	df	Cooking time index (mean square)	Protein content (mean square)
Location	2	1276.94 **	342.85 **
Variety	9	349.50 **	7.46[b]
Season	2	60.52	172.54[c]
Location x season	3	698.80 **	27.48 **
Location x variety	18	48.01	3.25 **
Variety x season	18	72.78[a]	4.71[a]
Location x variety x season	26	37.54	3.24 **
Rep (Location x season)	16	76.47	2.74
Error	135	29.08	1.26

[a] MS for location x variety x season used as an error term.
[b] MS for location x variety used as an error term.
[c] MS for location x season used as an error term.
** = $p \leq .01$

Table 9. Mean cooking time of varieties in the varietal versus environmental influence study over three seasons and three locations.

Variety	Mean cooking time index (minutes)
Rubona 5	46.39 a*
Kibobo	45.24 a
Kilyumumkwe	40.41 b
Ikinymba	40.04 bc
GIPX-1124	38.35 bcd
Nsizebashonje 4	38.33 bcd
Mutiki 2	36.59 bcd
Nyakizungi	36.36 bcd
Var II	35.52 cd
Calima	34.25 d

* Means within columns followed by the same letter are not significantly different (0.05 level) by LSD.

Concerning protein content, results from this study support prior research findings demonstrating a large environmental influence. The inability to distinguish varietal differences in protein content over different locations and seasons, suggest that a breeding program for high protein content is not feasible. It also seems unnecessary to screen varieties for protein content from only one location or season since single location and single season data will not be representative. Results regarding cooking time, however, indicate that for routine analysis samples may be obtained from only one season and location. To compare cooking times of different varieties, all samples should be obtained from the same location. It would appear that, unlike protein content, cooking time tends to be more influenced genetically than environmentally. This trend was also observed in the laboratory analysis of regional trial materials.

b. Cooking time evaluation of regional trial materials. The 15 varieties in the regional trial at Rwerere, Karama and Rubona were evaluated for cooking time in the food quality laboratory at ISAR, Rubona. (For description of regional trial, see varietal development section). Significant differences in the cooking time index were once again observed among locations and among varieties over locations (Table 10). In contrast to the varietal vs. environmental influence study, a significant interaction was found between location and variety.

Strong differences appear to exist among varieties regardless of location (Table 11). Urubonobono cooked significantly longer than all other varieties, taking nearly twice as long as the fastest cooking variety, Tostado. Five of these 15 varieties were also in the varietal/environmental influence study. Relative cooking times observed were compatible, with the exception of Ikinimba. Mutiki 2 and Calima were relatively fast cooking, Kilyumukwe- medium cooking, and Rubona 5 long cooking. Ikinimba cooked relatively faster in the environmental trial than the regional trial, but was still a medium-to-long cooking variety.

Table 10. Regional trial varieties analysis of variance of laboratory cooking time index obtained for 1985A from three regions in Rwanda.

Independent variables	DF.	Mean Square
Location	2	1061.67**
Variety	14	1715.19**
Location x variety	28	292.97*
Error	225	180.18

** = ≥ .01

* = ≥ .05

Table 11. Mean cooking time of varieties in the regional trial 1985A from Rwerere, Karama and Rubona, Rwanda.

	$\bar{X}$ cooking time index over locations	
Urubonobono	76.83	a *
Karama 1/2	65.28	b
Ikinimba[2]	63.17	bc
M. Local	59.61	bcd
Rubona 5[2]	59.44	bcd
Kirundo[1]	57.17	bcde
Muhinga[1]	55.67	bcdef
Kilyumukwe[2]	53.28	cdefg
Munyu	50.56	defgh
Inyumba	48.11	efgh
Nain de Kyondo	46.33	fgh
D 6	45.11	gh
Mutiki 2[2]	44.11	gh
Calima[1,2]	43.89	gh
Tostado	42.06	h

[1] Varieties unstable over locations.

[2] Varieties also in the varietal/environment influence study.

* Means within columns followed by the same letter are not significantly different (0.01 level) by LSD.

The cooking times of Calima, Kirundo and especially Muhinga were less stable over locations than other varieties. Variety/location interactions may be important depending on the varieties being screened. Neither Kirundo or Muhinga was in the varietal/environmental influence study where significant variety and location interactions were not observed. In general, interaction effects appear small compared to varietal effects.

Compatibility of on-farm sensory evaluations of cooking time with the laboratory cooking time index, and its influence on varietal acceptability. Results of diagnostic surveys indicate that beans are usually cooked without prior soaking for approximately three hours. Cooking is estimated in the laboratory by use of an index. It has not yet been established whether actual differences in cooking time under traditional preparation methods are compatible with the laboratory index of cooking time, or whether varietal differences in cooking time actually influence consumer acceptability. Samples of on-farm varietal trial materials were obtained from 20 farmers in 1985B. Their evaluation of cooking time of these varieties were compared to the cooking time index determined in the laboratory (Table 12). All farmers prepared and consumed the varieties in their own homes.

Table 12. A comparison of farmer's evaluation of cooking time of on-farm varietal trial varieties in the central plateau 1958B with the laboratory cooking time index.

Variety	Farmer evaluation of cooking time[a]	Cooking time index (minutes)	Farmer evaluation to continued planting
Kirundo	1.4 a*	46.0 ab	1.5 a
Kilyumukwe	1.5 a	46.4 ab	1.2 a
Umutikili	1.7 a	42.6 a	1.9 ab
ISAR mixture	2.0 ab	45.7 ab	2.0 ab
Local mixture	2.1 b	42.9 a	1.7 ab
A 197	2.2 b	44.0 a	2.1 ab
Rubona 5	2.2 b	51.3 b	2.1 ab
I Kinimba	2.5 b	61.2 c	2.4 b

[a] Based on a 5 point hedonic scale, 1 = excellent, 5 = unacceptable.

* Means within columns followed by the same letter are not significantly different (0.05 level) by LSD.

Ikinimba and Rubona 5, were rated as the longest cooking varieties both on-farm and in the laboratory. Ikinimba and Rubona 5 were also rated the least preferred varieties for planting. Results of this experiment indicate good compatibility between farmers' evaluation of cooking time under traditional preparation methods and the laboratory cooking index. Long cooking time appears to negatively influence varietal acceptability. The range in the cooking time index between Ikinimba and Kirundo was 15 minutes. The actual difference in cooking time under traditional preparation methods between two varieties which have a 15 minute difference in the cooking time index, and its corresponding impact on firewood consumption needs to be identified.

On-Farm research

A major goal of the regional program is reinforce the national programs' on-farm research capabilities to ensure that the varieties and technologies developed by the national programs are desired by and advantageous to farmers. This research includes: (1) diagnosis and description of farmers' practices, preferences and constraints; and (2) on-farm varietal and exploratory trials including both researchers' and farmers' evaluations of the varieties tested.

Diagnostic research

The on-farm diagnostic research consists of bean production and consumption surveys and exploratory trials to identify limiting

production factors. Ascertaining major production constraints, through both quantitative assessments from exploratory trials and farmers' qualitative evaluations, provide critical information for identifying relevant research strategies. Diagnostic research can provide information for use in varietal selection by identifying the agronomic and quality characteristics which farmers evaluate positively and negatively. Used systematically in varietal screening, this information greatly increases the likelihood of producing an end product that will be acceptable to farmers. Analyzing how farmers themselves diffuse and experiment with new varieties can have a direct impact on the design of on-farm trials and diffusion strategies for new varieties.

Bean consumption and varietal preference survey

Sixty people randomly selected from various communes in southern Rwanda were interviewed during the 1985A season in the prefecture of Butare. An identical survey was conducted in the North of Rwanda, in the prefecture of Ruhengeri in 1984. (CIAT Bean Program Annual Report 1984). The purpose of this survey was to identify preparation methods and preference criteria for bean leaves, green beans, immature dry beans and dry beans.

Much of the information obtained from southern Rwanda, such as cooking time, harvesting and preparation methods, was similar to northern Rwanda. Many of the differences observed may be explained by the dominance of climbing beans in Ruhengeri and bush beans in Butare. The preference for consuming a mixture of different varieties was more fixed in Butare than Ruhengeri, although the consumption of pure varieties was less preferred in both regions (Table 13). The average storage time prior to consumption was longer in Ruhengeri than Butare, indicating that people typically have larger harvests. According to the 1984 Rwandan Ministry of Agriculture survey, 60% of all farms in Butare are one hectare or less in comparison to Ruhengeri where 53% are greater than one hectare. This indicated that larger harvests in Ruhengeri may be due to larger areas cultivated per farm, not higher yield, although climbers typically outyield bush beans. The preference for large seeded varieties was more fixed in Ruhengeri than Butare, possibly because climbing beans have, on the average, a larger grain size. In Butare, grain size preferences for planting were the opposite of preferences for eating. Farmers like larger grains for consumption, but feel smaller seeded varieties yield more. Green bean consumption was also different in the two regions. In Butare, where bush beans predominate, green beans are usually harvested, prepared and consumed with immature dry beans. They are harvested by uprooting the plant containing pods. These plants are often the later maturing plants in a mixture. In Ruhengeri, where climbing beans are widely grown, people pick the pods of the climbing beans and add them as a complement to dry beans. The nutritional implications of these different practices, from the point of view of dry bean production losses and total food value harvested per plant, need to be evaluated.

Table 13: Some differences in consumption survey results between the prefectures of Ruhengeri and Butare (northern and southern Rwanda, respectively).

	Butare[a]	Ruhengeri[b]
Preference to consume beans pure or mixed:		
Preferred mixture	55	33
Preferred pure variety	27	15
No preference	18	53
Length of storage time of dry beans:		
Beans finished next harvest (6 months)	73	54
at harvest (6 months)	22	19
after next harvest (6 months)	5	27
Seed size preference:		
Small (planting)	31 (44)	0 (c)
Medium	33 (33)	8 (c)
Large	36 (23)	92 (c)
Green bean preparation method:		
Green beans are added to dry beans, which have just finishing cooking	6	46

[a] 60 people interviewed 1985A
[b] 100 people interviewed 1984C
[c] Question not asked in Ruhengeri

Some additional questions were identified and included in the survey in Butare based on the results of the Ruhengeri survey (Table 14.) The majority of people interviewed stated they noticed a difference in the cooking time of varieties grown in different fields, and that fields far from the house (which are often less fertile) cook longer. Almost 50% of the people interviewed felt they had enough wood for fuel. The length of time beans require for cooking may be important for the other 50% who experience a fuel shortage. In Ruhengeri, storability after cooking was identified as an important quality characteristic. Storability could possibly be prolonged if the whole pot of beans were reheated for each meal instead of only the quantity for immediate consumption. However, 90% of the people in Butare reheat only a small quantity for immediate consumption. Seventy percent of the respondents said they would stop planting a high yielding variety if it were not good to eat, indicating the importance of culinary and sensory characteristics and the role of beans for home versus market consumption.

Table 14. Some additional questions included in the Butare survey 1985A,[a] not asked in Ruhengeri 1984C[a].

	% replies
Cocking time varies according to field cultivated	92
Beans in field far from house cook longest	88
Have enough wood for cooking fuel	47
Reheat only a part of leftover beans	90
Would discontinue planting a variety if it had good yield but were not good to eat.	70

[a] A: First season, October' 84 planting. C: Dry season, August' 84.

Consumption and production survey work was initiated in Burundi this year. This work was facilitated by the hiring of a female agronomist for on-farm work by ISABU, paid within the ISABU legume program.

On farm exploratory trials quantify information about major agronomic production constraints and together with diagnostic surveys provide data to help establish program research priorities. A secondary use of the trials in Rwanda is to provide baseline data about bean yields in various agroecological zones and to serve as a demonstration tool for promoting awareness to farmers and extension personnel of diseases, pests and soil fertility.

In 1985 a total of 17 trials and 40 replications were installed in six ecological zones in Rwanda with the national program and various cooperating projects. Factors selected for testing were fungal and bacterial diseases, insect pests, soil fertility and acidity. Regional program personnel and extension services participated in the site selection, installation and evaluation. Evaluation consisted of disease, pest ratings and yield assessment at the end of the season. The farmer's role involved sowing and managing the bean field, while the reserach staff laid out the trial and managed treatments. Assessment and harvest were done together with farmers.

Results of two seasons indicate that diseases were the most limiting factor in most regions where the trials were installed (Table 15). In two seasons increases of 35% and 75% over regions were obtained. Ascochyta, anthracnose and angular leaf spot were the most predominant diseases in the regions where fungicide treatments increased yields, indicating that their control should be an important priority for the program (Table 16).

Table 15: The effect of four limiting factors on bean production (kg/ha) in six ecological zones of Rwanda over two seasons.

Season	Treatment	Limiting factors controled	Ecological zones						
			Central Plateau (1650)	Granitic Spur (1663m)	Mayaga (1415m)	Bugesera (1300m)	Z-N divide (2143m)	Buberuka highlands (2107m)	Treatment mean
1985 A	Farmer control	NIL	1804	864		628			1098
	Fungicide/ Bacteriocide	Fungal bac. diseases	2344	1590		619			1518
	Insecticide	Insects	1874	1314		925			1371
	Manure	Soil nutrit.	2097	1507		636			1413
	Lime	Soil acidity	1886	1171		544			1200
	LSD 99%		443	NS		NS			
	LSD 95%		307	NS		NS			
	LSD 90%		253	NS		NS			
	LSD 80%		193	NS		NS			
1985 B	Farmer control	NIL	339	1267	267		444	1500	764
	Fungicide/ Bacteriocide	Fungal/bac. diseases	728	2139	760		1000	2056	1337
	Insecticide	Insects	556	1339	433		1167	1300	959
	Manure	Soil nutrit.	281	1332	507		833	1344	859
	Lime	Soil acidity	381	1229	461		778	1433	856
	Fungicide + Manure						944		
	LSD 99%		264	494	NS		NS	513	
	LSD 95%		191	392	NS		NS	372	
	LSD 90%		157	299	NS		418	316	
	LSD 80%		120	230	NS		306	235	

TABLE 16. Predominance of pathogens and insects on *P. vulgaris* in the exploratory trials in the 1985A and B seasons.

Ecological area	Altitude (mean)	Ascochyta % surf. infected		Anthracno. % surf. infected		*Isariopsis* % surf. infected		Rust % surf. infected		Macrophom. % plants infected		BCMV avge. quot.[(a)]		Com Bac. % surf. infected		Beanfly avge. quot.[a]		Aphids avge. quot.[a]	
		85A	85B	85A	85B	85A	85B	85A	85B	85A	85A	85B	85A	85B	85A	85B	85A	85B
Central Plateau																			
Central Plateau	1650	0.0	0.0	25.0	7.2	18.4	13.7	0.0	0.3	0.0		1.2	0.0	0.0	2.3	7.0	0.0	-
Granitic Spur	1663	0.0	6.5	5.0	4.8	25.0	20.7	0.0	0.1	0.0			0.0	0.0	2.0	3.4	0.0	0.0
Mayaga	1415	-	0.1	-	0.5	-	11.8	-	0.0	-			-	0.0	-	7.0	-	0.0
Bugesera	1300	0.0	-	0.0	-	15.3	-	8.8	-	38.3			6.5	-	7.0	-	0.0	-
Zaire-Nile Divide	2143	-	20.5	-	8.8	-	8.0	-	0.0	-			-	0.0	-	5.5	-	2.3
Buberuka Highlands	2107	-	15.0	-	4.2	-	12.5	-	0.0	-			-	0.0	-	1.5	-	2.3

[a] scale of 1-9 : 1 = no symptoms; 9 = plants killed.

Yield increases due to insect control were on the order of 27 and 25% over two seasons. These increases were directly associated with a reduction in beanfly (Ophiomyia spp.). Beanfly was most prevalent in low lying regions such as the Bugasera, regions of poor soil fertility (the Crest) and late planted fields.

Soil fertility as measured by addition of manure or lime appeared limiting in all regions except the Bugasera and Buberuka. Over regions total yield increases using manure and lime were 29 and 9% respectively and 13 and 12% respectively in each of the two seasons. In the central plateau effects of manure were more prononunced in the first season than in the second, suggesting that either heavier rains leached nutrients and/or encouraged disease development thus negating the effects of manure, or the quality of manure was inferior.

A plus one design was used in 1985 to incorporate four factors considered important in the trials, while maintaining an acceptable trial size for on-farm use. To evaluate treatment interactions, a minifactorial design will be adopted next year. By removing lime as a treatment the same trial size will be retained.

On-farm varietal trials.

The on-farm varietal trials are one of the central elements of the program since, like the exploratory trials, they bring together research, farmer evaluation and extension activities. This year, for the first time, a total of 156 on-farm trials were established in four regions of Rwanda and two regions of Zaire (Table 17). They were organized in close collaboration with the national programs, a number of rural development projects and extension services, whose personnel participated actively in site selection, installation and evaluation. Collaboration with projects which have seed production and extension capabilities enhances the chances for rapid diffusion of acceptable new varieties, as well as promoting effective approaches to on-farm research.

The trials were made easily understandable to farmers by incorporating in their design data from the diagnostic surveys, showing how farmers themselves experiment with new varieties. Methodologies for a program of varietal evaluation and follow-up of varietal use and diffusion have been developed and are currently being tested. The results of the trials form the basis: (1) for recommending or rejecting varieties for the various regions; (2) for feeding additional information on varietal acceptability criteria back into the selection process; and (3) for feeding information on varietal performance, acceptability and diffusion in the form of varietal descriptions forward to the extension and seed production services.

Discussion of yield data. Varietal stability across different conditions is an important characteristic since the region has high environmental variability between seasons and across sites (usually even between sites on the same farm). Thus, average yield may not be the most appropriate basis for varietal selection.

Table 17. Average yields (kg/ha) of varieties tested on-farm during the 1985 crop year Sept. 84-Aug.85) in the Great Lakes region.

Region	Nyabisindu[4]		Ruhashya[1]		Gasenyi[4]	Mayaga[1]	Miti[2]	Bushumba[2]	
Saison / Varietés	85 A	85B	85 A	85 B	85 B	85 B	85 B	85 B	
Ikinimba	1824	1761	1567		700	1361			
Melange local[5]	1717	1294	1329	1029	370	760	835	539	
Kilyumukwe	1789	1324	1438		358	763	837	457	
Rubona 5	1623	1122	1375	1040	366	843	856	238	
Melange ISAR[6]	1765	1480	1521	934	430	1038			
Kirundo	1492	1439		850	426	564			
Mutiki 2			1150						
Umutikili		1137		1005		773			
A 197	1158			1314					
Munyu							509	387	
Muhinga							494	341	
V 79116[3]			1663						
Climbers mixture[3]				1411					Total of trials
Number of trials	41	21	50	14	10	9	7	7	156

1. Rwanda
2. Kivu, Zaire
3. Climbing beans
4. Together with Agro-Pastoral Project (GTZ) and Agricole Kibuye Project (SDC)
5. Farmer's mixture
6. Mixture of 10 best ISAR varieties

The stability analysis of Eberhard and Russel (1966) and Hildebrand (1984) provides useful data on yield stability. Stability is calculated using the regression of specific entries on an environmental index which is based on the average yield of all varieties at each specific site.

Many of the results of this years' on-farm trials were analyzed using this technique. Results show a relatively weak varietal/environmental interaction. Varieties which did well under favorable conditions also tended to be the best under poor conditions. However, relative yield differences were greater under poor conditions (Table 18).

At Nyabisindu (central plateau) among the eight varieties tested, Ikinimba, Kilyumukwe and the ISAR mixture outyielded the farmers' mixtures for both seasons of 1985 Table 18. Ikinimba was the highest yielding variety over all sites with an average yield advantage of 32% over the farmers' mixtures. The ISAR mixture also did well across sites with an overall yield advantage of 10%.

Other varieties may be more specifically adapted. Kilyumukwe did well at Nyabisindu and Ruhashya, but yielded less than the farmers' mixtures at Caseny and Bushumba.

A 197 yielded an average 22% more than farmers' mixtures at Ruhashya but performed poorly at Nyabisindu during the second season.

Table 18. On-farm variety trials Nyabisindu 85A/B: yield advantages of selected varieties against local mixture at different environmental quality levels.

Environmental index variety	Average yield advantage	
	800 kg/ha	2000 kg/ha
Kilyumukwe	+ 10.3% [a]	+ 6.5%
Ikinimba	+ 38.6 %	+ 21.7%
ISAR mixture	11.2 %	+ 6.8%

[a] Calculated yield local mixture = 100%

At Miti in Zaire, Rubona 5 and Kilyumukwe, both introduced from Rwanda, yielded marginally better than farmers' mixtures. However, when both sites (including Bushumba), are taken into account, the farmers' mixtures outperformed all national program selected varieties. This trend may indicate the need for strengthening the varietal selection program for these areas.

Trials at Ruhashya (Table 17) included a climbing bean entry, as a preliminary test of the climbing bean potential in the central plateau region of Rwanda and Burundi. Climbing beans outyielded the farmers' mixtures by an average of 31% over the two seasons, thus corroborating on-station results at Rubona indicating a yield advantage of up to 60% over bush beans.

If production increases from higher yielding new varieties are to be realized, they must be acceptable to farmers to be successfully diffused. This aspect becomes crucial when comparing the relative value of Ikinimba and Kilyumukwe.

Farmer evaluation of varietal trials. In 1985, a new method of including farmers' evaluations in the overall assessment of varietal trial materials was initiated. After the harvest, farmers were asked their opinion about various production and consumption characteristics. They were also asked to prepare, consume and evaluate the trial varieties in their homes. Farmer evaluations were measured using a five point hedonic scale. Culinary characteristics evaluated by farmers include: grain size and color; cooking time; broth quality; taste; waterswelling capacity and storability after cooking. The production characteristics they were asked to evaluate include: plant type, size of pods, number of pods, adaptation to fertile and infertile soils, adaptation under bananas, time to maturity, threshing ability and grain quality. Farmers were also asked how they felt about continuing to eat and plant the six different varieties in the trial.

These evaluations show that yield alone is not necessarily a good indicator of varietal acceptability (Table 19). In the central plateau the highest yielding variety (Ikinimba) was the least preferred, whereas the best liked variety (Kilyumukwe) ranked fifth in yield. There are, however, preliminary indications that under more marginal conditions, such as on the Zaire-Nile Crest, non-yield characteristics are of relatively lower importance. Very significant differences were observed among varieties in farmers' preferences both for eating and planting the trial materials. Kilyumukwe was significantly more preferred than Rubona 5 and Ikinimba for both planting and eating. When consumed alone, Kirundo, Umutikili, and Kilyumukwe were significantly more preferred to eat than the local mixture. No variety was significantly preferred for planting over the local mixture.

Table 19. A comparison of on-farm trial farmer evaluations of varieties with trial yield data in the central plateau of Rwanda, 1985 B.

	Farmer evaluation[a]		Yield[b]	
Variety	(Score)	Rank	(kg/ha)	Rank
Ikinimba	67	7	1650	1
A 197	88	4	1220	2
ISAR mixture	81	6	1215	3
Kirundo	92	3	1073	4
Kilyumukwe	99	1	1053	5
Local mixture	92	3	1048	6
Rubona 5	83	5	1039	7
Umutikili	95	2	1021	8

a The farmer evaluation score is the result of evaluation questions asking farmers how they feel about continuing to grow the variety as they see it in on farm trials. The score is based on a five point scale where: Excellent = 100, Good = 75, Average = 50; Fair = 25; and Poor = 0.

b Based on mean yield data of on-farm trials in Nyabisindu, Ruhashya, and Myaga.

Table 20 illustrates a comparison between the production and consumption characteristics that most clearly differentiate between the most liked, least liked and most diffused new varieties. Farmers realize that Ikinimba outperforms Kilyumukwe on both fertile and infertile soils, however, the variety is severely downgraded for a number of other production characteristics, principally its sprawling plant type, difficulty of threshing and poor grain quality. The sprawling plant type makes weeding difficult and farmers also say that since most of the pods lie on the ground there is greater danger of rot. This is reflected in the low evaluation of Ikinimba's grain quality. A high proportion of the grains were also observed to be of poor quality by the researchers.

Table 20: Results (%) of farmers evaluations of the production and consumption characteristics which clearly differentiated three varieties in on-farm varietal trials at Nyabisindu 1985B.

Characteristics	Pure varieties		
	Kilyumukwe	Rubona 5	Ikinimba
Overall farmer evaluation	94[a]	81	67
Adaptation to good soils	88	98	96
Adaptation to poor soils	82	78	97
Plant type	92	83	54
Grain quality	98	90	60
Threshing ability	100	97	42
Seed color	96	77	33
Broth quality	89	67	38
Cooking time	90	61	65
Seed size	94	67	69
Taste	96	71	62

[a] Results based on 13 farmers.

The culinary characteristics which distinguish Kilyumukwe from Ikinimba and Rubona 5 include seed color, broth quality, cooking time, seed size and taste. Ikinimba, a black-seeded variety, was the only variety that was significantly less preferred because of it's broth quality and seed color. Ikinimba and Rubona 5 were both significantly less preferred that Kilyumukwe for their cooking time, taste and seed size.

For sensory evaluations, the varieties were consumed and evaluated both pure and mixed at 20% of total weight with the local mixture (Table 21). Mixtures in general were equally preferred to pure varieties for eating, however, Kilyumukwe, Umutikili, and Kirundo were preferred pure over all mixtures. In general, Kilyumukwe was the most preferred variety for eating, both pure and mixed. It was significantly preferred pure over the local mixture.

Table 21: Consumption rating when consumed pure or mixed 20% by dry weight with the local mixture in Nyabisindu 1985B.

PURE	Score		MIXED	Score	
Kilyumukwe	1.15	d*	Local mixture	1.61	a
Umutikili	1.38	cd	Kilyumukwe	1.61	a
Kirundo	1.38	cd	Rubona 5	1.61	a
Local mixture	1.61	bc	A 197	1.92	a
A 197	2.0	bc	Umutikili	1.92	a
ISAR mixture	2.15	b	Kirundo	2.0	a
Rubona 5	2.54	ab	Ikinimba	2.15	a
Ikinimba	2.62	a	ISAR mixture	2.15	a
x =	1.85		x =	1.87	

* Based on a 5 point hedonic scale, 1 = excellent, 5 = unacceptable. means within columns followed by the same letter are not significantly different (0.05 level) by LSD.

The order of preference for consuming the pure varieties corresponds closely to the overall farmer evaluation score presented in Table 19. Although no significant differences were observed between varieties when consumed mixed, the rank order differed from pure consumption. Rubona 5, for example, consumed pure is one of the least preferred varieties, but when consumed mixed with the local mixture, is one of the most preferred. Since beans are almost always consumed as mixtures, the low preferrence for Rubona 5 consumed pure should not hinder its acceptance but may influence the level of its incorporation into the mixtures.

On-farm trial follow-up survey. These surveys were started two seasons after farmers had participated in their first on-farm trials, with the objective of starting a regular program of monitoring farmers' use of new varieties. The aspects monitored include: (1) the continued acceptability, or lack of it, of the varieties; (2) the extent to which farmers continue to experiment with the varieties to find their best micro-adaptation on their farm; (3) the channels and

the rate of diffusion of varieties as a function of their acceptability ratings. This survey is still in its initial stages, thus the results depicted in Table 22 should not be taken as conclusive. These are as follows: (1) all farmers were still growing the varieties two seasons after receiving them; (2) five of the farmers were still testing the varieties pure under different micro-conditions; (3) there appear to be varietal differences in the conditions under which they are tested; (4) most of the farmers passed the varieties on to others, usually family or neighbors. The variety with the highest acceptability rating (Table 19) Kilyumukwe, was passed on twice as often as any of the others; and (5) Kilyumukwe and Kirundo remain the most preferred varieties. The methodology for these surveys is still in the pre-testing stage thus some modifications are to be expected.

Future Plans

General strategies and activities for 1986 will remain similar to those reported for 1985. Additional emphasis will be placed on the following activities.

Higher priority will be given to encourage close collaboration between national bean research programs, development projects and extension services. Closer collaboration among these groups are necessary for building an efficient system of on-farm research and extension.

A second cycle of bean production and consumption surveys will be initiated in three regions in Burundi and Rwanda and also in the southern Kivu region of Zaire. Plans for these surveys have been made in Zaire with the INERA sociologist, and in Burundi both with ISABU and a Swiss-financed development project in an important climbing bean region.

Additional focus will be directed towards climbing beans, both in on-farm and station research activities. The objective of this focus is to evaluate the feasibility of extending climbing bean culture within the region.

Production of high quality seed will receive high priority, as will efforts to find and incorporate resistance to BCMV, anthracnose, angular leaf spot, and *Ascochyta* into locally adapted germplasm.

And finally, additional emphasis will be placed on increasing intraregional cooperation. A region wide varietal testing scheme is being discussed that would evaluate national program breeding lines for specific characters such as resistance to anthracnose or tolerance to beanfly. Additionally, planning has begun to establish regional subprograms to study important questions relative to region wide bean production constraints. An example of one such subprogram is the study and initiation of a varietal development program for tolerance to low phosphorous, high acid highland soils which are common throughout the region.

Table 22: On-farm trial follow up of nine farmers in Nyabisindu after one year.

		Yes		No	
1. Continue planting the varieties		9		0	
2. How planted		Pure		Mixed	
		5		4	
If planted pure,		Rich soil		Poor soil	Banana association
Kilyumukwe		4		2	3
Rubona 5		3		2	1
Ikinimba		2		2	2
3. Distributed varieties:		Yes		No	
		7		2	
If yes, to whom?		Family		Neighbors	
		5		2	
If yes, which varieties?	Kilyumukwe	Kirundo	Rubona 5	Ikinimba	
	4	2	2	2	
4. Most preferred varieties	Kilyumukwe	Kirundo	Rubona 5	ISAR M.	Ikinimba
	9	6	4	2	2

Eastern Africa

In eastern Africa, the program is still in the formulative stage. Plans to station staff in Kenya are in abeyance following the failure of the Government of Kenya to approve the original Memorandum of understanding (MOU), but a revised proposal has been submitted. Uganda signed an MOU with CIAT on 17 July and Ethiopia on 9 August. The latter has since been revised to enable the posting of CIAT staff in Ethiopia. An MOU is pending with the Government of Somalia for their approval.

A meeting of the Steering Committee for the East African project was held in Addis Abbaba in early December, attended by the national coordinators of bean research in Ethiopia, Somalia, Tanzania and Uganda and representatives from CIAT. The meeting reviewed present positions and established future priorities for research, training and equipment.

Meanwhile, CIAT continued to supply segregating materials and advanced lines to Ethiopia, Kenya and Uganda. In Ethiopia, CIAT lines are included in national trials and two, BAT 1102 and BAT 41, are being used in crosses as sources of rust resistance. Extension of materials in Kenya is being hampered by plant quarantine restrictions on seed movements and in Uganda by political unrest. Supply of materials was supported by visits of CIAT staff for discussions and to see the crop.

Southern Africa

In Southern Africa, CIAT has been named executing agent for bean research by the Southern African Development Conference Countries (SADCC) group and MOUS are now pending with the Governments of Malawi and Tanzania for their approval. CIAT staff visited Tanzania in June to see the crop and Malawi, Tanzania, Zambia and Zimbabwe in October/November for discussions and we continued to supply bean materials to national programs in the SADCC. The progress of some of these materials is described below.

Tanzania

One CIAT breeding line. BAT 317, has progressed to national variety trials; six (BAT 82, BAT 317, G 4738, G 5621, G 6499 and G7928) are in advanced trials; and some 50% of the entries in preliminary trials originate from CIAT. In advanced trials, G 5621 was the highest yielding entry with a yield of over 2.5 t/ha across two locations. In preliminary trials, XAN 66 (3270 kg/ha) and PVAD 1406 (2862 kg) yielded best and both were moderately disease free despite heavy halo blight pressure. In the IBYANs, the T 23 control (2227 kg) was the best yielder in one trial, followed by BAT 1387 (2076 kg). In a second trial, A 429 (2227 kg) yielded best. While the control, Kiburu, produced 1351 kg dry seed per hectare. Superior lines and single plants were selected in 267 F5/F6 generation progenies and families received as F4 and F5 from CIAT, and 46 advanced lines.

Zambia

Carioca continued to perform excellently in trials of the Eastern Province Agricultural Development Project. In on-farm trials, Carioca produced 76% more seed than the local variety without inputs. In national variety trials, it occurred among the top yielding group at every location and was the best yielder overall. Carioca's superiority derives partially from its tolerance to acid soil conditions but it was also resistant to all major diseases except Ascochyta. BAT 1671, BAT 85, BAT 331 and A 436 performed similarly to Carioca in national variety trials, except where pH was severely low. NEP 2 has given thrice the yield of Mexican 142, the currently grown navy bean cultivar. Carioca, BAT 331 and NEP 2 have been released for cultivation in Zambia.

CIAT lines also accounted for 15 of the 24 entries in national preliminary trials and A 429 and A 442 will be promoted to national variety trials in 1985-86, together with 2Pv 132, from the local collection. The climbing bean varieties, VCA 81007 and VRA 81027, will go to on-farm trials and VRA 81054 will enter the newly established national trial for climbing beans in the coming season.

In bush type IBYANs, PV 901 and BAT 1297 were outstanding, occurring among the top three entries at every location. PV 359, PV 702, PV 781. PV 791 and PV 1180 were also significantly better yielding than the control cultivar, Misamfu Speckled Sugar. The yields of these entries, compared with that of Misamfu Speckled Sugar, are shown in Table 1. All of them will proceed direct to national variety trials in 1985-86.

In climbing bean IBYANs in association with maize at Chipata, seed yields ranged upt to 2 t of beans plus 6 t of maize per hectare. ZAV 8308, ZAV 8332, ZAV 8349, ZAV 8313, ZAV 8344 and ZAV 8794 were selected for the national climbing bean trials in the coming season. CIAT materials from disease nurseries will also undergo further tests.

Zimbabwe

PV 901 was also outstanding in an IBYAN at Gwebi in Zambabwe, producing 1658 kg seed per hectare compared with 1081 kg/ha from Natal Sugar, the local control cultivar. In another trial at Harare, CIAT lines produced 1292 to 1812 kg seed per hectare, while Red Canadian Wonder produced 479 kg/ha. The CIAT lines included PV 359, PV 702, PV 781, PV 791 and PV 1180, all of which (together with PV 901) had performed well in Zambia. However, at Gwebi, the yield of BAT 1297 (539 kg/ha) was significantly less than that of Natal Sugar, demonstrating the importance of genotype x environment interaction in beans and the difficulty of predicting and interpreting varietal performance.

Table 1. Seed yields (kg/ha) of best entries and the local control, Misamfu Speckled Sugar, in IBYANs at three locations in Zambia in 1984/85 season.

Entry	Chipata	Mbala	Chilanga	Mean
		Group 23		
PV 901	464	542	1847	951
BAT 1297	432	525	1706	888
Misamfu	283	261	852	465
LSD	199.2	83.9	449.2	
		Group 25		
PV 359	522	470	1211	734
PV 702	556	375	1495	809
PV 781	664	421	1206	764
PV 791	624	322	1105	684
PV 1180	590	361	1224	725
Misamfu	390	245	741	459
LSD	154.6	109.6	406.1	

Table 2. Numbers of bean materials of different nurseries sent to African countries in 1985

	Great Lakes			Eastern Africa			Southern Africa					Western Africa		
	R	B	Z	E	K	U	A	T	Za	Zb	RSA	Gh	G	N
Segregating populations	615	302	13	-	216	250	-	260	-	-	-	-	-	-
Advanced lines	137	-	-	-	51	-	-	180	-	-	-	-	-	-
VEF	617	-	-	581	69	-	-	43	893	340	69	-	-	-
EP	-	-	129	-	38	-	-	-	202	-	-	-	-	249
IBYAN	19	-	34	-	-	17	256	36	164	19	149	17	36	-
TOTAL	1388	302	176	581	374	267	256	519	1259	359	218	17	36	249

R= Rwanda
B= Burundi
Z= Zaire

E= Ethiopia
K= Kenya
U= Uganda

A= Angola
T= Tanzania
Za= Zambia
Zb= Zimbabwe
RSA= Rep. of S. Africa

Gh= Ghana
G= Guinea
N= Nigeria

Table 3. Seed yield (kg/ha) of best entreis and the local control. Misamfu Speckled Sugar, in IBYANs at three locations in Zambia in 1984/85 season.

Entry	Chipata	Mbala	Chilanga	Mean
PV	464	542	1847	951
BAT 1297	432	525	1706	888
Misanfu	283	261	852	465
LSD	199.2	83.9	449.2	
PV 359	522	470	1211	734
PV 702	556	375	1495	809
PV 781	664	421	1206	764
PV 791	624	322	1105	684
PV 1180	590	361	1224	725
Misamfu	390	245	741	459
LSD	154.6	109.6	406.1	

V. Personnel (As of December 1985)

Aart van Schoonhoven, Ph.D., Entomology, Program Leader
George S. Abawi, Ph.D., Plant Pathology (Visiting Scientist)
David Allen, Ph.D.., Plant Pathology, Pathologist, Regional Coordinator, East African Bean Project (stationed in ILCA, Nairobi, Kenya)
Stephen Beebe, Ph.D., Plant Breeding
Jeremy H.C. Davis, Ph.D., Plant Breeding.
Michael Dessert, Ph.D., Plant Breeding, Regional Coordinator, Great Lakes Bean Project (stationed at Rubona, Rwanda)
Guillermo E. Galvez, Ph.D., Plant Pathology, Regional Coordinator, Central America Bean Project (stationed in San Jose, Costa Rica)
Guillermo Hernandez Bravo, Ph.D., Plant Breeder, Co-leader, World Bank/INIPA (Peru)/CIAT Collaborative Bean Project (stationed in Chincha, Peru)
Judith Kipe-Nolt, Ph.D., Microbiology
Julia L. Kornegay, Ph.D., Plant Breeding (Postdoctoral Fellow)
Porfirio N. Masaya, Ph.D., Plant Breeding (Visiting Scientist)
Francisco J. Morales, Ph.D., Virology
Silvio H. Orozco, MS., Agronomy, Central America Bean Project (stationed in Guatemala City, Guatemala)
Douglas Pachico, Ph.D., Economics.
Marcial Pastor-Corrales, Ph.D., Plant Pathology.
Nigel R. Sackville-Hamilton, Ph.D., Data Management Systems (Senior Research Fellow).
Shree P. Singh, Ph.D., Plant Breeding
Barry Smithson, Ph.D., Plant Breeding, East African Bean Project
Michael D. Thung, Ph.D., Agronomy (stationed at CNPAF, Goiania, Brazil)
Peter Trutmann, Ph.D., Plant Pathology, Great Lakes Bean Project (stationed in Rubona, Rwanda)
Joachim Voss, Ph.D., Cropping Systems Specialist, Great Lakes Bean Project (stationed in Rubona, Rwanda)
Oswaldo Voysest, Ph.D., Agronomy
Jeffrey White, Ph.D., Plant Physiology
Jonathan Woolley, Ph.D., Agronomy, Cropping Systems
Leif J. Youngdahl, Ph.D., Plant Physiology, IFDC (stationed in CIAT)

Research associates and other staff

Mauricio Castaño, Ing. Agr., Virology
Krista C. Dessert, M.Sc., Plant Nutrition, Great Lakes Bean Project (stationed in Rubona, Rwanda) (Visiting Researcher Associate)
Willi Graf, M.Sc., Agronomy, Great Lakes Bean Project (stationed in Rubona, Rwanda)
Jose Ariel Gutierrez, M.Sc., Plant Breeding.
Nohra R. de Londoño, Ing. Agr., Economics.
Jorge Ortega, M.Sc., Agronomy.
Veronique Schmit, M.sc., Associate Expert, FAO

Research assistants

Tomás Zúñiga, Ing. Agr., Entomology.
Carlos Pino, Ing. Agr., Physiology.
Lucía Afanador, Biol., Plant Pathology.
Jorge A. Beltrán, Ing. Agr., Cropping Systems.
César Cajiao, Ing. Agr., Plant Breeding.
Jesús A. Castillo, Ing. Agr., Physiology.
Carlos Francisco Chavarro, Ing. Agr., Office of the Coordinator.
Aurora Duque, Ing. Agr., Microbiology.
Oscar Erazo, Ing. Agr., Agronomy.
Ivan Ochoa, M.Sc., Breeding.
Carlos Jara, Ing. Agr., Plant Pathology.
Germán Llano, Plant Pathology.
Nelson Martínez, Ing. Agr., Agronomy.
Gustavo Montes de Oca, Ing. Agr., Agronomy.
Carlos Aníbal Montoya, Plant Pathology.
Andrea Niessen, M.Sc., Virology.
Gloria Isabel Ocampo, Bact., Microbiology.
Darío Ramírez, Ing. Agr., Plant Breeding.
Diego Santacruz, Ing. Agr., Agronomy.
Gerardo Tejada, Ing. Agr., Agronomy.
Grace Frenc, Nutritionist, Nutrition.
Carlos Urrea, Ing. Agr., Breeding.
Martin Prajer, Ing. Agr., Agronomy.
Maria del Pilar Guerrero, Ing. Agr., Economy.
Hernando Valderrama, Ing. Agr., Economy.

Appendix I: List of Collaborating Institutions

CARDI	Caribbean Agricultural Research Development Institute, West Indies.
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica.
CDA	Collaboration for Development in Africa.
CENARGEN	Centro Nacional de Recursos Genéticos, Brazil.
CENICAFE	Centro Internacional de Café, Colombia.
CENTA	Centro Nacional de Tecnología Agropecuaria, San Salvador, El Salvador.
CESDA - CENDA	Centro Sur de Desarrollo, Centro Norte de Desarrollo, Dominican Republic.
CGIAR	Consultative Group for International Agricultural Research, New York, New York.
CGPRT	Course Grains, Pulses, Roots and Tuber Crops Center,
CIAB	Centro de Investigación Agrícola del Bajío, México.
CIAGOC	Centro de Investigación Agrícola del Golfo Centro, México.
CIANOC	Centro de Investigación Agrícola Norte Central, México.
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, Londres, México.
CIP	Centro Internacional de la Papa, Lima, Perú.
CNP	Consejo Nacional de Producción, Costa Rica.
CNPAF	Centro Nacional de Pequisa em Arroz e Feijao, Brazil.
CIPA	Centro de Investigación y Promoción Agropecuario (I and II), Perú.
CPATU	Centro de Pesquisa Agropecuaria de Trópico Umido, Brazil.

CRSP	Collaborative Research Support Program, Tanzanía
CVC	Corporación Autónoma Regional del Valle y Cauca, Colombia.
DIGESA	Dirección General de Servicios Agropecuarios, Guatemala.
DRI	Desarrollo Rural Integrado, Colombia.
EEAOC	Est. Exptl. Agrícola Obispo Colombres, Brazil.
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brasilia, Brazil.
EMCAPA	Empresa Capichaba de Pesquisa Agropecuaria, Brazil.
EMGOPA	Empresa Goianía de Pesquisa Agropecuaria, Brazil.
EMPASC	Empresa de Pesquisa Agropecuaria de Santa Catarína, Brazil.
EPABA	Empresa de Pesquisa Agropecuaria de Bahía, Brazil.
ESAL	Escola Superior de Agricultura de Lauras, Brazil.
FAO	Food Agricultural Organization of the United Nations, Rome, Italy.
FEDECAFE	Federación Nacional de Cafeteros, Colombia.
IAPAR	Fundacao Instituto Agropecuario de Paraná Brazil.
IAR	International Agricultural Research.
IARC	International Agricultural Research Centers Network.
IBPGR	International Board for Plant Genetic Resources, Rome, Italy.
ICA	Instituto Colombiano Agropecuario, Colombia.
ICARDA	International Center for Agricultural Research in the Dry Areas, Beirut, Lebanon.
ICTA	Instituto de Ciencia y Tecnología Agrícola, Guatemala. Cita, Guatemala.

IDIAP	Instituto de Investigaciones Agricola Panameñas, Panama.
IICA	Instituto Interamericano para la Cooperación Agrícola, Costa Rica.
IITA	International Institute of Tropical Agriculture, Nigeria
INCAP	Instituto de Nutrición de Centroamérica y Panamá, Costa Rica.
INERA	Institut Nacional des Etudes es Rechervhes Agrícolas, Zaire.
INIA	Instituto Nacional de Investigación Agrícola, Perú.
INIAP	Instituto Nacional de Investigaciones Agropecuarias, Ecuador.
INIPA	Instituto Nacional de Investigaciones y Promoción Agraria, Lima, Perú.
INRA	Institut Nacional de Recherches Agronomiques, Guadalupe.
INTA	Instituto Nacional de Tecnología Agropecuaria, México.
INTA	Instituto Nacional de Tecnología Agropecuaria, Argentina.
INTA	Instituto Nicaraguense de Tecnología Agropecuaria, Nicaragua.
IPA	Instituto de Pesquisa Agropecuaria, Pernambuco, Brazil.
IPAGRO	Instituto de Pesquisas Agronómicas, Brazil.
ISABU	Institut de Sciences Agronomiques du Burundi, Burundi.
ISAR	Institut Scientifique et Agronomique du Rwanda, Rwanda.
ISNAR	International Service for National Agricultural Reserach, The Hague, Netherlands.
IVT	Institut Veredeling, Tuinbouwge, wassen, Holland.

NVRS	National Vegetable Research Station, Costa Rica.
ONS	Oficina Nacional de Semillas, Costa Rica.
PCCMCA	Programa Cooperative Centroamericano de Mejoramiento de Cultivos Alimenticios.
PESAGRO	Pesquisa Agropecuario - Rio, Brazil.
SADCC	Southern Africa Development Coordination Conference
SDC	Swiss Development Cooperation, Switzerland.
SEA	Secretaría de Estado de Agricultura, Dominican Republic
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture.
SRN	Secretaría de Estado de Recursos Naturales, Honduras.
UEPAE	Unidad de Execucao de pesquisa de Ambito Estadual, Brazil.
VISCA	Visayas State College of Agriculture, the Philippines.
VICOSA	Universidade Federal de Vicosa, Brazil.

Appendix II: List of G accessions

Number	Subnum	Identification	Local register	Origen	Source	Species	Subsp
2		Dorsett & Morse No. 6912	PI093303	CHI	USA	VUL	V
76						VUL	V
89		Rojo No. 20	PI150414	ELS	USA	VUL	V
677		Eyer No. 26 Aleppo	PI181892	SAR	USA	VUL	V
731		Tsib Tsinap Ul	PI189012	GTA	USA	VUL	V
790		Norvell No. 2663	PI195375	GTA	USA	VUL	V
811		Gentry 104437 Higuerillo	PI197683	MEX	USA	VUL	V
858		Novell No. 3594	PI261388	MEX	USA	VUL	V
1407		Gentry 11749 Lubia Sefid	PI226660	IRN	USA	VUL	V
1540		Bakum	PI284703	SWD	USA	VUL	V
1647		Roxinho Minas	PI298114	BZL	USA	VUL	V
2006		Gentry 21021	PI310740	GTA	USA	VUL	V
2331		Gentry 21825 Amar. Enredo	PI311996	MEX	USA	VUL	V
2333		Gentry 21835 Colo. Teopisca	PI311998	MEX	USA	VUL	V
2587		Mexico 425-1 Mex-19	PI313709	MEX	USA	VUL	V
2676		Guatemala 12-A-2 Mex-48 o	PI313830	GTA	USA	VUL	V
2816		Gentry 22135 Flor de Mayo	PI319618	MEX	USA	VUL	V
2829		Gentry 22160 Apetito	PI319631	MEX	USA	VUL	V
2858		Gentry 22220 Zacaticano	PI319665	MEX	USA	VUL	V
2883		Princess of Artois	PI319861	CDA	USA	VUL	V
2959		Pecho Amarillo	GTA-014	GTA	GTA	VUL	V
3017		Mezcla	GTA-084	GTA	GTA	VUL	V
3153		De Parra	GTA-350	GTA	GTA	VUL	V
3295		Aguascalientes 92		MEX	MEX	VUL	V
3306		Puebla 10		MEX	MEX	VUL	V

(Continued)

Number	Subnum	Identification	Local register	Origen	Source	Species	Subsp
3307		Puebla 10-A		MEX	MEX	VUL	V
3324		Puebla 35		MEX	MEX	VUL	V
3359		Puebla 172		MEX	MEX	VUL	V
3366		Puebla 240-A		MEX	MEX	VUL	V
3439		Zacatecas 81		MEX	MEX	VUL	V
3710		Redkote	I-981	USA	VNZ	VUL	V
3736		Alabama 1	I-1012	USA	VNZ	VUL	V
3807		Brasil 2 Pico de Oro	I-1098	BZL	VNZ	VUL	V
3884		Sucre 10		VNZ	VNZ	VUL	V
3954		WIS HBR 72	8-95	USA	CRA	VUL	V
3982		Amarillo 154	C-118	MEX	CRA	VUL	V
3997		T-51516-2-N-2	C-278		CRA	VUL	V
4000		NEP BAYO 22	C-286	CRA	CRA	VUL	V
4011		T-12-ROJO BLANCO	P-76		CRA	VUL	V
4229		STO. TOMAS 6N	N-593		CRA	VUL	V
4432		S-237-P	P-81		CRA	VUL	V
4446		Ex-Puebla 152 Brown seeded		MEX	MEX	VUL	V
4452		ICA GUALI		CLB	CLB	VUL	V
4459		NEP-2		CRA	CRA	VUL	V
4494		DIACOL CALIMA		CLB	CLB	VUL	V
4495		Porrillo Sintético		ELS	HDR	VUL	V
4498						VUL	V
4523		Ica Palmar Linea 17		CLB	CLB	VUL	V
4525		Linea 32		CLB	CLB	VUL	V
4727		Ancash 68		PER	PER	VUL	V
4738		Junin 25		PER	PER	VUL	V
4771		Puebla 158-B		MEX	MEX	VUL	V
4823		Pirata 2		BZL	BZL	VUL	V

(Continued)

Number	Subnum	Identification	Local register	Origen	Source	Species	Subsp
4830		Rio Tibagi Lote 10		BZL	BZL	VUL	V
5059		H6 Mulatinho	BZL-0349	BZL	BZL	VUL	V
5066			BZL-0374	BZL	BZL	VUL	V
5173		Seleccao L-39-PB	BZL-0987	BZL	BZL	VUL	V
5201		Mexico 528	BZL-1074	MEX	BZL	VUL	V
5207		I-116	BZL-1086	VNZ	BZL	VUL	V
5272		Santo Tomas 5N	N-592	CRA	CRA	VUL	V
5473		NEP-2		CRA	CRA	VUL	V
5476		JULES		USA	USA	VUL	V
5477		Great Northern No. 1 Sel.27		USA	USA	VUL	V
5621		Diacol Calima	HDR-2154	CLB	HDR	VUL	V
5653		Ecuador 299		ECD	ELS	VUL	V
5772		Diacol Andino		CLB	CLB	VUL	V
5971		Guatemala 256	HDR-2325	GTA	HDR	VUL	V
6040		Guatemala 488	HDR-0548	GTA	HDR	VUL	V
6071		Guatemala 567	HDR-0612	GTA	HDR	VUL	V
6074		Guatemala 576	HDR-6619	GTA	HDR	VUL	V
6278		Manda Wonder		USA	USA	VUL	V
6384		Red Mexican U. I. 35		USA	USA	VUL	V
6415		Mecosta 003		USA	USA	VUL	V
6416		Montcalm 023		USA	USA	VUL	V
6499		Fogo Na Serra	RU-72-45	BZL	UTK	VUL	V
6592		Canadian Wonder		USA	NZL	VUL	V
6719		Jubila		NLD	NLD	VUL	V
7148		211-95/50 P. S.	BZL-668	BZL	BZL	VUL	V
7928		DE 45		GRC	GRC	VUL	V
8108		Kabanima S. 74	IPV-20	NGA	NGA	VUL	V
8519		Guatemala 0450	GTA-0450	GTA	GTA	VUL	V

(Continued)

Number	Subnum	Identification	Local register	Origen	Source	Species	Subsp
9527		TMD-1		BZL	BZL	VUL	V
10011		Morelos 637	V-1431	MEX	UTK	VUL	V
10019		Michoacan 1002	V-1407	MEX	UTK	VUL	V
10019	A	Michoacan 1002	V-1407	MEX	UTK	VUL	V
10889		Guatemala 1382	GTA-1382	GTA	GTA	VUL	V
11024			DGD78/073	MEX	MEX	VUL	V
11027			DGD78/082	MEX	MEX	VUL	V
11027	A		DGD78/082	MEX	MEX	VUL	V
11027	C		DGD78/082	MEX	MEX	VUL	V
11032			DGD78/098	MEX	MEX	VUL	V
11032	A		DGD78/098	MEX	MEX	VUL	V
11051			DGD78/132	MEX	MEX	VUL	V
11052			DGD78/135	MEX	MEX	VUL	V
11060		Grullo	DGD78/151A	MEX	MEX	VUL	V
11125			DGD/HN397	MEX	MEX	VUL	V
11254		Red Mexican U.I.3	IVI-771017	USA	NLD	VUL	V
11506		Mexico 1290		MEX	ELS	VUL	V
11526		De Mata	VNZ--087		CLB	VUL	V
11766		Pajuro	BUV-067	PER	PER	VUL	V
12470		Peru 14-2 Loja	CAT-1020		ECD	VUL	V
12488		Pintado-43 Loja	CAT-1056	ECD	ECD	VUL	V
12592		Poroto	PG 0144	PER	PER	VUL	V
12666		Poroto amarillo	NAR-020	CLB	CLB	VUL	V
12669		Palomo		CLB	CLB	VUL	V
12858			PI260407	PER	USA	VUL	V
12858	A		PI26407	PER	USA	VUL	V
12858	B		PI260407	PER	USA	VUL	V
12858	C		PI260407	PER	USA	VUL	V

(Continued)

Number	Subnum	Identification	Local register	Origen	Source	Species	Subsp
12891			PI417624	MEX	USA	VUL	V
12952			PI417778	MEX	USA	VUL	V
12953			PI417780	MEX	USA	VUL	V
13614	De Celaya		X-16162	MEX	MEX	VUL	V
13671	Japones		VP-163	MEX	MEX	VUL	V
13673	Mantequilla		VP-168	MEX	MEX	VUL	V
13904			PI414816	HGY	USA	VUL	V
13922	Linea 24			CLB	CLB	VUL	V
13936	Don Timoteo			SPN	CLE	VUL	V
14016	ICA Tundama			CLB	CLB	VUL	V
14307	554/2/1				MW1	VUL	V

List of G Accessions which are not *P. vulgaris*

Number	Identification	Local Register	Origen	Source	Species	Subspecie
35010	M7285A Ayocote		MEX	USA	COC	C
35122	Gentry 22522	PI325601	MEX	USA	COC	P
35145	M7689 Patolo Blanco		MEX	USA	COC	C
35149	M7708-Bulk Patolo		MEX	USA	COC	C
35171	BLANC 5	NI-015	RWD	NGA	COC	C
35172	Violet 5	NI-016	RWD	NGA	COC	C
35182	Guatemala 1076 Piloy	GTA-1076	GTA	GTA	COC	P
35336			GTA	GTA	COC	P
35337	Nanasque-Ayocote	X-16019	MEX	MEX	COC	P
35338	Acalete	X-16483	MEX	MEX	COC	P
35339	Mateado	X-16497	MEX	MEX	COC	C
35340	Mateado	X-16498	MEX	MEX	COC	C
35341		X-16499	MEX	MEX	COC	C
35342		X-16500	MEX	MEX	COC	C
35343	Ayocote	X-16504	MEX	MEX	COC	C
35344		X-16545	MEX	MEX	COC	P
35345	Ibes	X-16596	MEX	MEX	COC	P
35346	Frijolon	X-16639	MEX	MEX	COC	C
35347		X-16727	MEX	MEX	COC	P
35348	Gordo	F-012	MEX	MEX	COC	P
35349	Gordo	F-015	MEX	MEX	COC	P
35350	Exoyeman	MA-1249	MEX	MEX	COC	P
35351	Xoyeman O Acalete	MA-1301	MEX	MEX	COC	P
35352		CP-346	MEX	MEX	COC	C
35353		CP-367	MEX	MEX	COC	C
35354	Ayocote	CP-370	MEX	MEX	COC	C
35355		CP-378	MEX	MEX	COC	C

(Continued)

List of G Accessions which are not *P. vulgaris*

Number	Identification	Local Register	Origen	Source	Specie	Subspecie
35356	Ayocote grande	CP-382	MEX	MEX	COC	C
35359	De vida 3		CLB	CLB	COC	C
35360	De vida 4		CLB	CLB	COC	P
35372	Cacha Potrerillo		CLB	CLB	COC	P
35373	Sibundoy 2	Sanudo0024	CLB	CLB	COC	P
35380	M8151 Palostle		MEX	USA	COC	P
35391		X-15962	MEX	MEX	COC	P
35415	De red	X-16543	MEX	MEX	COC	P
35417		X-16559	MEX	MEX	COC	P
35452	Acalete	F-006	MEX	MEX	COC	P
35456	Exoyeman o gordo	F-443	MEX	MEX	COC	P
35458		MA-1245	MEX	MEX	COC	P
35467	Exoyeman	CP-176	MEX	MEX	COC	P
35468	Exoyeman	CP-179	MEX	MEX	COC	P
35472	Acalete	CP-229	MEX	MEX	COC	P
35473	Exoyeman	CP-230	MEX	MEX	COC	P
35481	Gordo Exoyeman	CP-332	MEX	MEX	COC	P
40034	Nayarit 13B		MEX	MEX	ACU	L