Output 4. Improved cultivars and management practices developed and tested in partnership with IP-2 Project (Africa), NARS, and Regional Networks

Activity 4.1 Supporting breeding programs in NARS, Regional Networks, farmers' associations, and CIALs with germplasm and technical knowledge

Highlights:

- Evaluation of red-mottled, and red- and cream-speckled bean genotypes by farmer-led research committees (CIALs) in Colombia has identified broadly adapted bush bean varieties for mid-elevation ecosystems.

- Characterization of on-farm diversity of local common bean varieties in Nicaragua showed greater than expected genetic variability, which will be correlated with agro-morphological variability in the upcoming season.

- The IPHIS database was published for the first time with bean pedigrees, and remaining pedigrees are now incorporated into the IPHIS format.

- A project on breeding for aluminum resistance in bean was approved.

- Continuous support was given to breeding programs in PROFRIJOL, the Andean zone, and African networks.

- Seed was distributed to all collaborating partners.

4.1.1 Evaluation of bean genotypes through farmer-led research committees (CIALs)

Rationale: Participatory research with farmers can expedite the process of variety release. Feedback from producers on the advantages and disadvantages of varieties is critical to the success of any breeding program. Knowledge of the germplasm and the genetic management systems employed by farmers can help plant breeders to tailor varieties to their needs. Selections made at the farm or community level can benefit greatly from a precise description of the genetic variability present; which in turn can determine the need for infusion of new germplasm from plant breeding or genetic resources programs. On-farm testing exposes potential varieties to the range of abiotic and biotic stresses that the crop will face in a "real-life" situation as well as to the agronomic management practices that the farmer will apply to crops on a "day-to-day" basis. Farmers in Colombia grow beans under a range of agroecosystems and have different germplasm needs for these different growing environments. On-farm testing can help to find the perfect niche between germplasm and grower that will satisfy the common goal of the farmer and the plant breeder to create and use valuable new genetic resources.

Materials and methods: Farmer participatory research organizations (CIALs) planted bean variety trials during several growing seasons (1999-2000) in three regions of southwest Colombia:

(1) Pescador / Carpintero (Cauca) - initiating with six farms in two locations and with additional farms in El Jardín and Frontino the following season, supported by the CIAT- Participatory Research in Agriculture (IPRA) program and Consorcio Interinstitucional para una Agricultura Sostenible en Laderas (CIPASLA).

(2) Caicedonia (Valle) - initiating on three farms and supported by the local extension service (Unidad Municipal de Asistencia Técnica Agropecuaria [UMATA]), the CIAT-IPRA Program, and the departmental Coffee Growers' Committee (Comité de Cafeteros del Valle).

(3) Restrepo (Valle) - initiating on four farms and supported by a local NGO (Fundación para la Investigación y el Desarrollo Agro-industrial Rural [FIDAR]).

Monocultures of beans were followed by rotations with maize / vegetables and cassava in Restrepo, Pescador, and Carpintero; while in Caicedonia the bean varieties were planted in double rows as an intercrop in between pruned coffee bushes. From 10 to 22 varieties and advanced lines were tested at any one location. The plots consisted of four or five 5-m rows. The genotypes included red-mottled "Calima", large red "Radical", and cream-speckled "Sugar" types (Table 46). All the genotypes were bush beans with a general adaptation to altitudes of 1000 to 2000 m. The crop cycle of the bean varieties was 80 to 100 days depending on the prevailing weather conditions. The farmer committees evaluated the varieties for vegetative characteristics during the season and for yield and seed characteristics at harvest.

Results and discussion: Several red-mottled and red-seeded lines performed well over various sites. Several of the CIALs preferred the genotypes AFR 188, AFR 612, BRB 181, and CAL 96 over the current check varieties Calima, Guarzo, and Caucaya. The farmers in Caicedonia achieved the highest yields because fertility within the coffee-intercropping experiments was high due to residual fertilizer from the coffee harvest. In this setting, many of the varieties yielded well even under high plant densities. This system made efficient use of space with two rows of beans separated by 0.4-m spacing between coffee rows separated by 2-m spacing. In Restrepo, the plantings were plagued by drought. However, AFR 612 performed very well in two plots with irrigation and new farmers were interested in joining the effort. The Restrepo CIAL presently consists of eight farmers (six men and two women of different ages). During their experiments, the farmers from the Restrepo CIAL were invited to visit the CIAT research plots in Darien. Their criteria for plant and seed types were taken into consideration for the selection of promising material from over 1000 advanced $F_{6:7}$ lines derived from gamete selection. Their priorities were for commercial seed types, especially dark red seed colors. Although they were willing to accept varieties that had moderate levels of disease infection, any lines with light red seed color were eliminated.

Table 46. Genotypes tested in the Comités de Investigación Agrícola Local (CIALs) across three locations in southwest Colombia.

Locations	Bean genotypes			
	Red-mottled		Large red	Cream-speckled
Trial 1	A 36		AFR 188	
Caicedonia	AFR 612		ICA Cerinza	
Pescador/Carpintero	AND 279		Chocho	
	CAL 96		Guarzo	
	CAL 143			
	Caucaya			
Trial 2	AFR 735	CAL 181	AND 1088	SEQ 1027
Caicedonia	AND 1085	Caucaya	BRB 189	SEQ 1035
	AND 1089	POA 10	BRB 219	SEQ 1036
	AND 1090	POA 12	DFA 2	SEQ 1038
	BRB 189	SEQ 1039	SEQ 1033	SEQ 1040
	CAL 180	SEQ 1040		
Trial 3	AFR 612		AFR 188	
Restrepo	CAL 96		AND 1088	
	CAL 143		BRB 181	
	Caucaya		Chocho	
	Calima		SEQ 1033	
			SEQ 1031	
Trial 4	300 advanced $F_{6:7}$ lines			
Restrepo	AFR 612		AFR 188	
	CAL 96		BRB 181	
	Calima		Chocho	
	300 advanced $F_{6:7}$ lines			
	AFR 612		AFR 188	
	CAL 96		BRB 181	
	Calima		Chocho	

Future plans: The varieties selected by the CIALs in the initial trials are being tested in validation trials using larger plots (10 rows x 10 m). In the future, the best varieties may be grown in commercial plots for seed production to satisfy the local demand for new varieties among other farmers. Angular leaf spot was observed to be the primary disease in the bean fields of Restrepo during the previous season. We are expanding the range of germplasm available to the farmer committee in Restrepo and are planning a disease-resistance screening trial with them for the current season. With their help, we selected a group of 300 CIAT advanced $F_{6:7}$ red-mottled lines with good seed color for early on-farm testing. Most of these genotypes are derived from crosses that included parents that were resistant to ALS, anthracnose, and BCMV. The genotypes will be planted between spreader rows of the susceptible local check variety, Calima, and near a large bean field that contains the farmer's variety. Genotypes that are successful in this on-farm trial will be put into replicated and inoculated trials in CIAT plots in Darien, and subsequently the best lines will be distributed to other CIALs and collaborators.

Contributors: MW Blair (IP-1); I Roa (CIAT-IPRA Project); C Gallego, J Restrepo (FIDAR, Cali, Colombia)

4.1.2 Characterization of on-farm diversity of local common bean varieties in Nicaragua

Rationale: Common bean (*Phaseolus vulgaris* L.) is a self-pollinated crop with a very low rate of out-crossing. It is commonly assumed that in such a crop, modern varieties grown on medium to large farms are maintained as pure lines while traditional landrace varieties grown on small farms are maintained as populations of mixed genotypes. In this study we attempt to describe the amount of genetic variation at the molecular level that is found within and between on-farm populations (here referred to as local varieties) collected from farmers in different geographical regions of Nicaragua. Seed color is an important commercial trait in Nicaragua, and farmers predominantly grow small, red-seeded beans, although they also have landraces that have brown- or cream-colored seed. Within these seed classes, seed size and pigment tones vary slightly. The genes underlying these differences in seed appearance are not well understood, but the discovery of allelic variation at molecular markers may give some clues as to how farmers maintain the diversity in their seed stocks.

Materials and methods: Thirty-three local varieties representing three seed classes (30 small red, three brown/ cream) were genotyped with bean microsatellite markers (Table 47). Seven Nicaraguan varieties that are part of the CIAT Core Collection were used as controls for gel-to-gel variation. Of the five most genetically diverse local varieties, 40 seeds were grown out in the screenhouse. The single plant selections are being grown in the field in Nicaragua as pure lines to distinguish phenotypic differences related to the genetic variability.

Results and discussion: The results indicate that microsatellites were ideal markers for detecting DNA polymorphisms in the closely related, but somewhat divergent, genotypes of Nicaraguan farmers. The genetic markers facilitated the differentiation of subpopulations within all the local varieties even when the individuals within the variety were all similar in terms of seed color and other phenotypic characteristics. This intra-population diversity was not correlated with agroclimatological zones or other variables. Although most of the individuals were homozygous for most loci, the frequency of heterozygous individuals in several of the populations was higher than 10%. This suggests that out-crossing had occurred at the farm level and that gene flow between diverse individuals within the population, or between adjacent populations from neighboring farms, might be important. The presence of individuals with different alleles is proof that farmers are planting genetic mixtures or populations rather than pure line varieties. These results suggest that traditional farmer-managed local varieties are reservoirs of genetic diversity and highlight the importance of preserving genetic resources by *in situ* conservation.

Table 47. Characteristics of the 21 local varieties from Nicaragua tested in this study.

Variety	Local name	Site	Department	Grain color
V1	Chile Rojo	Santa Rosa, Condega	Estelí	Red
V5	Rojo Criollo	La Zopilota, Diriomo	Granada	Red
V6	Rojo Criollo	Palo Quemado, Diriomo	Granada	Red
V7	Rojo Criollo	Palo Quemado, Diriomo	Granada	Red
V9	Rojo Criollo	El Guarumo, Nandaime	Granada	Red
V10	Rojo Criollo	La Orilla, Nandaime	Granada	Red
V11	Rojo Criollo	La Granadilla, Nandaime	Granada	Red
V12	Kaki	El Horno	Matagalpa	Dark brown
V16	Rojo Criollo	Santa Cruz, Estelí	Estelí	Red
V17	Chile Rojo	Condega	Estelí	Red
V18	Rojo Criollo	San Fco del Gamalote, Juigalpa	Chontales	Red
V19	Mono	Pantasma	Jinotega	Light brown
V21	Gualiceño	Pantasma	Jinotega	Light green
V22	Chile Rojo	Yali, Condega	Estelí	Red
V23	Vaina Roja	Estelí	Estelí	Red
V24	Chile Pando	Yali, Condega	Estelí	Red
V26	Rojo Criollo	Monte Grande, Nandaime	Granada	Red
V27	Rojo Pajiso	Santa Lucía	Boaco	Red
V28	Rojo Criollo	Santa Lucía	Boaco	Red
V29	Ligero Nacional	Santa Lucía	Boaco	Red
V30	Bayo	El Loro, San Juan del Sur	Rivas	Light yellow

Conclusions and future plans: On-farm trials of single-plant selections (pure lines) from the mixed varieties are being grown in Nicaragua to determine the morphological variability associated with the genetic diversity identified in this study. The introgression and mixing of improved, BGMV-resistant, modern varieties into the local populations will be studied by comparing the microsatellite fingerprints of varieties released in Nicaragua in the last 20 years to the alleles observed in this study. The amount of genetic variability present in today's landraces will be compared to that of the "same" varieties stored in gene banks in CIAT and in Nicaragua to determine the changes that occur over time with *in vitro* germplasm storage.

Collaborators: MW Blair (IP-1); E Gaitán, J Tohme (SB-2); OJ Gómez (Ministerio de Agricultura, Nicaragua); U Gullberg, B Frankow-Lindberg (Sveriges Lantbruks Universitet [SLU], Uppsala, Sweden)

4.1.3 Populations created and distributed

Rationale: Breeding has traditionally been a collaborative effort between CIAT and national programs, combining the strengths of the several institutions. The Center has been a source of both segregating populations and fixed lines. Reduced budgets require that efficient systems be created that exploit comparative advantages. The strength of

CIAT lies in the genetic variability housed in the gene bank, the novel gene combinations that have been created, and the capacity to create large numbers of populations.

Materials and methods: Populations were created including parental genotypes that had proven their worth across sites, and under multiple stresses in CIAT's trials and in the international nursery for this purpose. These include A 774 and VAX 1, among others. Populations were screened in the F_2 generation for resistance to diseases and for agronomic worth. In the subsequent generation, seed was planted at CIAT headquarters for clean seed increase for distribution. With the revival of the breeding program in Guatemala, a set of black seeded populations was sent that were prescreened in Colombia under fertility stress at the Santander de Quilichao site. With the initiation of collaboration with a Haitian NGO, these same populations were shipped to Haiti also. The same strategy was used to select populations of red-seeded beans for Costa Rica.

Results: Among nine populations planted in Haiti, four or five were promising in terms of potential to select superior plants. This modus operandi will be explored in the next few years to determine if it can optimize efficiency in the breeding program. The inferior populations would be weeded out in Colombia and generations advanced to near homozygosity (F_5 or so), while the latter phases of selection (line development and family testing) are practiced in individual countries. We would like to work molecular markers into this scheme as well, whereby we would apply markers in early generations to increase the frequency of desirable genes in populations that pass to NARS.

Conclusions: are pending.

4.1.4 Databases

Rationale: The interchange of information about genetic resources and improved germplasm is as important as the germplasm itself in assuring adequate use of that germplasm in breeding programs and in production. The Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) and the International Rice Research Institute (IRRI) are developing a crop generic, integrated model of International Crop Information System (ICIS). The model is centered on the germplasm, in particular on the pedigree management and agronomic data generated on improved lines. Pedigrees are managed within the Germplasm Management System (GMS) and agronomic data with the Data Management System (DMS). We have been working on adapting bean pedigrees and data to the ICIS model for 2 years.

Materials and methods*:* CIAT data are stored in Oracle and are available internally, but are not accessible to partners outside of CIAT. Data include pedigrees of over 40,000 crosses and genealogies of over 6000 bred lines. These have resulted from more than 20 years of work involving six different breeders using essentially the same notation system, but each with variations. These data represent the raw material for ICIS. Last year we reported that these data had been adapted to the ICIS model.

Results: Early in 2000, IRRI and CIMMYT published the first CD-ROM of ICIS. It included a database on bean crosses, which was designated IPHIS (for *Phaseolus*). The IPHIS first edition carried about 30,000 crosses and 5000 pedigrees, with a second edition soon to be released, which should carry all CIAT crosses. The ICIS translates pedigrees into dendrograms or "trees", which visually display the parentage of a line over its several generations of crossing and selection, and this aspect of IPHIS is fully functional. The second edition of IPHIS should also contain evaluation data on the lines that passed through the bean team evaluations and the international trials.

Conclusion: The publication of IPHIS represents a milestone in the progress of data management and in user access to CIAT data on pedigrees. We expect this to be a highly popular item among national programs.

Contributors: S Beebe, H Terán, C Cajiao, A Hoyos (IP-1);
F Rojas, AF Guerrero (Databases)

4.1.5 Data analysis of the International Bean Yield and Adaptation Nursery (IBYAN)

Rationale: For nearly 20 years, the IBYAN was distributed and planted in bean production regions around the world. These data are stored at CIAT, and represent a substantial bank of biological information on the adaptation of bean to contrasting environments. Last year we reported on the application of the SEQRET program to the IBYAN data, to group environments based on crop yield response. However, the SEQRET program did not permit analysis of much of the IBYAN data because of restrictions on the minimum number of sites in which a variety must be planted to be included in the analysis, or the minimum number of years and common varieties to include for a site. These problems are common in multi-locational analysis, because the same trial is seldom planted over several years, and thus data matrices are invariably incomplete. This year, a novel data analysis technique was developed with the Land Use Project that overcomes many of these restrictions and permits analysis of highly incomplete matrices.

Materials and methods: A highly modified leader cluster algorithm was written that can create a dimension independent distance measure in the variable dimensioned subspaces. The crux to the working of this algorithm is, we think, what is known as the "Small World" or the "Kevin Bacon" effect. The essence of the game is to link any Hollywood actor to Kevin Bacon by the pairings of actors working together in films in the least number of steps. Thus: Charlie Chaplin acted with "X" in Limelight, "X" acted with "Y" in The Great Escape, "Y" acted with Kevin Bacon in "The Most Mindless Film Ever Made". The link from Chaplin to Bacon is made in three steps even though many thousands of actors have worked in Hollywood. This is becoming widely researched in the investigation of network connectivity. The important result is that regular networks should show a very poor connectivity on large scales, but by adding a few long-range connections the performance of a regular network can be made to approximate very closely to a truly random network.

The tool was developed with a set of simulated data, starting with a full matrix and eliminating data progressively until the limits were found of how little data could give the right results. The tool was then applied to bean yield data over sites. Over the years of its existence, from 1978 to 1987, the black-seeded IBYAN was the trial that had the longest history and the widest distribution. Therefore our statistical analysis focussed on the black IBYAN, obtaining clusters of environments based on response of bean varieties. Once the black bean trials were analyzed by this method, the coordinates of the resulting clusters of sites were fed into the FloraMap program to visualize similar environments.

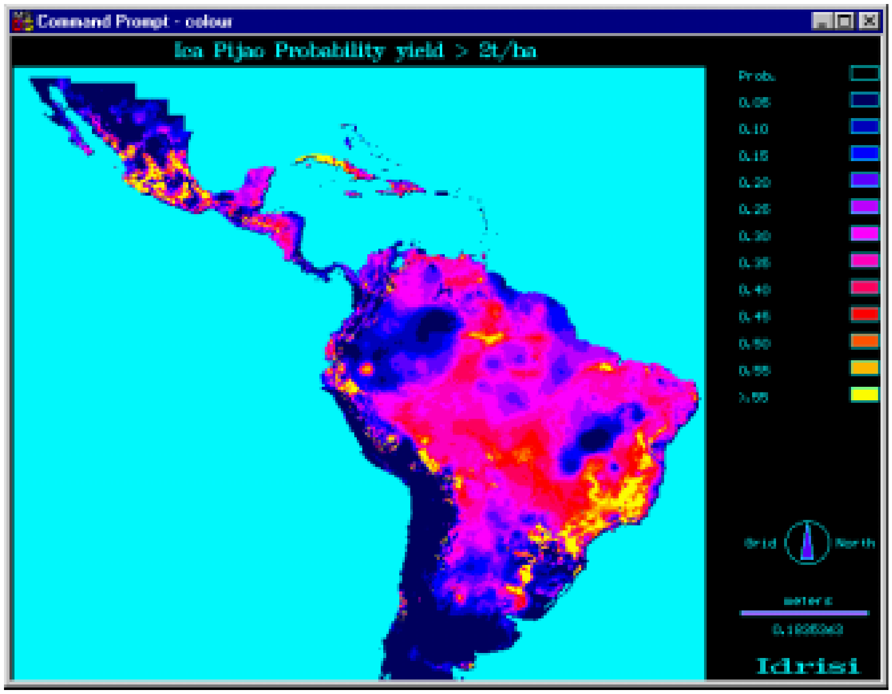
Results: A novel method of data analysis was developed that permits the analysis of very sparse matrices in which many of the data in a site x variety matrix do not exist. A simulated data matrix suggests that as little as 15% of the data can produce the same clustering of sites as a full matrix. Other multi-variate methods discard sites or varieties that are incomplete in the matrix, but this method permits including many more sites in the analysis and the classification of these in relation to other sites. We think that this represents a vast improvement over previous analyses and is a great contribution to multi-locational analysis. The mapping exercise produced maps that were logical, and climatically similar regions were mapped. This resulted in regions that could be associated with contrasting altitudes or latitudes, and were in some degree discrete. This suggests that the multi-locational analysis had in fact extracted differential response to environments.

Additionally, the yield patterns of two well-known varieties, ICA Pijao and Porrillo, were compared and the probability functions developed as described above. Experience suggests that Pijao adapts better at moderate temperatures while Porrillo performs well under high temperatures. In the two maps, although they are similar, some subtle differences show that confirm this empirical experience (Figure 69). Porrillo is shown to be adapting down to the Pacific coast of El Salvador, which is exactly where it was originally selected (and named! Porrillo is a site in coastal El Salvador); while Pijao is doing better in the central, higher (800-1000 m) environments of Central America. In the broad swathe of the hot, Brazilian cerrados, Porrillo is better.

Conclusions: A promising, novel data analysis was developed that permits grouping environments despite very incomplete data matrices. This could be a breakthrough in the analysis of multi-locational trials. An initial attempt to apply the FloraMap program to the clusters so derived suggested that even with year-round climate comparisons that are used in FloraMap, some logical patterns could be discerned.

The Australian Center for International Agricultural Research (ACIAR) funded this research.

Contributors: P Jones (PE-4); S Beebe (IP-1)



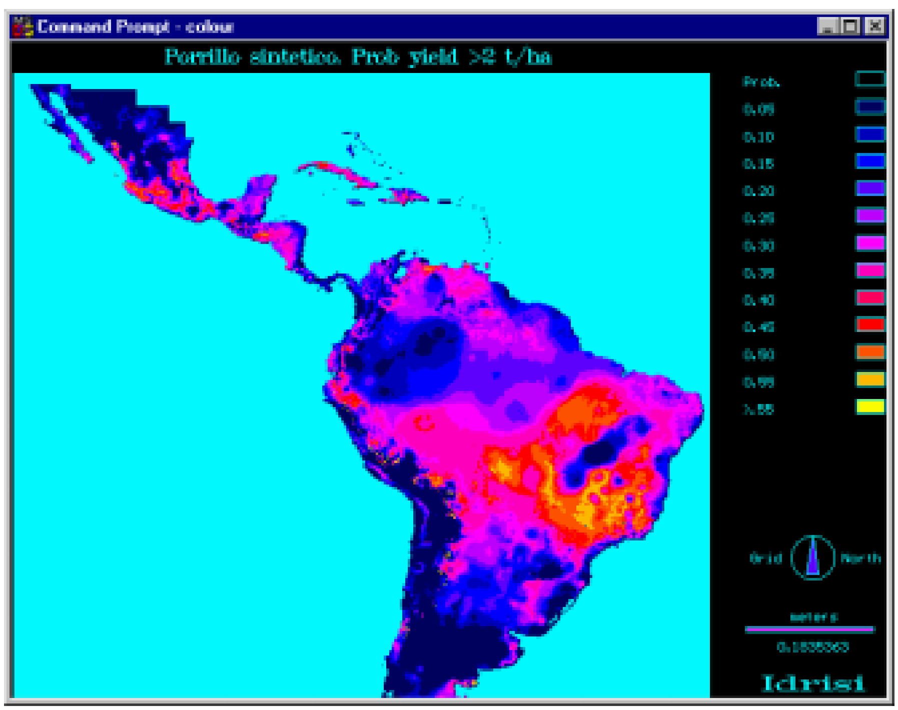


Figure 69. Maps of adaptation ranges of two closely related black bean varieties, ICA Pijao and Porrillo.

4.1.6 Distribution of seed to partners

I. International nurseries

A. Observational Nurseries (IBN)
(Formed by advanced lines Andean type)

B. Specialized Nurseries *Empoasca*

C. Snap Bean Germplasm

II. Dry bean breeding nurseries

III. Germplasm characterization

IV. Others

DIFALS (Angular Leaf Spot Differentials)
DIFANT (Anthracnose Differentials)
DIFFUS (*Fusarium* Differentials)
DIFRUST (Rust Differentials)

I. International Nurseries

A. Observational Nurseries

Nursery	Country	No. of lines	Institution
2000 IBN (Andean types)	Bolivia	40	Universidad Autónoma Gabriel René Moreno (UAGRM)
	Colombia	99	Corporación Colombiana de Investigación Agropecuaria (CORPOICA)
		20	Corporación para el Fomento de los Comités de Investigación Agrícola Local, Colombia (CORFOCIAL)
		60	Federación Nacional de cultivadores de Céreales (FENALCE)
		20	Ministry of Education (MINEDUCACION)
		40	UMATA
		39	Universidad de Nariño (UDENAR)
	Ecuador	40	Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP)
	Haiti	31	Organization for the Rehabilitation of the Environment (ORE)

B. Specialized Nurseries

Nursery	Country	No. of lines	Institution
Single crossing (individual selections) and backcrossing of Berna x EMP 419	Canada	161 (35 kg)	University of Guelph

C. Snap Bean Germplasm

Institution	Country	No. of lines	Collaborator
ORE	Haiti	78	E Magloire, L Eugene
	Honduras	20	L Brizuela
University of Nairobi	Kenya	70	P Kimani
Chitedze Agricultural Research Station	Malawi	69	RM Chirwa

II. Dry Bean Breeding Nurseries

Nursery	Country	No. of lines	Institution
Bean nursery of red-seeded lines	Bolivia	39	UAGRM
	Honduras	18	Dirección de Investigación de Ciencias y Tecnología Agrícola (DICTA)
	Honduras	39	EAP-Zamorano
	Peru	39	Comisión para la Promoción de Exportaciónes (PROMPEX)
	Puerto Rico	39	University of Puerto Rico
Bean nursery of red-seeded lines and sources of BGMV	Dominican Republic	23	Secretaría de Estado de Agricultura (SEA)
BGMV-resistant parents and advanced lines	Haiti	11	ORE
Bred lines	Haiti	5	Instituto Interamericano de Cooperación para la Agricultura (IICA)
BRB lines	Colombia	38	CORPOICA
Climbing accessions from Rwanda	Haiti	35	ORE
Core Collection accessions	Costa Rica	10	Ministry of Agriculture

II. **Dry Bean Breeding Nurseries** (continued)

Nursery	Country	No. of lines	Institution
Common bean lines	England	69	University of Reading
	Hawaii	8	University of Hawaii
	Peru	98	Universidad Nacional Agraria "La Molina" (UNALM)
	Uganda	4	Kawanda Research Station
Common bean lines – CBB	China	19	Inst. Germplasm Resources
Common bean lines – Low P	Brazil	2	Instituto Agronômico de Campinas (IAC)
	Haiti	45	ORE
	USA	11	University of Pennsylvania
Common bean lines – races	Costa Rica	26	University of Costa Rica
	USA	17	University of California
Common bean lines Andean type	China	32	Inst. Germplasm Resources
Common bean lines Ñuña germplasm	Guatemala	6	Instituto de Ciencia y Tecnología Agrícolas (ICTA)
Common bean lines Pinto type	Puerto Rico	60	University of Puerto Rico
	USA	60	Colorado State University
Common bean lines White type	Peru	10	PROMPEX
Common bean lines for registration in Crop Science	USA	9	University of Idaho
DOR 364 RILs	USA	175	University of Pennsylvania
Early lines of common bean	Canada	36	University of Saskatchewan
F_1 hybrids	Guatemala	45	ICTA
	USA	3	Oregon State University
F_2 populations for BGMV	Haiti	12	IICA
F_2 populations of G 2333 x G 23338	USA	1	Michigan State University
F_2 populations of single crosses	Iran	6	Seed Plant Improvement Institute (SPII)

II. **Dry Bean Breeding Nurseries** (continued)

Nursery	Country	No. of lines	Institution
F_2 populations of triple crosses	Iran	12	SPII
F_3 bulks bush Cargamantos	Iran	48	SPII
F_3 bulks early Cargamantos	Colombia	67	CORPOICA
F_3 bulks late Cargamantos	Colombia	62	CORPOICA
F_3 families of G 35172 x G 35337	Guatemala	103	ICTA
F_3 segregating populations – Cranberry type	Iran	66	SPII
F_4 segregating populations	Costa Rica	7	Ministry of Agriculture
	Guatemala	9	ICTA
	Haiti	9	ORE
F_6/ F_8 advanced red-mottled bush bean lines	Haiti	35	ORE
Interspecific crosses families	Guatemala	516	ICTA
	Mexico	516	
P. coccineus and *P. polyanthus* core accessions	Guatemala	248	ICTA
	Mexico	124	
	Puerto Rico	69	University of Puerto Rico
Potential parents	Costa Rica	263	Ministry of Agriculture
	Guatemala	16	ICTA
	USA	559	University of Idaho
Resistance sources of CBB	USA	57	United States Department of Agriculture (USDA)- Agricultural Research Service (ARS)- Irrigated Agriculture Research and Extension Center (IAREC)
Resistance sources of common bean lines	USA	76	University of Idaho

II. Dry Bean Breeding Nurseries (continued)

Nursery	Country	No. of lines	Institution
Resistance sources of *Fusarium*	USA	5	Colorado State University
Resistance sources of halo blight, cold, heat	Iran	30	SPII

III. Germplasm Characterization

Nursery	Country	No. of lines	Institution
Core Collection accessions	Bolivia	9	UAGRM
	Haiti	10	ORE
Core Collection climbing accessions	Haiti	14	ORE
DOR 364 x G 19833 recombinant inbred lines (RILs)	England	32	University of Reading
	USA	89	University of Pennsylvania
DOR 364 x G 19833 F_2 populations	England	40 seed	University of Reading
G 2333 x G 19839 RILs	England	32	University of Reading
	USA	86	University of Pennsylvania
G 24404 x Radical-Cerinza backcrosses families	Colombia	100	CORPOICA
Local variety – single plant selections	Nicaragua	240	Universidad Agraria

IV. Others

Nursery	Country	No. of lines		Institution
DIFALS (angular leaf spot differentials)	Bolivia	1 set	(4 checks)	Instituto de Investigaciones Agrícolas (IIA) "El Vallecito"
	Costa Rica	2	(200 g)	Universidad de Costa Rica
	Colombia	12		CORPOICA
	Peru	12		UNALM
DIFANT (anthracnose differentials)	Bolivia	1 set	(4 checks)	IIA "El Vallecito"
	Colombia	12		UDENAR
		12		CORPOICA
	Costa Rica	12	(700 g)	Universidad de Costa Rica
	Slovenia	12		Agricultural Institute
	South Africa	12	(500 g)	Dept. of Plant Pathology
	Ecuador	12		Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP)
	Peru	12		Universidad Nacional Cajamarca
		12		UNALM
DIFFUS (*Fusarium* differentials)	Uganda	9		Kawanda Research Station
	USA	9		Colorado State University
DIFRUST (Rust differentials)	Ecuador	20		INIAP
	Bolivia	3	(50 g)	IIA "El Vallecito"
	Colombia	20		UDENAR
Resistance sources of angular leaf spot (ALS)	Brazil	25	(500 g)	Centro Nacional de Pesquisa de Arroz e Feijão (CNPAF)/ Empresa Brazileira de Pesquisa Agropecuária (EMBRAPA)
	Haiti	19	(450)	ORE
	Uganda	26	(1500 g)	Kawanda Research Station
Resistance sources of anthracnose (ANT)	Peru	4		Universidad Nacional Cajamarca
Resistance sources of root rots	Uganda	4	(200 g)	Kawanda Research Station
Xanthomonas campestris pv. *phaseoli* lyophilized bubbles	Cuba	60	(300)	Instituto de Investigaciones Hortícolas

Contributors: IP-1 Team

Activity 4.2 Collaborative projects developed and executed with NARS and Regional Networks

Highlights:

- CIAT scientists participated in the planning of activities of PROFRIJOL, the Andean zone, and African Networks.
- Individual training of national scientists was provided.
- Joint collaboration and concept notes were prepared.

4.2.1 Regional bean project for Central America (PROFRIJOL)

In 1980, CIAT established a formal regional research project in Central America with funding from the Swiss Development Cooperation (SDC). The project has evolved to the point that today its operative administration is in the hands of an Executive Committee of five members that in turn carries out the decisions of the General Assembly in which all participating countries are represented. The Bean Project Manager represents the CIAT-based Bean Team on the Executive Committee. Furthermore, CIAT headquarters gives administrative backstopping in financial management.

With regard to research, priorities are set in consultation with NARS in a joint planning session. All CIAT activities are coordinated with the planning matrix, and CIAT delivers a yearly work plan relating goals to budget allotments. Thus, CIAT activities are totally coordinated with the regional project structure and CIAT functions as a full partner with NARS.

The project structure involves five main subprojects:
(1) Improved bean varieties of the Mesoamerican gene pool, including red- and black-seeded types;
(2) Improved bean varieties of the Andean gene pool, for use in the Caribbean basin and Panama;
(3) Support to breeding efforts, including analysis of genetic variability of pathogens, broadening the genetic base of resistance, and developing molecular markers for traits;
(4) Developing improved crop management techniques including soil conservation and fertility management; and
(5) Socioeconomic studies including adoption and impact studies.

CIAT participates directly (with project funds) in subprojects 1 and 3, and indirectly (with core funds) in subproject 2. Technical results are presented in the respective sections under output.

The IP-1 team members participated in the Project Planning by Objectives (PPO) for preparation of the next phase of PROFRIJOL and the following contributions are to be made and are consistent with the overall plan for the next phase:

- Varietal improvement in both black and red small-seeded beans. Emphasis on resistance to biotic constraints (BGMV, ALS, anthracnose, *Apion*, CBB, BSMV, BCMV, and web blight), and abiotic constraints (drought and low soil fertility).
- Pathogen diversity, specifically, ALS and anthracnose.
- Marker-assisted selection for BGMV and CBB.
- Germplasm characterization.
- Collaboration (mainly by supplying populations) with participatory breeding initiatives in the region.
- Artesanal seed production (with emphasis on seed quality, especially in relation to phytosanitary standards).
- Statistical analysis of Ensayo regional de Rendimiento (ECAR) trials.

In addition, CIAT's IP-1 Project will be an important member of a foundation, tentatively called Fundación Regional de Investigación y Desarrollo Agropecuario (FRIDA). The SDC donor is planning to create FRIDA with CIMMYT, national programs, the private sector, and other partners interested in bean research in Central America and the Caribbean.

In 1999, SDC approved a new phase of PROFRIJOL. This will last for 2 years and its continuity will depend on the outcome of FRIDA. An agreement between SDC, CIMMYT, and CIAT to create FRIDA was signed with the aim of promoting the establishment of this foundation. A Task Force led by a Swiss consultant will examine the logistical, legal, and operational issues of the sustainability and feasibility of establishing FRIDA. There will also be an Advisory Group (one member each from CIAT, CIMMYT, SDC, PROFRIJOL, and the Programa Regional de Maíz [PRM]). This group will be in charge of providing guidance, and will establish the terms of reference and monitor progress. During 2000, two FRIDA Task Force meetings were attended. Meanwhile, activities within PROFRIJOL will continue as per the PPO approved in Guatemala City in 1999.

Contributors: C Cardona (IP-1); A Viana (PROFRIJOL)

4.2.2 Regional bean project for the Andean zone (PROFRIZA)

The Regional Bean Project for the Andean Zone (PROFRIZA) has operated since 1988. Until 30 June 1998, PROFRIZA was one of CIAT's regional projects; on 1 July 1998, it became a project of the SDC, an entity that has financed this project from the beginning. The continuous technical and scientific support, which CIAT provided, ended on 31 December 1999. However, CIAT will continue to include bean as a mandated crop because of its importance as a staple food for large sectors of the Latin American rural and urban populations. For this reason, CIAT sent a project proposal to the SDC for beans and other legumes for year 2000 and beyond. The proposal is entitled “Consortium for promoting the production and marketing of grain legumes in the Andean Region”. The SDC has agreed to fund legume research and promotion in the region for the next 3 years on a separate bilateral basis with each country.

Bilateral bean projects for the Andean Region (Ecuador, Peru, and Bolivia)

The national bean programs of Bolivia, Ecuador, and Peru continued to be important partners for the CIAT bean project this year. The regional PROFRIZA project, which previously linked the countries formally into a network, ended. However, the programs remain in contact with one another and with the CIAT bean project. In the new phase of the bean project for the region, the national programs are interested in continuing their strong historical ties and close interaction with the CIAT bean project. Germplasm from CIAT has been instrumental in the past successes of these programs and will continue to be important to their advances. Each national program has prepared rough drafts of the new bilateral projects, and in the new format CIAT will be subcontracted for germplasm and specific services that are of interest to the country.

As part of the planning stage for this project, visits were made during the past year to each of the principal sites for bean research in the region. The plant breeder for Andean beans visited Peru during the irrigated winter season on the northern coast / sierra (Chiclayo and Cajamarca) and visited Bolivia during the winter season in the Inter-montane valleys (Santa Cruz and Cochabamba). The purpose of these trips was to discuss breeding strategies, observe the Vivero de Padres Donanates de Genes Necesarios (VIPADOGEN) and IBN 1996 nurseries, and to see CIAT germplasm that has been released recently as varieties. Both the bean pathologist and Andean breeder visited sites in Ecuador (Chota, Ibarra, Bolivar, and Quito) during the first semester plantings to observe bush and climbing bean trials, collect pathogen isolates, and consult on future breeding goals and methodologies.

Breeding of Andean and Mesoamerican beans, IPM, and MAS are highly important areas of research for the new phase of the project. Joint breeding objectives across the region are needed to get the most varieties from each program. Bolivia covers lowland breeding and Ecuador covers highland breeding, while CIAT covers the full range of adaptation zones including mid-elevation breeding. Peru has no formal breeding programs, but has plant breeders placed in Universities and at the export board. Therefore, CIAT can continue to contribute to the national programs with germplasm and research. New interest has been expressed in applications of biotechnology to plant breeding in the region. The program in Bolivia plans to invest in some equipment for DNA extraction and in a screenhouse where they can carry out controlled inoculations and pathotyping. The DNA extraction will be used for collaborative work with CIAT on MAS and pathogen strain characterization. Ecuador has a modest laboratory working on molecular markers and genetic diversity characterization and is interested in applying MAS for resistance breeding.

Germplasm exchange has continued over the last year. An Andean bean nursery of advanced lines with commercial seed types was distributed to Ecuador and Bolivia for their upcoming planting seasons. The most important genetic resources for the region are the traditional commercial classes, new seed classes with export potential, and sources of disease and insect resistance. Although Colombian bean researchers are no longer within a formal Andean network, they can benefit from the germplasm developed in the region. For example, 10 local and regional research entities in Colombia have received the same CIAT advanced lines as their counterparts in Ecuador and Bolivia and will be trying them at the same time.

Training has been an important benefit of the regional network. A course was offered during the past year for the principal bean researchers from the region in modern techniques of the use of MAS and pathogen characterization in plant breeding and pathology. Training and regional collaboration will continue in the upcoming year with a visit to CIAT of a student from Ecuador for anthracnose isolation, inoculation, and resistance breeding.

Possibilities for joint fund-raising and collaborations in the region are promising. Many donors would be receptive to projects presented to them by the national programs. Future projects might revolve around specialty grain types and small-scale farmers who are growing beans for commercial and export production (as on the Peruvian coast and Bolivian lowlands). The Peruvian government is interested in capitalizing on and conserving their genetic resources, especially popping beans or ñuñas and the yellow- and white-seeded Canario and Caballero beans typical of Peru. Ecuador has started work in participatory plant breeding and export production. Bolivia has an interest in expanding bean production at higher elevations.

Contributors: MW Blair, O Voysest, G Mahuku, C Cardona

4.2.3 Joint collaboration and concept notes

Projects approved

The Administration Generale de la Coopération au Développement (AGCD)-Belgium approved a project, "Broadening the genetic base of common beans (*Phaseolus vulgaris* L.) through biotechnology", to extend activities carried out previously with Ghent University on interspecific hybridization and transformation.

The Belgian government tentatively approved a project, "Integration of biofertilisation in bean cultivation by optimizing the use of the *Rhizobium*-bean symbiosis", to work with Mexico and with the Catholic University of Leuven on the topic of symbiotic nitrogen fixation (SNF). This will permit follow-up on the gene tagging work initiated several years ago to improve SNF under conditions of low P availability.

The Federal Ministry for Economic Cooperation and Development (BMZ), Germany, approved a collaborative project entitled "An integrated approach for genetic improvement of aluminum resistance of crops on low-fertility acid soils". Four other CIAT projects (IP-2, SB-2, IP-5, and PE-2), one network (Pan-Africa Bean Research Alliance [PABRA]),and two systemwide programs (Soil Water Nutrient Management [SWNM] and Systemwide Livestock Program [SLP]-TROPILECHE) are collaborating to explore aluminum tolerance in bean and *Brachiaria*. The bean component includes on-site selection of aluminum-resistant genotypes in Africa, and will serve to maintain contact between headquarters and African breeders.

Another collaborative project with IP-2 was prepared and the Rockefeller Foundation approved funding. The project is entitled "Increasing food security and rural incomes in eastern, central, and southern Africa through genetic improvement of bush and climbing beans". It will start in 2001 and finish in 2003.

The Wallace Genetic Foundation, Inc. approved a 1-year grant to support "The development of molecular markers for breeding of common beans".

The USDA- Pan American Development Foundation (PADF) Hurricane Georges Recovery Program (HGRP) for Haiti gave the bean project funds for a project.

Another project for Haiti, "RFP No. 521-00010 for the Haiti Hillside Agricultural Program", was approved, funded by the United States Agency for International Development (USAID).

Projects submitted

The project "Sustainable management of P and N to improve production and quality of peanut (*Arachis hypogea* L.) in Latin America" was submitted to the European Union with partners in Belgium, France, Scotland, Spain, Cuba, Argentina, Mexico, and Brazil. It will permit exploring further applications in the use of FloraMap in predicting crop productivity across environments.

"Broadening the genetic base of common beans (*Phaseolus vulgaris* L.) through biotechnology", the same project that was approved by AGCD-Belgium with Ghent University, was submitted for extension.

A request was made for extension of the project "Interspecific solutions to intractable problems of common bean: Understanding the genome of the secondary gene pool to facilitate interspecific transfer of genes and broadening the genetic base of common bean". This has been ongoing for the past 4 years, in partnership with Gembloux University, to exploit the diversity of *P. coccineus* and *P. polyanthus*.

The proposal "Breeding beans for resistance to drought, mites, and root rots for Iran" was submitted for extension of collaboration with the Ministry of Agriculture of Iran.

The proposal “Food security for Central America and the Caribbean through a regional collaborative bean research network”, funding of PROFIJOL 2001-2003, was submitted to SDC.

Projects in preparation

“Real digestibility and stimulating effect of phaseolin, the bean storage protein, on endogenous secretion in rats”, a proposal developed with the Universidad Nacional de Palmira to study the effects of different morphotypes of phaseolin protein on endogenous protein loss from the gut, is to be submitted to the Volkswagon Foundation.

“Exploiting diversity among gene pools of common bean for underprivileged farmers in the highlands of Mesoamerica and Ecuador”, a pre-proposal developed with NARS of Guatemala, Mexico, and Ecuador, and with Michigan State University, was submitted to the McKnight Foundation. It is intended to extend the benefits of breeding to farmers that have been bypassed by past efforts in varietal development.

“Breeding staple crops for improved micronutrient value”, a concept note, was submitted to the Gates Foundation to improve the nutritional status of bean consumers in Africa and Middle America.

“Mineral-rich grains for better nutrition: Beans with higher zinc and iron for African farmers and consumers”, a concept note, was developed for submission to USAID-Uganda.

Concept notes prepared

- “Plan de fomento para reactivar la producción de frijol en Colombia”, prepared with FENALCE.

- Safeguarding bean farmers’ health from pesticide abuse through IPM approaches through COLCIENCIAS.

- “Recuperación y utilización de los recursos fitogenéticos del Perú: Mejoramiento del frijol reventón (ñuña/poroto) y caballero” submitted to the Ministry of Agriculture of Peru, for the regions of Cajamarca, La Libertad, Ancash, Ayacucho, Apurimac, and Cusco.

- “Estrategias de manejo de insectos plaga y enfermedades para pequeños productores de habichuela en suelo de planicia aluvial de piedemonte en el Valle del Cauca”, a project submitted to Progama Nacional de Transferencia de Tecnología (PRONATTA), Colombia, together with CORPOICA.

- Sustainable soil-crop-pest management strategies for integrating staple food crops with high value crops in hillside environments.

- Identification of dry bean germplasm tolerant to soil zinc deficiency for cultivar development for low-input sustainable agriculture.

- Phosphorus efficiency in common bean (*Phaseolus vulgaris* L.) in east and south African agroecosystems.

- Root rot problems: impact of beneficial soil microorganisms and soil nutrient management strategies in bean cropping systems.

- Increasing economic and food security for African households headed by women in sub-Saharan Africa.

- Integrating nutrient and pest management approaches for agroecosystem health sustainability.

Contributors: S Beebe, MW Blair, C Cardona, G Mahuku, IM Rao

Activity 4.3 Supporting NARS and Regional Network researchers on soil and crop management

Highlights:

- Partners are evaluating a set of 49 genotypes for their adaptation to abiotic constraints such as drought, aluminum toxicity, and low nutrient supply.

- Partners are evaluating a set of 19 genotypes for their response to ALS.

4.3.1 Evaluate elite bean genotypes for their tolerance to low fertility conditions in soil on farmer fields in Costa Rica, Mexico, Cuba, and Haiti

Collaborators in Mexico are evaluating a set of 49 promising genotypes for tolerance to low fertility in soil. Collaborators are:

Mexico: Javier Cumpian Gutierez, Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP), and Cd. Isla, Veracruz.
Cuba: German Hernandez, Ministerio de Agricultura (MINAG), and Quivican.
Costa Rica: Rodolfo Araya, Univ. of Costa Rica, Alajuela.
Haiti: Eliassaint Magloire, Organization for the Rehabilitation of the Environment (ORE), and Camp-Perrin.

Mexico: The most promising genotypes identified from the acid soil site in Veracruz, Mexico based on grain yield were: A 774, G 983, CAP 4, MAR 1, MAM 38, and

G 13755. These genotypes not only were adapted to acid Al-toxic soil conditions, but also were responsive to lime and fertilizer inputs. Among the plant attributes measured, number of pods per plant was identified as an important trait related to seed yield.

Costa Rica: Evaluation in Costa Rica was carried out at two sites (Fraijanes and Alajuela) with two levels of P supply (no P application and 200 kg ha^{-1} P application). At Fraijanes, V 8025, A 321, G 19833, DICTA 17, G 11640, and A 752 were identified as outstanding genotypes for their adaptation to low P-supply in soil. Among these six genotypes, A 321 was also highly responsive to P application. At the Alajuela site, CAP 4, A 774, FEB 192, Carioca, and FEB 190 were identified as low-P adapted genotypes. Among these five genotypes, FEB 190 was also highly responsive to P application.

Cuba: Field evaluation of 49 genotypes resulted in identifying eight promising genotypes (A 321, A 774, G 92, DICTA 17, FEB 190, CAP 4, SEA 13, and MAM 46) with adaptation to soil and climatic conditions of Quivicán. Seed multiplication of these materials is in progress.

Haiti: Field studies are in progress at two sites, an acid soil site at Deron (mid-altitude) and a high temperature site in the lowlands at Camp-Perrin. Genotypes that looked promising for acid soil conditions were BAT 304, BAT 477, BAT 881, FEB 192, ICTA-Ostua, BH 21134-66, DOR 364, DOR 390, G 18479, G 21212, BT-21138-98, and Tio Canela. Genotypes that showed better adaptation to high temperature stress were A 774, BAT 304, BAT 477, DOR 364, DOR 390, BT-21138-98, Tio Canela, and Quimbaya.

Contributors: IM Rao, S Beebe, H Terán

4.3.2 Evaluate elite bean genotypes for their tolerance to drought on farmer fields in Nicaragua

A set of 49 promising genotypes was planted along with a regional yield trial, to obtain baseline data on drought tolerance or susceptibility of regional breeding lines in relation to some well-known drought tolerant genotypes. Evaluation at San Diego identified G 18479, G 21212, and SEA 13 as promising materials for adaptation to drought. A bred line, SEA 5, was affected by BGMV and therefore was not among the best performers.

Contributors: IM Rao, S Beebe, H Terán

4.3.3 Evaluate genotypes for their response to angular leaf spot

A set of 19 potential sources of resistance is being evaluated for resistance to ALS in Nicaragua, Honduras (Juan Carlos Rosas, Zamorano), El Salvador, Bolivia, Costa Rica (Carlos Araya, University of Costa Rica), and Haiti (ORE, Camp-Perrin, Haiti).

Results from Honduras have shown that the lines G 5686, G 6727, G 8152, G 14301, AFR 702, AFR 703, and AFR 735 have high levels of resistance.

Haiti: Little incidence of ALS was observed partly because the trials were established under very high temperatures and low rainfall. The conditions were not conducive for disease incidence. These materials will be screened again during the main October season. The genotype AFR 702 showed very good heat tolerance.

Contributors: G Mahuku, C Jara

Activity 4.4 Supporting human resource development in NARS and Regional Networks

Highlights:

- CIAT bean project scientists actively participated in international conferences and meetings that they attended.
- Individual and group training of national and international scientists was provided.
- A marker database was constructed for an RAPD survey of Andean common bean germplasm.
- Colombian research and extension agents identified regional bean production problems.
- The Web page for IP-1 in English and Spanish was updated and expanded http://www.ciat.cgiar.org/projects/ip-1/bar_ip1.htm.

4.4.1 Trips and attendance at meetings

The breeder and plant nutritionist visited Cuba to evaluate bean trials during February.

The bean-breeding assistant visited Guatemala and Costa Rica to evaluate bean fields in April.

The team entomologist, plant nutritionist, breeder, and pathologist, together with the research assistants in breeding and germplasm characterization laboratory attended the

XLVI annual meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (PCCMCA) and the PROFRIJOL general assembly meeting in San Juan, Puerto Rico, during May.

The breeder and plant pathologist visited Iran in July-August to present a course on bean breeding-pathology, to familiarize themselves with the production constraints, to identify areas for collaboration, and to review field trials.

The breeder, plant pathologist, and plant nutritionist visited Haiti to familiarize themselves with bean production in Haiti and to evaluate bean trials during September.

The Project Manager made the following trips:

- To Guatemala in February to attend the First FRIDA Task Force and in July for the Second FRIDA Task Force.

- To Haiti in April in order to become acquainted with the Germplasm Improvement and On-Farm Adaptive Research Program and to plan the activities conducted in collaboration with ORE.

- To Bogota in July to elaborate the National Plan on Legumes with FENALCE and CORPOICA.

The breeder visited the following countries:

- Mexico, in September 1999, to familiarize himself with highland bean production and coordinate activities.
- El Salvador, in October 1999, to review field trials including heat tolerance studies.
- The Philippines, in October 1999, to the Consultative Group on International Agricultural Research (CGIAR) workshop on nutritional quality, IRRI.
- Brazil, in November 1999, to attend the national bean meeting, Reunião Nacional de Pesquisa de Feijão (RENAFE).
- Nicaragua and Honduras, in December 1999, to review field trials.
- East Lansing, Michigan, USA, in April 2000, to attend the Meeting of Bean /Cowpea Collaborative Research Support Project (CRSP), to plan the renewal phase.
- Guatemala, in April 2000, to evaluate bean fields.
- Cuba, in May 2000, to attend the planning session for a project to be submitted to the European Union.

The Andean breeder/germplasm specialist made the following visits:

- Peru, in November 1999, to discuss breeding strategies and to observe nurseries.
- San Diego, California, USA, in January 2000, to attend the Plant and Animal Genome (PAG)VII - genomics conference.
- Bolivia, in March 2000, to discuss breeding strategies and to observe nurseries.

- Ecuador, together with the plant pathologist in May 2000, to observe bush and climbing bean trials, collect pathogen isolates, consult on future breeding goals and methodologies, and discuss possible areas of collaboration.
- USA, in June 2000, to attend a tour of MAS facilities in Novartis, Monsanto, University of Minnesota, and Washington University.

Bean breeding supported the participation of the ICIS Workshop at CIMMYT, Mexico.

The plant nutritionist gave a seminar on abiotic stress adaptation of common bean to MSc students of the National University, Palmira and to UMATA technicians from Colombia.

4.4.2 Training and courses

- Active participation of the breeder and the plant pathologist was given to the workshop for the PROFRIZA network held at CIAT from October 25 to November 5, 1999. The workshop was entitled "Curso internacional para mejoradores y patólogos de la región Andina - Técnicas modernas en el mejoramiento y estudios de patología de frijol" and was addressed to the 22 bean researchers from the Andean zone (Colombia, Bolivia, Peru, and Ecuador).

- The plant pathologist gave a talk on the use of microsatellites in population genetics studies of plant pathogens during a course on "Técnicas moleculares aplicadas a la identificación de la resistencia a enfermedades en diferentes cultivos" held at CIAT 9–12 December 1999.

- A Legume Planning Workshop on "Discusión de un plan nacional de investigación, transferencia de tecnología y promoción del comercio de leguminosas alimenticias" was held at CIAT, 16-17 March. Researchers from CORPOICA (Regionals 1, 4, 5, 6, and 7), FENALCE, and UDENAR attended this workshop.

- Plans for the fieldwork of a Cuban MSc student were solidified during a visit to La Habana in May. The student will carry out a physiological analysis of lines derived from the cross of DOR 364 x BAT 477, the latter of which has expressed resistance to multiple abiotic stresses. The study will reveal the physiological relationship between resistances to low P, nitrogen, and drought stress.

- Twenty-two legume researchers from Colombia and Ecuador participated in "Primer curso avanzado de producción y gerencia de proyectos sobre el cultivo de frijol" held at CIAT from 12 to 23 June.

- A bean breeding-pathology course was given to Iranian bean scientists on bean breeding and pathology in Karaj, Iran, from July 29 to August 4.

- Researchers and extension workers from Bolivar, Colombia, visited CIAT from 11-15 September, for a training course in bean production.

- The plant pathologist participated in training a Cuban scientist, using molecular techniques (DNA extraction, REP-PCR) to characterize the CBB pathogen.

4.4.3 PhD, MSc, and pregraduate thesis students

- An Argentinean PhD candidate was hosted for 2 weeks to prepare data analysis for his thesis work, involving a statistical analysis of multi-locational trials carried out over a 15-year period in the northwest of Argentina. The study will help to orient a strategy for future bean trials in the region.

- A PhD student from the Universidad del Valle is conducting his research on molecular characterization of NL4 BCMV strain.

- A PhD student from the Ecology and Crop Production Science Department of SLU, Uppsala, Sweden and Universidad Nacional Agraria, Nicaragua, made an analysis of on-farm genetic diversity in Nicaragua, where he is a germplasm specialist with the University.

- A PhD student from the University of Wageningen, The Netherlands, finished her thesis research on biological control of whiteflies.

- A PhD student from ETHZ, Zurich is conducting her thesis research on host plant resistance to *Thrips palmi*.

- Two MSc students from the Universidad Nacional are finishing their thesis research. One is conducting a study on " Efectividad de método de selección por gametos en la F_1 de cruzas múltiples para resistencia a enfermedades en frijol común *P. vulgaris* L." The other thesis is on "Análisis de la herencia en la resistencia a *Phaeoisariopsis griseola*, hongo causante de la mancha angular en 87 líneas recombinantes de frijol común, *Phaseolus vulgaris* L.

- A visiting scientist from ETHZ, Zurich is conducting a 6-month training period in bruchid management.

- A pregraduate student from the University of Tolima was supervised and completed his laboratory work toward obtaining his undergraduate agronomist degree. His thesis involved the identification of QTL for agronomic traits that had been introgressed from wild bean to cultivated bean.

- A pregraduate student from the University of Tolima is conducting her project on a wild QTL study to see whether cultivated beans of Andean and Mesoamerican gene pools can be improved via crosses with wild bean accessions from divergent gene pools.

- A pregraduate student from the Universidad del Valle started his thesis studies on using molecular markers to study the genetic diversity of *Colletotrichum lindemuthianum*.

- A pregraduate student from the Universidad Nacional is finishing her thesis on Pathogen diversity of the ALS pathogen, *Phaeoisariopsis griseola*.

- Two new undergraduate students from the Universidad del Valle have begun their thesis research. One is studying the inheritance of micronutrient content in bean seeds, especially for the minerals iron and zinc; the other is testing microsatellite markers from other legumes, such as soybean and cowpea, in common bean.

- Two pregraduate students from the Universidad Nacional are finishing their theses on ecology and phenology of *Thrips palmi* as a pest of beans and snap beans.

4.4.4 Databasing

Molecular genetics database constructed for an RAPD survey of Andean common bean germplasm

Rationale: We are developing a database to store the information from the RAPD analysis of genetic diversity of the Core Collection of Andean common beans. Our first step was to find a software system for storing, handling, and presenting images within a relational database. Fortunately, a new version of the Oracle software, v. 7.3.2, has been released that has these capabilities and has a more user-friendly interface and the capacity to be loaded onto the Web. As a relational database, Oracle has the advantage of being an efficient program for organizing and managing data; it has multiple layers of relational structure and is based on a series of data tables. This software provides a set of tools for building new interfaces for a database and asking new questions of that database. The three principal components are tools to generate worksheets, reports, and graphic images. The program DEVELOPER/2000, part of the Oracle suite, has a Web-compatible format that uses windows and buttons to allow for interactive searches and queries. Oracle software is the standard program for databasing the information from the breeding programs at CIAT. We hope that this preliminary database will be the basis for collecting genotypic information on common bean, and will be a dynamic analysis tool allowing researchers to ask such questions as: How many polymorphisms can I expect when comparing two varieties that might be potential parents? Which polymorphisms distinguish one variety from another?

Materials and methods: Using the software package Quantity One from Biorad, 330 photographs of RAPD banding patterns were scanned and analyzed. These represented 10 primers run on 680 genotypes. The annotated gel images were loaded into the database using the Oracle graphics development tool and the estimated band sizes were loaded using the Oracle worksheet development tool. The finished database has three main windows for “gel”, “accession”, and “bands”. Each of these has a datasheet format with columns and entries. The “gel” window indicates the center of origin for the genotypes, the molecular technique and the primer used, and shows all of the genotypes run together in a given gel. Clicking on a genotypes entry brings up all the sized bands for that individual. Embedded windows are used to call additional items such as the gel images. The “accession” window can be used to compare the markers present in two genotypes. Activities are realized either through the menu bar or action buttons. A console line indicates the status and location of the user. The first version of this database was written in Spanish.

Future plans: Future plans are to load additional molecular marker data into the present database. We hope to place the database on the Internet using Microsoft Interdev or with the Oracle software tool, Web-DB. With either system, the database can be accessed from any type of computer, via common Web-browsers such as Netscape or Internet Explorer. To date, the database contains RAPD fingerprints, but could also accommodate data from other multiple-copy marker systems such as AFLP fingerprints. The information stored in this Oracle database could be amenable to incorporation into databases that use other software applications. The basic components of this database will be easy to transfer to ICIS (http://www.cgiar.org/icis), which is the database system for managing and integrating genetic resource, crop improvement, and crop management information of the CGIAR-system. The IPHIS database has been developed at CIAT to hold bean-breeding data. Molecular data are foreseen to be an important part of these databases in the future. It would also be important for this database to be interactively linked with the BeanGenes database (http://beangenes.cws.ndsu.nodak.edu/), which was established by the USDA-Plant Genome program to specialize in the genetic information relating to common bean. To realize the maximum potential of a molecular marker database, it should also be linked with other existing databases that contain germplasm data on *Phaseolus* including SINGER (http://singer.cgiar.org), the principal database on genetic resources held in the CGIAR system and GRIN (http://www.ars-grin.gov/npgs/). The potential for linkages between all these databases is shown schematically in Figure 70.

Collaborators: MW Blair, M Muñoz, S Beebe, AF Guerrero, F Rojas

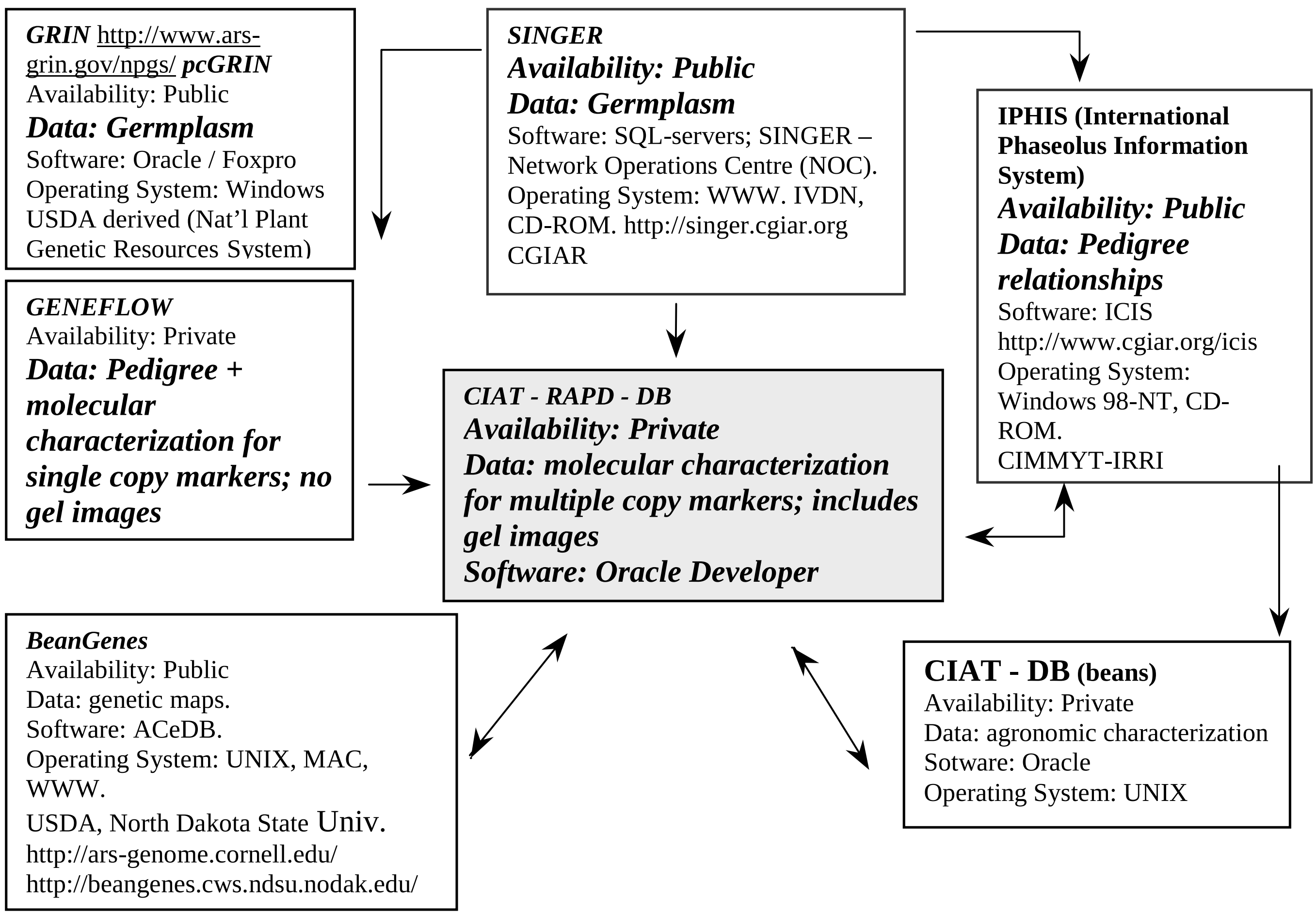


Figure 70. Databases for common bean germplasm and genetic information. Web sites are given for those databases available on the Internet.

Identification of regional bean production problems by Colombian research and extension agents

Rationale: A workshop sponsored by the Colombian Ministry of Agriculture was held in June 2000 for researchers and extension agents from all over Colombia who had an interest in bean production. As part of the exchange that developed during the workshop, the idea was born of a questionnaire to assess the current situation of bean production in Colombia. The objective of this report is to summarize the data collected from the Colombian researchers and extension agents.

Materials and methods: The questionnaire was distributed to 20 participants. Questions came under nine headings: area planted, grain preferences and varieties, planting dates, cropping systems, diseases, insects, market opportunities, nursery management, and germplasm interests. Where appropriate, the answers were given separately for bush versus climbing beans. The participants were from private (FENALCE - 5; NGOs -3) and public institutions (ICA/CORPOICA - 6; SEA - 1; UMATA - 3) and came from seven departments of Colombia (Antioquia - 3; Boyacá - 1; Cauca - 2; Huila - 3; Nariño - 4; Norte Santander - 1; Santander -2; Tolima -1). FENALCE is the national cereal and legume producers association, ICA/CORPOICA is the national research service and the UMATAs are local extension services. The information was tabulated according to the departments from which the participants came.

Results: All participants answered the questionnaire enthusiastically and completely. In the first question, they estimated the area planted across their regions. These estimates were comparable to previous estimates from the Ministry of Agriculture for the areas in beans for each department. The breakdown between bush and climbing beans across the departments showed that bush beans predominate, but that climbing bean production is substantial in the departments of Antioquia, Boyacá, and Nariño. Climbing beans are also found in departments that are not believed to have as much climbing bean, such as Cauca, Huila, and Tolima. The other surprise was the interest in expanding the hectares of bush beans, especially at lower elevations, in traditional climbing bean growing departments, such as Antioquia and Nariño.

Table 48 shows the varieties of bush and climbing beans identified by the participants as important for their regions. While most of the bush bean varieties were modern releases from ICA, most of the climbing beans were landraces. Two breeding programs at the University of Nariño and at the La Selva experiment station are addressing the paucity of improved climbing bean varieties. In addition, an interesting program run by a group of farmers in Nariño, in conjunction with CORPOICA, is selecting better-yielding varieties from local landraces of climbing beans.

Table 48. Bean varieties identified by participants as important in seven departments of Colombia.

Department	Bush		Climber	
	Variety	Origin	Variety	Origin
Antioquia	Uribe Rosado	ICA	Cargamanto	ICA
	Citara	ICA	Cargamanto Rojo	Local
	Quimbaya	ICA	Cargamanto Blanco	Local
	Regional	Local	--	--
	Radical	ICA	--	--
	Llanogrande	ICA	--	--
Boyacá	Rovirense	ICA	Bola Roja	ICA
	ARS-59	ICA	--	--
Cauca	Cerinza	ICA	Bola Roja	Local
	Caucaya	ICA	Cargamanto	Local
	Cacha	Local	--	--
Huila	Diacol Calima	ICA	Bolón Rojo	Local
	Diacol Catio	ICA	Cargamanto Rojo	Local
	Radical	Local	Variedad	Local
	Cajamarca	Local	Sabanero morado	Local
	Calima	ICA	--	--
	Bola Roja	Local	--	--
Nariño	Bachue	ICA	Rumichaca	ICA
	Cerinza	ICA	--	--
	Guaitara	ICA	--	--
Norte Santander	Zaragoza	Local	--	--
Santander	Froilan	ICA	--	--
	Guanenta	ICA	--	--
	Rovirense	ICA	--	--
	ARS-59	ICA	--	--
Tolima	Caucaya	ICA	Bola Roja	ICA
	ICA-60	ICA	Cargamanto Rojo	Local
	Algarrobo	Local	--	--

The planting dates identified by the participants varied depending on the region. At higher elevations in Nariño and Antioquia, planting dates were more likely to be once a year, but in any month. At lower elevations, they were associated with the bimodal rainfall, except in the irrigated areas of Santander. A range of cropping systems were mentioned, however, bush beans were usually planted as a monocrop while climbing beans, when not grown on trellises, were sometimes planted as an intercrop with maize.

Table 49 shows the diseases and insects mentioned most often by participants for bush or climbing beans. Anthracnose was the most important disease of both bean systems. Rust was the second most important disease in bush beans, but not in climbers, followed by ALS and *Ascochyta*. Leaf feeders, including the Chrysomelids, were the most important insects in bush beans, while pod borers were more important in climbing beans. Other important insects were *Empoasca* and Cutworms. According to the participants, the price received at the farm was about 60%-70% the price of beans sold by the intermediaries.

Table 49. Frequency of diseases and insects mentioned by participants as important in bush and climbing beans in seven departments of Colombia.

Pathogens	Bush	Climber	Insects	Bush	Climber
Anthracnose	82.4	76.5	Aphids	17.6	5.9
Ascochyta	23.5	35.3	Borers	11.8	17.6
Ashy stem blight	17.6	11.8	Cutworms	29.4	29.4
Angular leaf spot	23.5	35.3	*Empoasca*	41.2	29.4
BCMV[a]	5.9	5.9	Leaf feeders	52.9	23.5
Fusarium wilt	0.0	5.9	Leaf miners	5.9	5.9
Powdery mildew	11.8	5.9	Pod borers	23.5	47.1
Root rots	17.6	17.6	Slugs	23.5	5.9
Rust	35.3	17.6	Thrips	17.6	17.6
Web blight	23.5	0.0	Whiteflies	17.6	23.5

a. BCMV = bean common mosaic virus.

Conclusions and future plans: We plan to use the information collected to help orient the Andean bean breeding program at CIAT and to make recommendations that can be used in the national plan for research in pulse crops, which is being formulated this year by government and non-governmental agencies. Increased attention to climbing beans and resistance to diseases such as anthracnose and *Ascochyta* blight are needed.

Contributors: MW Blair, P Zamorano, C Cardona

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Increasing food security and rural incomes in eastern, central, and southern Africa through genetic improvement of bush and climbing beans	Rockefeller Foundation	USA
A coordinated effort to mark and map important genes in commom bean: Universities of California, Cornell, Michigan State, North Dakota and Puerto Rico	USAID	USA
Germplasm improvement on-farm adaptive research program in Haiti	USAID/ PADF	USA
The development of molecular markers for the breeding of sustainable pest resistance in common beans: a novel strategy	Wallace Genetic Foundation, Inc.	USA

a. For acronyms used see page 187.

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List of Acronyms and Abbreviations Used

ACIAR	Australian Center for International Agricultural Research
AFLP	amplified fragment length polymorphism
AGCD	Administration Generale de la Coopération au Développement, ISABU, Burundi
AgrEvo	Agricultura en Evolución, compania
AID	Agency for International Development
ALS	angular leaf spot
AMOVA	analysis of molecular variance
ANT	anthracnose
ARC	Agricultural Research Council of GCRI, South Africa
ARO	advanced research organization
ARS	Agricultural Research Service, USDA, Washington
ASCOLFI	Asociación Colombiana de Fitopatología y Ciencias Afines
ASOCOLFLORES	Asociación Colombiana de Productores de Flores
BADC	Belgian Administration for Development Cooperation
BCMV	bean common mosaic virus
BCMNV	bean common mosaic necrosis
BGMV	bean golden mosaic virus
BGYMV	bean golden yellow mosaic virus
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (*Federal Ministry for Economic Cooperation and Development*), Germany
BOL	Bolivia
BSMV	bean severe mosaic virus
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CBB	common bacterial blight
CCMV	cowpea chlorotic mottle virus
CDC	Crop Development Centre, University of Saskatchewan, Canada
CENTA	Centro Nacional de Tecnología Agropecuaria, El Salvador
CGIAR	Consultative Group on International Agricultural Research
CIAL	Comité de Investigación Agrícola Local (*farmer-led research committee*)
CIAS	Centro de Investigaciones Agrícolas del Sureste, SEA, Dominican Republic
CIDA	Canadian International Development Agency
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, Mexico
CIPASLA	Consorcio Interinstitucional para una Agricultura Sostenible en Laderas, Colombia
CL	*Colletotrichum lindemuthianum*
CNIA	Centro Nacional de Investigación Agropecuaria, Nicaragua
CNPAF	Centro Nacional de Pesquisa de Arroz e Feijão, Brazil
COL	Colombia

COLCIENCIAS	Instituto Colombiano para el desarrollo de la Ciencia y la Tecnología “Francisco José de Caldas
CORFOCIAL	Corporación para el Fomento de los Comités de Investigación Agrícola Local, Colombia
CORPOICA	Corporación Colombiana de Investigación Agropecuaria
CPSMV	cowpea severe mosaic virus
CRDA	Centre Recherche de Agriculture, Haiti
CRSP	Collaborative Research Support Project of USAID
CSU	Colorado State University, USA
DANIDA	Danish International Development Agency
DFID	Department for International Development, UK
DICTA	Dirección de Investigación de Ciencias y Tecnología Agrícola, Honduras
DIFALS	Angular Leaf Spot Differentials nursery
DIFANT	Anthracnose Differentials nursery
DIFFUS	*Fusarium* Differentials nursery
DIFRUST	Rust Differentials nursery
DMS	Data Management System of ICIS
EAP	Escuela Agrícola Panamericana, Zamorano, Honduras
ECAR	Ensayo regional de Rendimiento, PROFRIJOL
EEA	Estación Experimental Agroindustrial
EMBRAPA	Empresa Brazileira de Pesquisa Agropecuária
ERIC	enterobacterial repetitive intergenic consensus REP-PCR primers
ETHZ	Eidgenössische Technische Hochschule-Zentrum, Switzerland
ETHZ-ZIL	ETHZ– Zentrum für Internationale Landwirtshaft
FENALCE	Federación Nacional de cultivadores de Céreales, Colombia
FIDAR	Fundación para la Investigación y el Desarrollo Agroindustrial Rural, Colombia
FRIDA	Fundación Regional de Investigación y Desarrollo Agropecuario
FT Seeds	Francisco Terasawa Semente e Genética, Brazil
GCRI	Grain Crops Research Institute, South Africa
G x E	genotype x environment
GMS	Germplasm Management System of ICIS
HFI	high fertilizer input
HGRP	Hurricane Georges Recovery Program of USDA for Haiti
HTI	Haiti
IAC	Instituto Agronômico de Campinas, Brazil
IAREC	Irrigated Agriculture Research and Extension Center, USA
IASA	International Alliance for Sustainable Agriculture
IBN	International Bean Nursery
IBYAN	International Bean Yield and Adaptation Nursery
ICIS	International Crop Information System
ICTA	Instituto de Ciencia y Tecnología Agrícolas, Guatemala City, Guatemala
IDIAP	Instituto de Investigación Agropecuaria, Panama
IDRC	International Development Research Center, Canada

IFPRI	International Food Policy Research Institute
IGS	intergenic spacer region
IIA	Instituto de Investigaciones Agrícolas, Bolivia
IICA	Instituto Interamericano de Cooperación para la Agricultura
INIAP	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Ecuador
INIFAP	Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Mexico
INRA	Institut National de Recherche Agronomique, France
INTA	Instituto Nacional de Tecnología Agropecuaria, Nicaragua
IPEL	Instituto Peruano de Leguminosas de Grano
IPHIS	International *Phaseolus* Information System, an ICIS
IPM	integrated pest management
IPRA	Investigación Participativa en Agricultura / Participatory Research in Agriculture of CIAT
IRRI	International Rice Research Institute, Philippines
MAE	Ministère des Affaires Etrangères, France
MAS	marker-assisted selection
MINAG	Ministerio de Agricultura, Cuba
MINEDUCACION	Ministry of Education, Colombia
MWI	Malawi
NARIs	national agricultural research institutes
NARS	national agricultural research systems
NFI	no fertilizer input
NGO	nongovernmental organization
NIC	Nicaragua
NOC	Network Operation Center
NTSYS	numerical taxonomy system (a type of computer package)
ORE	Organization for the Rehabilitation of the Environment, Haiti
PABRA	Pan-Africa Bean Research Alliance
PADF	Pan American Development Foundation of USDA
PAG	Plant and Animal Genome conference, USA
PC	*Phaseolus coccineus*
PCCMCA	Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, Guatemala
PCR	polymerase chain reaction
PG	*Phaeoisariopsis griseola*
PP	*Phaseolus polyanthus*
PPO	Project Planning by Objectives
PRM	Programa Regional de Maíz, Guatemala
PROFRIJOL	Proyecto Regional de Frijol para C entro América, México y el Caribe
PROFRIZA	Proyecto Regional de Frijol para la Zona Andina, CIAT
PROMPEX	Comisión para la Promoción de Exportaciónes, Peru
PRONATTA	Progama Nacional de Transferencia de Tecnología, Colombia
QTL	quantitative trait locus or loci

RAM	random amplified microsatellites
RAPD	random amplified polymorphic DNA (a technique for mapping genomes)
RCBD	randomized complete block designs
RENAFE	Reunião Nacional de Pesquisa de Feijão
REP-PCR	repetitive extragenic palindromic polymerase chain reaction
RFLPs	DNA restriction fragment length polymorphisms
RILs	recombinant inbred lines
SAHN	sequential, agglomerative, hierarchic, and nonoverlapping clustering methods
SCAR	sequence characterized amplified region molecular markers
SDC	Swiss Development Cooperation
SEA	Secretaría de Estado de Agricultura, Dominican Republic
SLP	Systemwide Livestock Program
SLU	Sveriges Lantbruks Universitet (Swedish University of Agricultural Science)
SNF	symbiotic nitrogen fixation
SPII	Seed Plant Improvement Institute, Iran
SPS	single plant selections
SSR	simple sequence repeat
SWNM	Soil Water Nutrient Management Program (SWP of the CGIAR)
TNC	total nonstructural carbohydrates
TROPILECHE	Sistemas de Alimentación a base de leguminosas mejoradas para pequeños productores con ganado de doble proposito en América Latina tropical ("Improved legume-based feeding system for smallholder dual-purpose cattle production in tropical Latin America"), a CGIAR project
TZA	Tanzania
UAGRM	Universidad Autónoma Gabriel René Moreno, Bolivia
UDENAR	Universidad de Nariño, Colombia
UMATAs	Unidades Municipales de Asistencia Técnica Agropecuaria, Colombia
UNALM	Universidad Nacional Agraria "La Molina", Peru
UPGMA	unweighted pair-group distance method of averaging
USAID	United States Agency for International Development, Washington
USDA	United States Department of Agriculture
VIPADOGEN	Vivero de Padres Donanates de Genes Necesarios
XCP	*Xanthomonas campestris phaseoli*
XCPF	*X. campestris phaseoli* pv. *Fuscans*
ZIL	Zentrum für internationale Landwirtshaft (Centre for International Agriculture)