19791

Germplasm Screening and Genetic Improvement

Germplasm Collection and Evaluation

New Introductions

During 1981 the germplasm bank continued the acquisition of Phaseolus germplasm either through donations from national institutions or through expeditions The total collection increased by 1754 accessions (Table 1)

Under IBPGR funding expeditions were made to Brazil and Peru to collect land races and wild forms of both P vulgaris and P lunatus In Brazil five priority areas had been determined for exploration in collaboration with CENARGEN three expeditions have been carried out so far the first of which was reported last year The last two expeditions in the North of Rio Grande do Sur Santa Catarina Parana and Goias yielded 427 accessions In Peru six collection trips were made in 1979 three in 1980 and three in 1981 In 1980 a total of 135 accessions mostly of P vulgaris were collected In future expeditions emphasis will be placed on collection of wild forms

Additionally IBPGR sent to CIAT as a repository bank for Phaseolus 312 accessions collected in Zambia and Malawi IITA sent 497 accessions of P lunatus which completed a duplicate collection of this species in CIAT

Status of the Phaseolus Collection

The size of the Phaseolus collection held in the bank has increased to 32 042 accessions (Table 2) Most of the germplasm 89% is Phaseolus vulgaris (common bean) and its wild types 7% is Phaseolus lunatus (lima bean) 3% is all subspecies of P coccineus (scarlet runner bean) and 0 5% is Phaseolus acutifolius (tepary bean) The rest approximately 0 5% includes noncultivated species of Phaseolus Additionally there are 429 accessions of other genera mainly Vigna and Psophocarpus in the germplasm bank at CIAT

Germplasm Evaluation and Seed Increase

Cultivated Phaseolus vulgaris

Evaluation The morphoagronomic evaluation of Phaseolus vulgaris continued at CIAT-Palmira with descriptions of 702 new materials and updating of descriptions of 1416 accessions by adding more complete data

Table 1 Bean germplasm bank accessions received in 1981

Country	Acquisition and/or expedition[a]				
	P vulgaris	P lunatus	P coccineus	Other	Total
Argentina			1		1
Brazil	12				12
	152[a]	4[a]			163[a]
Chile	1				1
Colombia	22				22
Ecuador	1				1
El Salvador	1				1
Guatemala	11				11
Holland	36		3		39
Malawi	125[a]	19[a]		21[a]	165[a]
Mexico	2			1	3
Nicaragua	1				1
Nigeria		497			497
Dominican Republic	3				3
Peru	2				2
	135[a]				135[a]
Spain	457		7	1	465
United States	3				3
Zambia	187[a]	16[a]	—	26[a]	229[a]
Total	1151	563	11	56	1754

a Expeditions funded by IBPGR

Evaluation of germplasm adapted to higher altitudes has been initiated in cooperation with breeders and is more oriented toward adaptation and yield potential A total of 450 climbers were evaluated in Popayan (1800 masl) several of which were included in the breeding program Currently 1235 additional climbing accessions are being evaluated

Seed increase A two-step procedure has been established to increase new germplasm accessions a post-quarantine greenhouse or meshhouse planting and a subsequent increase in an isolated dry area near Dagua where the incidence of bacterial and fungal diseases is low and virus detection is easy

More than 1600 accessions of P vulgaris were increased in this way but due to the heterogeneity of the germplasm and the lack of previous information problems of adaptation or seedset arose which consequently limited the number of seeds available for further evaluation This year 5110 previously evaluated accessions were seed increased and another 3230 are being multiplied

Table 2 Collection of *Phaseolus* beans stored in the Genetic Resources Unit (as of October 1981)

Species	No of accessions
Cultivated	
P. vulgaris cultivated forms	28 117
P. vulgaris wild forms	332
P. lunatus cultivated forms	2 221
P. lunatus wild forms	62
P. coccineus subsp. *coccineus* cultivated forms	707
P. coccineus subsp. *polyanthus* cultivated forms	317
P. coccineus wild form	58
P. acutifolius cultivated forms	89
P. acutifolius wild forms	59
Noncultivated	
P. anisotrichus	25
P. metcalfei	11
P. ritensis	8
P. filiformis	10
P. wrightii	4
P. microcarpus	9
P. pedicellatus	6
P. polystachyus	8
P. galactoides	1
P. parvulus	1
Total *Phaseolus*	32 042
Other genus	
Vigna spp.	258
Psophocarpus spp.	106
Other	65
Total other	429

In CIAT-Palmira the standard procedure to increase seed of germplasm bank accessions is by planting 80 seeds in a 6-m row which produces an average of 520 g seeds per accession (Table 3). Due to lack of adaptation (also under greenhouse conditions) however this rate of seed increase is too slow. Therefore in the future seed increases will be made with increased numbers of rows per accession.

Wild forms of Phaseolus vulgaris L. *and cultivated and wild forms of* Phaseolus coccineus L. A project to increase the variability of the common bean *Phaseolus vulgaris* L. by interspecific hybridization with its wild relatives as well as with other species of the genus

Table 3 Seed increase of germplasm bank in Palmira Seed yield/plot (1981)

Growth habit	Days to flower			Yield (g/plot)		
	Min	Max	$\bar{x}$	Min	Max	$\bar{x}$
I	28	41	31	172	1064	446
II	29	60	37	70	1188	680
III	30	56	37	54	1133	507
IV	30	55	37	250	950	446
Average per accession						520

especially Phaseolus coccineus L is being carried out in collaboration with the University of Gembloux in Belgium Seed increase and intensive evaluations of these materials are needed to select the most valuable accessions for the interspecific crossing projects

Seed increase and evaluation of the wild Phaseolus vulgaris accessions CIAT s germplasm bank has in total 332 accessions of wild forms of Phaseolus vulgaris distributed as follows

Phaseolus vulgaris var aborigineus	8
Phaseolus vulgaris Mexican wild form	153
Phaseolus vulgaris weedy type	171

Most of these wild forms are adapted to altitudes above 1600 m The differences among these forms refer mostly to their origin

> P vulgaris var aborigineus (Burk) Baudet whose origin is South America is the ancestral form of the common bean in Burkart s opinion (1953) Seeds are grey or brown mottled with black lines The average 100-seed weight is 12 0 g
> The Mexican wild form which Gentry found (1969) in Mexico between 800 and 2000 masl is he claims the ancestral form Seed may be mottled or of uniform color (brown green black) The average 100-seed weight is 6 2 g
> The weedy type concept was introduced by Baudet (1977) for some Mexican forms presenting characters frequently found in a cultivated form These forms would result from regressions or crosses between wild and primitive cultivated forms Seeds are mottled or of a uniform color (cream pink yellow) They are often bigger than the ones of the Mexican wild form Average 100-seed weight is 15 7 g

All 332 accessions have been seed increased The results of 255 accessions evaluated up to now indicate that most of the wild forms are not an interesting source for plant architectural characters

evaluation of wild forms for disease and pest resistance is shown in Table 4 The promising accessions need further more detailed evaluations to confirm their potential as a source of germplasm for the improvement of the common bean

In addition a preliminary study of variability is underway to find discriminant characters to eliminate duplicates and to establish a possible relationship between the three wild P vulgaris forms

Seed increase of the Phaseolus coccineus accessions

P coccineus is the species most closely related to P vulgaris It encompasses a great number of cultivated and wild populations representing a large variability of characters Many breeders consider these features useful for the improvement of common beans

Unlike the common bean P coccineus has an outcrossing mechanism therefore a special seed-increase method should be devised in order to

Favor cross-pollination within the accessions to maintain their natural variability and to avoid inbreeding depression
Preserve the integrity of each population by avoiding cross-pollination among accessions

Two experiments were carried out to test the usefulness of two pollinating insects--honeybees (Apis melifera) and bumblebees (Xylocopa sp)--compared to manual pollination Because of the amount of seed production cross-pollination and cost bumblebee pollination is recommended to seed increase P coccineus germplasm But the lack of knowledge about the ethology of this insect and the difficulty in finding a high number of nests may lead to the choice of manual pollination Honeybee pollination was excluded because of its high cost and the low amount of cross-pollination achieved

Table 4 Evaluation of wild forms of P vulgaris for disease and pest resistance to date

Disease or pest	No of accessions evaluated	No of accessions selected for futher testing
Bean golden mosaic virus	137	2
Common bacterial blight (Xanthomonas phaseoli)	189	9
Ascochyta leaf spot	175	121
Leafhopper (Empoasca kraemeri)	234	0
Zabrotes subfasciatus	193	29
Acanthoscelides obtectus	178	163

Seed increasing P coccineus germplasm is accomplished as follows 13 plants per accession are planted in a meshcage of 2 x 2 x 2 m This number of plants provides a 25% probability that alleles with frequencies of 20% or more will pass to the next generation A higher number of plants would be desirable but would involve an important cost increase Moreover many accessions consist of less than 10 seeds This method allows the seed increase of 200 accessions per year

The other cultivated species P lunatus and P acutifolius are being increased and evaluated at a slower pace

Long-Term and Short-Term Storage

Germplasm preservation is a chief responsibility of the Genetic Resources Unit Germplasm for long-term storage is submitted to a germination test (established by the International Seed Testing Association) and subsequent seed drying with silica gel Those materials with germination higher than 90% and vigor higher than 40% are put in long-term storage in sealed laminated foil bags at -2 C room temperature

So far 5450 accessions have been tested for germination (Table 5) of which 2437 have been processed for long-term storage The average germination was very high (94% long term and 88% short term) which indicates good viability of germplasm stored in CIAT s bank

Data Management and Documentation

All data concerning introduction maintenance evaluation and distribution of germplasm have been organized in computer files for each one of the four cultivated species Additional files are stored describing the handling of germplasm in the cold rooms i e germination tests seed inventory and greenhouse increase

Table 5 Germination tests for P vulgaris to date [a]

Type of storage	No of accessions tested	Mean high vigor	Mean germination
Long term	2437	59%	94%
Short term[b]	5450	57%	88%

a Using procedures established by ISTA (International Seed Testing Association)
b Includes accessions also tested in long-term storage

The germplasm catalog of Phaseolus vulgaris was distributed to 23 countries and an updated issue is being prepared for release in 1982

Distribution of Germplasm and/or Information

A primary objective of the germplasm bank is to serve agricultural scientists by providing either seeds or information both to researchers in the main commodities within CIAT and to scientists and national institutions outside CIAT As part of this goal a total of 20 988 bean germplasm accessions was distributed within and outside CIAT during 1981

As in previous years in 1981 there was a great demand for germplasm from CIAT s Bean Program chiefly from the breeding section Of the 12 794 accessions distributed to the Bean Program (Table 6) 54% went to breeders this implies that the germplasm is actively used This high demand is expected to continue especially for newly acquired germplasm

Likewise there was a strong demand for germplasm from scientists in national programs outside CIAT with a total of 8194 accessions from 69 requests (Table 7) The Central American and Caribbean region requested 85% of the total accessions in 1981 in South America the non-Andean zone requested 6% and both Oceania and North America each requested 3%

Table 6 Germplasm seeds supplied to the CIAT Bean Program in 1981

Unit	No requests	Total no accessions
Breeding II[a]	12	5062
Breeding I[a]	21	1019
Breeding III[a]	6	899
Entomology	14	4503
Pathology	4	45
Py iology	1	115
Microbiology	4	1009
Agronomy	1	16
Nutrition Lab	1	53
Other CIAT Programs	5	73
Total	69	12 794

a See Table 8 for areas of research responsibilities within CIAT

Table 7 Requests for seed service from institutions outside CIAT in 1981

Location	No requests	Total no accessions
North America Canada USA	10	218
Central America Caribbean Costa Rica Mexico Nicaragua Panama Puerto Rico Dominican Republic	13	6974
South America Andean Zone Bolivia Chile Colombia Peru Venezuela	11	94
Non Andean Zone Argentina Brazil	14	477
Europe Belgium France Holland England Germany (East & West)	8	77
Africa Egypt Morocco Nigeria Zaire	4	67
Asia China Philippines India	6	59
Oceania Australia Guinea New Zealand	3	228
Total	69	8194

Bush Bean Improvement

Germplasm Evaluation

Germplasm evaluation continued at a good pace during 1981 Search for parental sources for both specific characters and commercial grain types of different production regions received attention Bean germplasm bank accessions from G 10001 to G 14466 which were evaluated previously in various groups were grown together in hill plots at CIAT-Popayan and ICA-Obonuco Also over 2500 accessions previously

evaluated in hill plots were planted in single-row plots at CIAT-Palmira CIAT-Popayan ICA-La Selva and ICA-Obonuco for further evaluations Based on these results and those from the VEF EP IBYAN and other nurseries parents for 1982 crossing programs will be selected Table 8 lists the character-improvement projects and bean-production regions under breeders responsibilities and Table 9 indicates the number of parents available for hybridization for each of these regions and character-improvement projects in 1981

Hybridization

The number of crosses made for various characters and bean-production zones is given in Table 10

Among the total number of crosses effected to improve bush beans approximately 60% were single crosses 15% each of three-way and double crosses and the rest modified double crosses {Diacol-Calima x [A 179 x (Sangretoro x BAT 44)] F_1} and topcrosses [Alubia x (A 48 x Fabada) F_3] The latter four types of crosses facilitate easy recovery of desirable grain color and size especially when large-seeded parents are crossed with small-seeded types or red-mottled parents with brown and blacks The recombination of two or more traits when not found in the same parent and stability of performance adaptation and the level of expression of a given character are also enhanced

The number of experimental lines developed for the bush bean production regions and submitted to VEF is given in Table 11

Climbing Bean Improvement

The breeding program for climbing beans aims to improve resistance to production constraints and increase yield potential in indeterminate climbing varieties which are mostly intercropped or associated with other crops particularly maize Materials are evaluated and selected with maize at all stages They should be relatively competitive (vigorous) and able to produce well at lower densities than those used for monoculture bush beans

Germplasm Screening

Germplasm evaluation in 1981 concentrated on accessions with G numbers up to 10 000 for reds in CIAT-Palmira and with G numbers 10 000 to 14 000 in other locations As reported last year adaptation to temperature was found to be quite specific particularly between the locations ICA-La Selva and ICA-Obonuco (mean temperatures 17 and 13 C respectively) One of the objectives of germplasm evaluation has been to identify accessions that bridge this adaptation gap To date two outstanding varieties have been found for wide temperature adaptation these are G 12476 (E 1034) and G 12488 (E 1056) both from the

Table 8 Projects for improvement of specific characters and bean types for major production regions

Character	CIAT breeding section	Bean production regions	CIAT breeding section
Biological stress		Andean Region Colombia and Ecuador	III
1 Diseases		Argentina	II
Bean common mosaic virus	I	Brazil	
Bean golden mosaic virus	I	Black	I
Rust	I	Nonblack	II
Web blight		Mexico	
Anthracnose	II	Temperate highlands	II
Angular leaf spot	II	Warm humid and dry winter coast	I
Powdery mildew	III	Central America	I
Common bacterial blight	I	Caribbean and Venezuela	I
Halo blight	III	Peru and Chile	I
Ascochyta leafspot	III	Africa	III
2 Insects			
Epilachna	II		
Leafhoppers (Empoasca)	I		
Bean pod weevil (Apion)	III		
Storage insects (Zabrotes)	III		
Bean fly	III		
Edaphic stress			
Improved nitrogen fixation	I		
Low soil phosphorus	II		
Climatic stress			
Low temperature	III		
Drought	II		
Architecture and yield	II		
Extreme maturities	II		

Table 9 Number of lines currently being used and evaluated as potential parents for crosses in bush bean breeding in 1981

Specific characters		Multiple character recombination	
Project	No of lines	Production region	No of lines
Anthracnose	180	Andean Region	840
Angular leaf spot	70	Brazil	708
Leafhoppers (Empoasca)	64	Argentina	311
Web blight	30	Mexico temperate highlands	289
Bean golden mosaic virus	30	Mexico Peru coast (Canarios Bayos)	163
Bean pod weevil (Apion)	29	Central America (small red grain types)	79
Common bacterial blight	23	Caribbean	68
Powdery mildew	21	Mexico Central America Brazil (black grain types)	40
Drought	17	Peru Chile (small medium white)	32
Low soil phosphorus	16		
Plant architecture	15		
Halo blight	14		
Improved nitrogen fixation	12		
Cold tolerance	10		
Early maturity	6		
Bean common mosaic virus (recessive gene resistance)	5		
Storage insects (Zabrotes)	5		
Subtotal	547		2530
Total			3077

Table 10 Number of crosses made for specific characters and bean production regions in 1981

Specific characters		Multiple character recombination		
Factor	No of crosses	Production regions	Grain type	No of crosses
	Breeding I			
Leafhopper (Empoasca)	228	Caribbean	Red small	250
Improved nitrogen fixation	200	Mexico		
Bean golden mosaic virus	147	Central America	Black small	210
Common bacterial blight	103	Caribbean	Red mottled kidney	
Bean commo mosaic virus	74		medium	174
Web blight	41	Mexico Peru	Canario Bayo white	
Bean pod weevil (Apion)	32		medium/large	63
Storage insects (Zabrotes)	5	Peru Chile	White mall/medium	49
	Breeding II			
Plant architecture	75	Andean Region	Red mottled large	182
Anthracnose	34	Brazil	Cream pink etc small	118
Drought	22	Argentina	White large	114
Angular leaf spot	18	Mexico temperate	Cream brown pinto	
Halo blight	16	highlands	medium	96
Powdery mildew	10			
Subtotal	1005			1256
Total				~261

Table 11 Number of experimental lines developed for production regions and submitted to VEF 1981 by the bush breeding programs

Production region/grain type	No of experimental lines: Grain type total	Region total
Andean Region		35
Purple-mottled	17	
Red-mottled	4	
Pink-mottled	8	
Cream-mottled	6	
Argentina		2
Large white	2	
Brazil		189
Mulatinho	74	
Carioca	48	
Pardo	24	
Roxo	15	
Preto	28	
Mexico temperate highlands		66
Flor de Mayo	13	
Bayo	2	
Pinto	47	
Ojo de Cabra	4	
Mexico warm humid Central America		42
Small black opaque	42	
Central America		176
Small red brilliant	133	
Small red opaque	43	
Caribbean		68
Red purple-mottled	68	
Mexico warm arid Peru		54
Canario Bayo	54	
Peru and Chile		49
Small white	39	
Medium white	10	
Total		681

Table 12 Germplasm accessions identified as promising parents in the 1981 VEF

CIAT No	Identification	Days to flowering	Growth habit	Resistance rating to [a]					Efficiency rating[b]	Color
				Anthracnose	Ascochyta	Angular leaf spot	Rust	Powdery mildew		
				In CIAT Palmira (1000 masl)						
G 00130	Guatemala?	48	IIIb				1		2	Red
G 02124		43	IVa				2		2	Red
G 04297	Mezclado	43	IIIb				1		2	Red
G 04565	Ant 120	37	IIIb				3		2	Red
G 04857	Guat 516	31	IVa				2		2	Red
G 04871		39	IIIb				1		2	Red
G 04893	Rojo (21535)	39	IIIb				3		2	Red
G 05041	Vermelhao	39	IIIb				2		2	Red
G 05197	50613	43	IIIb				4		2	Red
G 06936	Chile 14	41	IIIb				4		2	Red
G 07052	Nicaragua 59	41	IIIb				3		2	Red
G 07071	San Jose Rojo (21663)	33	IIIb				2		2	Red
G 07164	Guatemala 578	33	IVa				3		2	Red
G 07756	Oaxaca 107	41	IVa				3		2	Red
G 07781	Guatemala 26	37	IIIb				3		2	Red
G 07794	Honduras 33	37	IVa				2		2	Red
G 08255	Talete 21692	33	IIIb				3		2	Red
G 13944	Arg 8008	37	IVa				2		2	Red mottled
				In CIAT Popayan (1850 masl)						
G 11596	Percala (ECD 202)	54	IVa		2				2	Cream mottled
G 11759 B	Tiacho (BUV 059)	50	IVa		2				1	Purple mottled
G 11761 E	Pintado (BUV 061)	58	IVb		2				1	Cream mottled
G 11780 B	(BUV 081)	74	IVb		2				2	Cream
G 11790	Poroto (BUV 091)	64	IVb		2				2	Cream mottled
G 11791	Poroto (BUV 092)	64	IVb		2				2	Yellow mottled
G 11792	Poroto (BUV 093)	74	IVb		2				2	Purple mottled

G 11795	Poroto (BUV 096)	64	IVb	2				2	Cream mottled
G 11801	(BUV 102)	62	IVb	2				2	Yellow mottled
G 11807	Poroto (BUV 108)	69	IVb	2				2	Cream mottled
G 12094	Ayacucho 120	50	IVb	2				1	Beige
G 12205	Poroto Nacional	45	IVa	2				2	Beige mottled
G 12572	Ñuna Mani Palida 1	56	IVb	2				2	Pink
G 12585	Ñuña Frontina Negra	56	IVb	2				2	Purple mottled
G 12634	Ancash 162	62	IVb	2				1	Cream mottled
G 12636	Ancash 178	62	IVb	2				1	Yellow
			In ICA La Selva (2100 masl)						
G 12032	Apurimac 2	59	IVa	1	2	2		2	Yellow
G 10508	Guate 925	68	IVa	3	3	3		2	White
G 10747	Guate 1174	70	IVb	1	2	2		1	Black
G 10494	Guate 910	68	IVa	3	3	2		2	Black
G 10588	Guate 1008	69	IVb	3	3	3		1	Black
G 04488	IAN 5091	66	IIIb	3	3	2		2	Black
G 13929	Amarillo Quetzaltenango	56	IVa	3	3	3		2	Yellow
G 13932	Labor Ovalle	58	IVa	1	3	2		1	Black
G 12031	Ancash 113	58	IVa	1	3	2		2	Red mottled
G 12128	Cajamarca 159	61	IVa	3	3	3		2	Pink
G 12158	Junin 204	59	IVa	3	3	3		2	Red mottled
G 10813	Guate 1240	68	IVb	1	3	3		1	Red
			In ICA Obonuco (2710 masl)						
G 07383	Cund 19	100	IIIb	3		3	3	2	Red
G 12650	Boyacá 38 A	111	IVa	3		3	3	1	Pink
	Sangretoro (Potosi)	113	IVa	3		3	3	2	Purple
G 12667	Blanco Sabanero	101	IIIb	3		3	3	2	White
G 11768	Blanco	108	IVa	1		3	4	1	White
G 13925	Juanoy	116	IVb	3		3	3	2	Cream mottled
G 12669	Palomo	117	IIIb	3		3	3	2	White
G 11770	Serrano	116	IVa	3		3	3	2	Cream
G 11776 C	Chusho	129	IVa	3		3	3	2	Red mottled

a Evaluation scale 1 Excellent or absence of disease 5 Very poor or proliferation of disease
b Efficiency Visual evaluation of productivity

Ecuadorian collection A new project has been started to screen cool temperature-adapted material in Popayan for photoperiod reaction

A total of 814 accessions was tested in CIAT-Palmira 506 in Popayan 235 in ICA-La Selva and 303 in ICA-Obonuco The most promising materials selected for further testing and use as parents are shown in Table 12

Hybridization and Early-Generation Selection

The number of crosses made by grain type and production region is given in Table 13 Of these 104 involved three parents and first-generation backcrosses were used for improving national cultivars As improved resistance is becoming increasingly available in lines selected from crosses these are themselves being incorporated into the crossing block particularly in the case of the reds for Central America in which 56% of the parents were selected from hybrid materials

Crosses were planted in the F_2 and F_4 with maize and with susceptible spreader varieties for BCMV and anthracnose A total of 1363 F_3 and F_5 progenies were evaluated in CIAT-Palmira 2059 in Popayan 965 in ICA-La Selva and 278 in ICA-Obonuco all planted with maize and simultaneously evaluated in the screenhouse for resistance to BCMV and anthracnose Those with appropriate agronomic characters disease resistances and grain types were advanced to the VEF in the F_6 generation these were in total 235 lines of which 69 were red lowland types 79 reds for high altitudes 48 yellow or cream for the Andean Zone 18 blacks for Central America and 21 blacks for the Guatemalan and Mexican highlands

Table 13 Number of crosses made in climbing beans for grain type and production region in 1981

Grain type	Principal production region	No of crosses	No of parents
Red lowland	Central America	125	48
Red highland	Andean Region	90	49
Yellow/cream highland	Mexico Andean Region	29	17
Black highland	Guatemala	17	14
Black lowland	Mexico Central America	7	6
Total		268	134