Annual Report 1988

Bean Program

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Centro Internacional de Agricultura Tropical

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BEAN PROGRAM HIGHLIGHTS 1988

Progress in Africa

National programs in Africa have made impressive strides in identifying outstanding materials from germplasm introduced through CIAT. Although the Bean Program has been working intensely with African national programs only since 1983, in several African countries farmers are already growing new bean cultivars introduced from Latin America by CIAT.

A major premise of the CIAT Bean Program's strategy in Africa has been that the largely informal transfer to Africa of the common bean from its Latin American center of origin has not included an immense amount of potentially useful genetic material. This premise is being borne out by the performance in Africa of several materials recently introduced to Africa from the CIAT germplasm collection. Germplasm bank accessions have so far done particularly well in Burundi, Rwanda and Zaire.

Moreover, there have already been extensive efforts at bean improvement in Latin America and many of these materials have also performed well in Africa, for example in Burundi, Ethiopia, Rwanda and Zambia. These materials have come from research programs in Brazil and Colombia as well as from CIAT lines originally bred for Latin America. Many of these materials have had outstanding performance in Africa.

In Zambia the national program has released Carioca which is rapidly winning approval among farmers, particularly in Central and Northwestern provinces. The Zambia Seed Company (ZAMSEED) is producing seed of Carioca for distribution. Carioca was originally selected by the IAR in Sao Paulo State, Brazil, and was introduced into Zambia through the CIAT IBYAN nursery.

In Zaire, the national program (PLN) has identified two outstanding materials, G2333 and G3444, both accessions from the CIAT germplasm bank. G3444 is particularly well accepted because its seed color is prized in the Goma and Kinshasa markets. Seed of these materials is being distributed to farmers by a local cooperative (UCOOPANOKI) and a seed project (CAPSA).

Some 200 farmers in the Kalungu area of Zaire are growing Rubona 5 (a line developed by the Colombian national program, ICA, and introduced to Rwanda through CIAT), while 60% of farmers are reported to be growing Dore de Kirundo, a cultivar introduced from Burundi to Zaire by the CIAT regional project. A197, a CIAT bred line, is being cultivated by farmers in the area of Kabati.

In Burundi, the CIAT bred line A410 has been named "Khaki" by the national program, ISABU, and is reportedly achieving widespread adoption in Imbo Nord. Several other introductions from CIAT have also been released, including Calima (bred by ICA of Colombia); Nsosera (a Brazilian cultivar); and in Ambumbari (a Mexican cultivar).

In Rwanda, Mubanomwiza (G2333, a CIAT germplasm accession) is being widely diffused in the area of the Project Kigali Nord. Moreover, ISAR, the Rwandan national program, has recently named several new cultivars, "Unuinkingi" (G685); "Muhondo" (G858); "Puebla" (G3444). All of these are CIAT germplasm bank accessions.

In Ethiopia, the national program (IAR) has proposed the release of several materials obtained from CIAT that have consistently outyielded local checks in several locations over three seasons. These include the CIAT bred lines BAT338 and A176 as well as Carioca and Ex-Rico 23 (from the CIAT germplasm bank).

Most of these new varieties are still in the early stage of diffusion among farmers and field studies are needed to confirm reports of adoption. Nevertheless it appears that the Bean Program's strategy of introducing to Africa new genetic variability from the Latin American center of origin, is already yielding results.

Regional Networks

As promising as the progress derived from germplasm transfer may be, equally important for CIAT's strategy to increase bean productivity is the strengthening of national programs. The generation of superior technology requires effective national program research to achieve adaptation to the myriad of local circumstances---biotic, edapho-climatic, cropping systems, and farmer resources.

Because bean production constraints are so numerous and difficult, and because many national programs have such extremely limited resources, CIAT Bean Program strategy focuses on building regional networks of collaborative and complementary research among national programs.

Working alone, the vast majority of national programs have woefully inadequate resources to tackle the variety of problems that their farmers face. However, by combining efforts, sharing responsibilities, and freely exchanging results, progress for all can be made much more rapidly.

Research specialization by national programs is a key element of the Bean Program strategy. In this model each national program in a region undertakes specialized research on a problem (or problems) in greater detail than would otherwise be justified from a purely national viewpoint. In doing so more rapid progress is made, and results are shared with regional partners. At the same time each national program receives from their partners in the network what their partners have achieved from their regional research sub-projects.

This strategy is working effectively in Central America where Guatemala has research leadership in developing early varieties; Cuba specializes in CBB; Costa Rica specializes in web blight; and Honduras specializes in Apion.

In a meeting of the working group in CBB in Havana, June 21-22, joint research was planned that included a common set of check varieties and agreement on a common scale of evaluation. Similarly the web blight working group met in San Jose, Costa Rica, May 5-6 where research results on web blight were exchanged; the regional web blight nursery (VIM) discussed; and, agreement made to train scientists from Panama and Honduras in inoculation methods in Costa Rica. Finally, a workshop on Apion research was held Nov. 29-December 1, in Danli, Honduras.

Such regional specialized research sub-projects are also operational in the three regional networks in Africa (Table 1). Anthracnose, for example, is probably the most important seed-borne pathogen in the Great Lakes. ISAR, the Rwandan national program, has found extensive pathogenic variability, with four races identified in Burundi, and seven in Rwanda. The ISAR sub-project also includes crossing popular farmer cultivars from Burundi, Rwanda and Zaire with sources of resistance. CIAT has provided parents known to be resistant to the anthracnose races that have been identified in the region.

In the Eastern Africa network, Ethiopia, Somalia and Uganda are all active in regional research sub-projects (Table 1). While Ethiopia has been specializing in drought and rust research, Somalia has focused on storage insects (bruchids) and Uganda on bacterial blight, Ascochyta, and bean common mosaic virus. In this latter project the University of Makerere is conducting laboratory research while also collaborating in a viral survey conducted with the University of Braunschweig, West Germany.

In the common bacterial blight sub-project, the national program of Uganda is screening a number of materials from CIAT to identify resistant lines that may be useful both in Uganda and elsewhere in the region.

In Southern Africa, regional research sub-projects have recently been initiated in Malawi, Tanzania, and Zambia on angular leaf spot, improved nitrogen fixation, and drought. It is worth noting that the drought research is being carried out as part of a pan-Africa network that includes the participation of Ethiopia.

This year a new regional bean network for the Andean countries was formed (Peru, Ecuador, Bolivia, Colombia, and Venezuela). Special project funding was obtained from the SDC of Switzerland to initiate this new network.

This project started with participative planning workshops, the first held in Chaclacay, Peru, May 9-13, and the second in Ibarra, Ecuador, August 15-18. In each workshop participants attended from the national research program, universities, the seed sector, extension, and CIAT to jointly plan combined efforts to improve bean productivity.

High priority for on-farm research and seed multiplication systems emerged from both workshops, and the project has already responded with training courses in both topics.

Longstanding close relations with Brazil were strengthened even further this year when CNPAF, the Brazilian national program, for the first time invited CIAT participation in annual regional planning meetings for the northeast, and the central west. Various representatives from Brazilian state research institutes attended. The invitation to CIAT to these internal Brazilian meetings, is an indication of the closeness of relationships with Brazil.

This year the improved variety Ruby, bred by CNPAF breeders, was released by EMGOPA, the state program of Goiania.

Research Highlights

CIAT scientists both at headquarters and in regional projects devote their major effort to conducting research that can yield useful results for national programs.

Research emphasis continues to be placed on the identification of sources of desirable traits; the development of practical rapid screening techniques; the study of mechanisms conferring desired characters; and the development of breeding materials with desired traits in useful backgrounds. Thus CIAT's focus is increasingly on developing parental materials and methodologies while national programs increasingly assume responsibility for the selection of advanced lines.

In a collaborative study with the Mexican national program, INIFAP, preliminary results showed that the best performing F_2 populations under drought stress in the Mexican highlands were progeny from crosses of CIAT-identified drought tolerant parents and local Mexican cultivars. Since these populations generally outperformed progeny of crosses between Mexican cultivars, it suggests that CIAT materials contain desirable characteristics for performance under drought that are not found in Mexican highland materials.

Detailed studies were initiated in 1988 on the possible toxic effects of arcelin, the protein found only in wild materials that confers resistance to the storage weevil, Zabrotes subfasciatus. CIAT will not release any materials containing arcelin, until mice-feeding trials have shown that no toxic effects exist.

Studies of materials from 18 different species from the genus Phaseolus identified for the first time very high levels of antibiotic resistance to the storage weevil Acanthoscelides obtectus in all 22 P. lunatus accessions studied. Electrophoretic studies of the resistant materials are now being conducted in a search for a chemical marker that is associated with resistance to A. obtectus that could be used as a rapid screening technique.

A study of an ideotype for optimal nitrogen efficiency found significant differences in N acquisition that might, therefore, lend to breeding for improvement of N uptake. Contrary to current theories about root activity for grain legumes, net N uptake was observed to continue physiological maturity.

The discovery of genetic variability in P. vulgaris for early nodulation has been previously reported, and the progeny of crosses between donors of this trait and African cultivars have obtained increased nodulation this year. Moreover, in 1988 excellent sources of late nodule senescence were found and the existence of striking insensitivity of nodulation to mineral N was confirmed. These materials can now be used as parents in a breeding strategy of recombining different traits associated with improved biological nitrogen fixation.

A simple method of measuring the binding capacity of condensed tannins by radial diffusion in agarose media of starch or proteins, developed this year in CIAT's nutritional laboratory, offers a potentially valuable rapid screening technique for selection for improved digestibility in the common bean.

An evaluation of lines isogenic except for growth habit, indicated that there is potential for increasing yield in large seeded bush beans without increasing days to maturity by means of changing bush bean growth habit from determinate to indeterminate. Since almost all large seeded bush beans are determinate, this finding suggests one possible strategy of breeding for indeterminate growth habit in order to increase yield.

Preliminary studies of popbeans (nuñas) have been initiated. This is a group of varieties of common beans which burst when heated, rather like popcorn. Toasting popbeans requires much less fuel than boiling beans, and they may, therefore, have an important potential in areas where firewood is scarce, for example, in most of Central Africa.

Studies to identify the mechanism responsible for popping are being carried out. Once the mechanism is established, it will then be possible to attempt to transfer this trait to varieties of diverse genetic backgrounds adapted to different regions and cropping systems.

An economic study of the potential for another type of bean, snap beans, indicates that they are produced principally by small farmers, both in Latin America and Asia where production is for local consumption, and Africa, where production is for export. Even among these small farmers, though, an alarming use of crop protection chemicals has been found. This suggests the need for improved disease and pest resistance in snap beans to reduce environmentally damaging and potentially toxicological consequences.

Studies carried out in the CIAT Biotechnology Research Unit and independently at the University of California, Davis, have confirmed through analysis of polymorphisms in phaseolin proteins, that there is indeed greater genetic variability at the biochemical level within wild P. vulgaris, then among cultivars. This suggests that there may be other desirable traits found only in wild materials, as was the case of the arcelin based resistance to Zabrotes.

Table 1. Selected specialized research sub-projects conducted by National Programs in Regional Networks, 1988.

National Programs	Research Sub-project
Burundi	Bean fly; Halo Blight
Costa Rica	Web Blight
Cuba	Common Bacterial Blight
Ethiopia	Drought; Rust
Guatemala	Early maturity
Honduras	Bean pod weevil (Apion)
Malawi	Biological nitrogen fixation; Angular Leaf Spot
Rwanda	Anthracnose; Ascochyta
Somalia	Storage weevils
Tanzania	Drought
Uganda	Bean Common Mosaic Virus; Common Bacterial Blight

GERMPLASM RESOURCES

Acquisition

New germplasm was added to CIAT's bean collection through expeditionary collecting trips to centers of domestication and diversification (Mesoamerica: Mexico-Guatemala), as well as through donations from national programs. A total of 1057 materials was introduced to the bank, of which 81% correspond to P. vulgaris, 2% to other cultivated species, and 17% to wild species including both wild ancestrals of the cultivated and non-ancestral. All this germplasm comes from 20 countries from the five continents (Table 1).

The wild species were collected mostly in Mexico, Guatemala and Peru. Two direct donations of P. vulgaris germplasm were received for the first time from Syria and from Angola. In addition, two very interesting collections from Africa were received: one from Burundi collected in 1979 by C. Leakey and another from Malawi collected by Gregory Martin (Michigan State University). The variability of this latter collection has been intensively studied through its morphology, isoenzymes and RFL's DNA---consequently, it is one of the most informative of all collections.

Status of the Phaseolus Collection

In 1988 the germplasm bank had a total of 41,061 accessions of Phaseolus beans, including five cultivated species, their correspondent wild ancestral species and 28 non-ancestral species. Collecting expeditions of the last 4 years have concentrated on both the landraces and on the wild species, resulting in an increase of the number of wild forms introduced. Of the total germplasm introduced so far, 23,734 accessions have been increased and are available for distribution. The proportion of the cultivated species and their wild ancestral forms in the available germplasm is as follows: 91.5% to P. vulgaris, 4.1% to P. lunatus, 3.3% to P. coccineus complex, and about 0.3% to P. acutifolius; as for the wild non-ancestral the percentage is 0.3% (Table 2).

Increase - Multiplication

Because the greatest demand is for Phaseolus germplasm, priority was given to increasing materials that had very little seed in the bank, or to materials that were needed in the bean program. This resulted in the increase of about 1400 accessions from 12 countries. The collections of P. vulgaris from Malawi and Burundi, and of wild species from Mesoamerica were included among those multiplied in the greenhouse. The increase-multiplication of wild non-ancestral species, however, is more difficult due the special environments required for adequate adaptation. These environments are not available at CIAT, so the quantity of seed from these species is extremely limited.

Likewise, emphasis in the field stations at Palmira, Popayan, and Dagua was placed on the multiplication of germplasm required by the bean program. 2172 accessions from 56 countries were planted in the three locations, and comprised the following growth habits: habit 1 made up 21.3% of the total, habit II equalled 1.5%, 61.7% of the seed planted was of habit III and 15.3% of habit IV. All types III (mostly from Central America origin), were planted in Palmira, while types IV were planted in Popayan; types I and II were planted mostly in Dagua (Table 3).

Seed Distribution Service

Germplasm requests have increased astronomically during 1988, both from within and outside of CIAT. In fact, the Genetic Resources Unit filled 44 requests from 22 countries for a total of 11,916 P. vulgaris accessions (90%) followed by P. lunatus (6%), P. coccineus (1.2%), and P. acutifolius (0.3%). However, almost 3% of the germplasm distributed went to a P. vulgaris x P. coccineus crossing project (Table 4).

Requests for seed from CIAT's Bean Program also increased this year. A total of 48,556 accessions were supplied to the Bean Program through 164 requests across the different disciplines (Table 5). These figures are equivalent to a bit more than twice the size of the present Phaseolus collection.

Table 1. *Phaseolus* germplasm introduced in 1988

Region/Country	*P. vulgaris*	Other Cultivated	Wild	Total
North America				
United States	7	-	-	7
Central America				
Guatemala	-	4	71	75
Mexico	-	-	75	75
Andean South America				
Colombia	1	3	-	4
Peru	139	5	33	177
Non-Andean South America				
Argentina	-	-	1	1
Europe				
Belgium	-	-	5	5
Spain	20	1	1	21
Bulgaria	-	6	-	6
Italy	19	-	-	19
Netherlands	1	-	-	1
Africa				
Malawi	372	-	-	372
Burundi	155	-	-	155
Tanzania	50	-	-	50
Rwanda	11	-	-	11
Zaire	5	1	-	6
Angola	26	-	-	26
Middle East Asia				
Syria	15	1	-	16
Iran	12	-	-	12
Taiwan	19	-	-	19
TOTAL	851	21	185	1057
%	81	2	17	100%

Note: Other cultivated include *P. lunatus*, *P. coccineus*, *P. polyanthus*. Wild includes ancestral and non-ancestral

Table 2. Status of the <u>Phaseolus</u> beans colection held at the Genetic Resources Unit at CIAT (as for Nov/88)

Species	No. of accessions Introduced	Increased
P. vulgaris	35516	21326
P. vulgaris wild ancestrals	434	372
P. lunatus	2,847	904
P.. lunatus wild ancestrals	107	67
P. coccineus subsp. *coccineus*	936	490
P. coccineus subsp. *polyanthus*	461	271
P. coccineus wild ancestrals	149	32
P. acutifolius	143	123
P. acutifolius wild ancestrals	59	59
Wild non-ancestral *P. angustissimus*, *P. leptostachyus*, *P. esperanzae*, *P. filiformis*, *P. glaucocarpus*,*P. pauciflorus*, *P. glabellus*, *P. grayanus*, *P. jaliscanus*, *P. microcarpus*, *P. macrolepis*,*P. maculatus*, *P. pedicellatus*, *P. polystachyus*, *P. pluriflorus*, *P. pachyrrhizoides*, *P. polymorphus*, *P. scabrellus*, *P. ritensis*,*P. ovatifolius*, *P. tuerckheimii*, *P. chiapasanus*, *P. oligospermus*, *P. floribundus*, *P. neglectus*, *P. striatus*, *P. xanthotrichus*, *P. parvulus*	409	90
Total	41,061	23734

Table 3. Regional frequency of germplasm multiplied during 1988 (Percentage)

Origin	Palmira	Dagua	Popayan	Total (%)
Central America	33.8	2.3	4.4	40.5
Andean South America	6.3	1.1	6.3	13.7
Non-Andean South America	2.9	1.5	0.8	5.2
Caribbean	-	0.3	-	0.3
Europe	1.0	5.4	5.5	11.9
Africa	1.1	2.4	1.2	4.7
Asia-Oceania	1.1	2.0	0.4	3.5
Middle East	4.1	4.0	0.7	8.8
Unknown	3.8	0.4	2.1	6.3
TOTAL	55.3	20.7	22.8	100.0

Note: Total of materials multiplied: 2172

Table 4. *Phaseolus* seed distribution outside CIAT (1988)

Region	Countries	No. of requests	No. of accessions
North America	United States	5	33
Central America	Costa Rica, Nicaragua, Mexico	6	9815
Andean South America	Colombia, Peru	7	58
Non-Andean South America	Argentina, Brazil	5	69
Europe	England, W. Germany Belgium, Italy, Bulgaria, Spain, Poland	12	1178
Africa	Zaire, Rwanda, Ethiopia, South Africa, Zambia	6	269
Asia-Oceania	Taiwan, Korea	3	494
TOTAL	22 countries	44	11916

Table 5. Bean seed distribution within CIAT (1988)

Program	No. of requests	No. of accessions
Breeding I	21	12060
Breeding II	30	30891
Breeding III	47	2479
Physiology	6	135
Entomology	25	893
Virology	15	1865
Pathology	4	128
Economy	1	4
Microbiology	4	7
Biotechnology	11	94
TOTAL	164	48556

AGROECOLOGICAL STUDIES

The CIAT Annual Report 1987 describes briefly the methodology of the construction of the distribution map of <u>Phaseolus vulgaris</u> on a continental scale, with subsequent allocation of soil classification units and soil physical and chemical properties to each 1000 Ha point, representing the bean growing areas in Latin America.

The high level continental study of the geography of the crop has yielded information on the occurrence and extent of potential soil and climatic problems in bean growing areas, which previously have not been quantified. This information serves at the level of target area and research area planning, also providing a base for subsequently more detailed environmental classification within chosen target areas in the future.

The quality of the information used to construct the bean distribution map is of vital importance in a realistic interpretation of the study's results. A country by country catalogue of bean nomenclature, information sources (including personal information), information level (e.g. by municipio, state or country), bean area hectareage and mapping assumptions was produced. (J.N. Fairbairn, Estudios Agroecológicos, 1988). Maps 1 and 2 broadly classify information quality.

Results

In collaboration with Bean Program physiologists the following critical values were used to estimate the extent of bean area at risk from soil nutrient deficiencies and low values for other soil properties:

Potassium	: Deficiency risk < 0.15 me100g^{-1}
Phosphorus	: Deficiency risk < 8.0 ppm
Cation Exchange capacity	: Serious effects < 10 me100g^{-1}
pH	: Serious effects < 20 cm
Total Nitrogen	: a) **Warm climates**, with average growing season temperature >23.5^{o}C; deficiency risk <775ppm N.
	b) **Intermediate climates**, with average growing season temperature of 18.5^{o}C-23.5^{o}C; deficiency risk <1160 ppm N.

c) **Cool climates**, with average growing season temperature <18.5°C; deficiency risk <1150 ppm N.

Table 1 summarizes the results for the above, barring Nitrogen which is discussed separately in addition to drought and Manganese toxicity.

Drought Risk Areas in Mexico

Map 3 represents areas of beans occurring in dry areas in which bean plants are at risk from drought. Drought can be said to occur when the number of consecutive months in which rainfall exceeds potential evapotranspiration (calculated using the Linacre method), is less than the crop phenology for the prevailing temperatures in the predominant wet season. The phenology of a typical bush bean is approximated in Table 2.

It was also assumed that beans are planted at the start of the rains.

Drought risk is highlighted in the **zona humeda** (central states) and the **zona templada semiarida** (Chihuahua, Zacatecas, Durango). Beans are sown in June and July respectively at the start of the only wet months in the year.

Bean growing regions in Sonora and Sinola appear on the map as droughty areas, although they are commercial irrigated areas.

In the **zonas templadas** a small percentage of the bean area is also irrigated; Zacates with 40,000 Ha irrigated, Durango 10,000 Ha, 6000 Ha for Aguascalientes and 4,000 Ha in Chihuahua.

Mexico has two very distinct types of drought.

In the Southern Region beans are sown in relay, after maize. These areas are sown to beans towards the end of the growing season in September, October, and even November. These areas and areas where planting is delayed due to excess rain at the start of the wet period, have been excluded due to the simple nature of selection of drought susceptible bean areas. Production on the Gulf of Mexico and the Pacific Coast, in Veracruz, Southern Tamaulipas and Chiapas may thus also be susceptible to drought.

Detailed information on planting cycles and sowing dates is thus required in order to more accurately determine drought risk in Mexico. The next stage of the study will involve definition of **macro-regions** within Mexico to collect detailed information on cropping practices, planting cycles, varieties, soil management and soils information, for each broad region, from the experts of that region.

Manganese Toxicity

Manganese toxicity is most likely to occur in moderately to very acid soils which run the risk of waterlogging. No figures for Manganese level were encountered in the profile descriptions and laboratory analyses of the FAO Soils Map of the World. Map 4 shows the extent of bean areas with soil pH<5, which have more than 200 mm monthly average precipitation for 3 or more months of the year. The following soils were included:

Acrisols	(Af, Ah, Ao, Ap)
Cambisols	(Bc, Bd, Bf)
Ferralsols	(Fa, Fh, Fo, Fr, Fx)
Gleysols	(Ge, Gc, Gd, Gm, Gh, Gp)
Fluvisol	(Jd)
Nitosol	(Nd)
Andosols	(Th, Tv)

The total area was 724,950 Ha, or 11.9% of the Latin American bean area.

The map reveals potential risk areas in Brazil (in the states of Minas Gerais, Southern Goias, Sao Paulo); in Mexico (largely on the poorer Andosols (Tv) of the Southern Central states) throughout Central America; on the poorer Andosols (Th) of the Southern Chilean bean growing area; and in Antioquia, Colombia.

This area should be taken to be the area within which Manganese toxicity could potentially occur.

Total Nitrogen

The effect of temperature on the rate of nitrogen mineralization and thus efficiency of <u>Rhizobium</u> nitrogen fixation was considered in combination with soil nitrogen data (FAO-Unesco Soil Map of the World 1974) to estimate the bean area deficient in nitrogen.

he critical values for nitrogen deficiency in warm, medium and cold climates have been discussed. The results for Latin America are shown in Table 3.

Table 1. % bean area and hectares at risk from soil nutrient deficiencies, and other soil and climatic problems.

	K		P		pH		CEC		Mn Tox.		Depth		Drought		Total Bean Area
	%	'000 Ha	%	'000 Ha	%	'000 Ha	%	'000 Ha	%	'000 Ha	%	'000 Ha	%	'000 Ha	'000 Ha
BRAZIL	30	93	51	1579	61	1889	33	1021		NA*	12	372	NA		3096
MEXICO	1	31	55	1053	2	38	5	96		NA	5	96	76	1465	1915
CENTRAL AMERICA	10	45	62	281	19	86	20	91		NA	7	32	NA		454
SOUTHERN CONE	9	32	22	79	13	46	8	29		NA	1	4	NA		358
ANDEAN REGION	17	45	66	174	26	68	10	26		NA	5	13	NA		263
LATIN AMERICA	4	246	52	3166	35	2127	21	1263	12	725	8	517	-		6086

*NA: Not assessed.

Table 2. The phenology of a typical bush bean

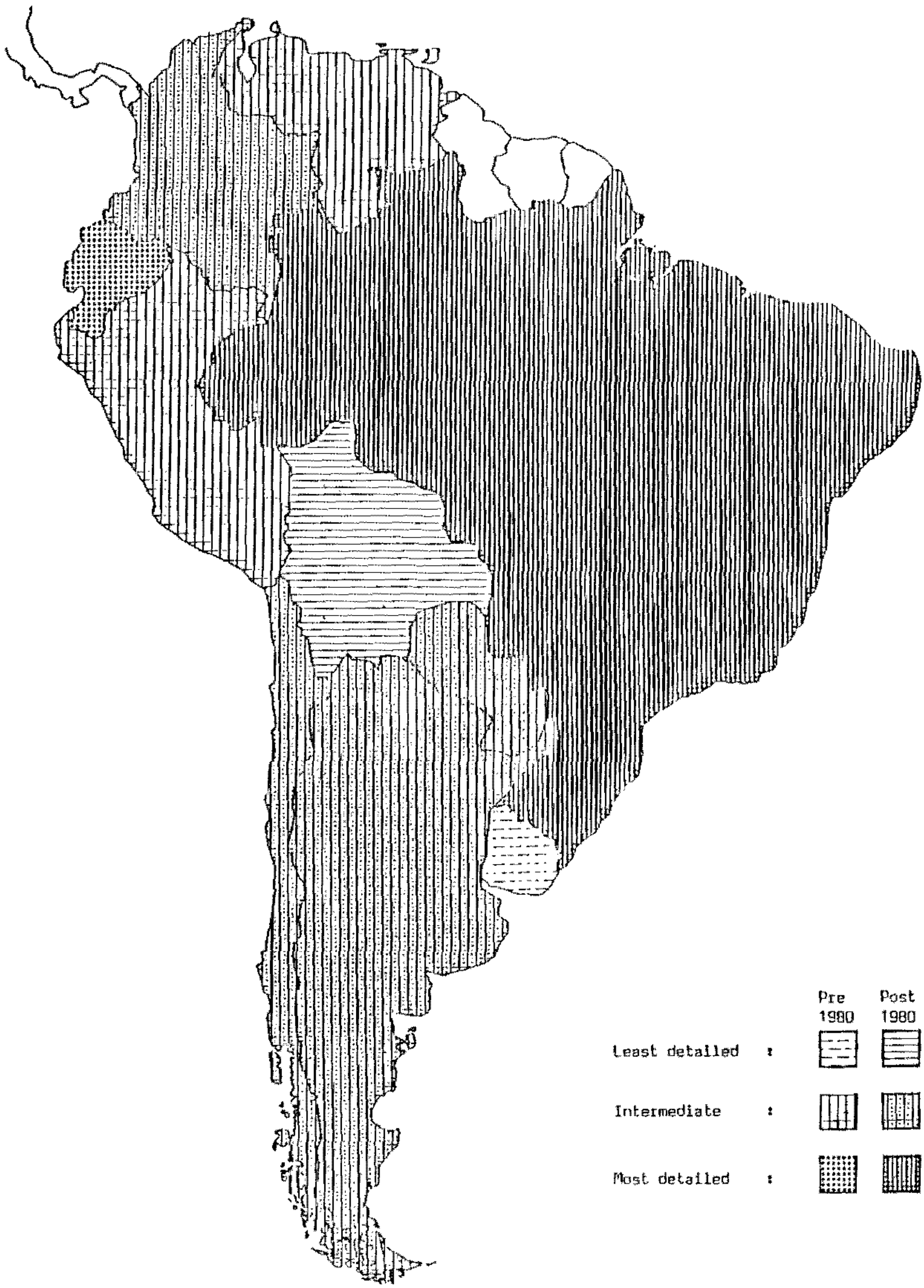
Temp (%)	Days to flower	Growing Season Months
10	210	7
12	180	6
14	160	5
18	120	4
20	90	3
22	80	3
24	80	3
26	80	3
28	80	3
30	90	3

(Estimated from bean phenology model; Laing R. DR, Jones PG, Davis JHC. 1984. Chapter 9. Common Bean (*Phaseolus vulgaris* L.) In: The Physiology of Tropical Field Crops. PR Goldsworthy, NM Fisher. Wiley)

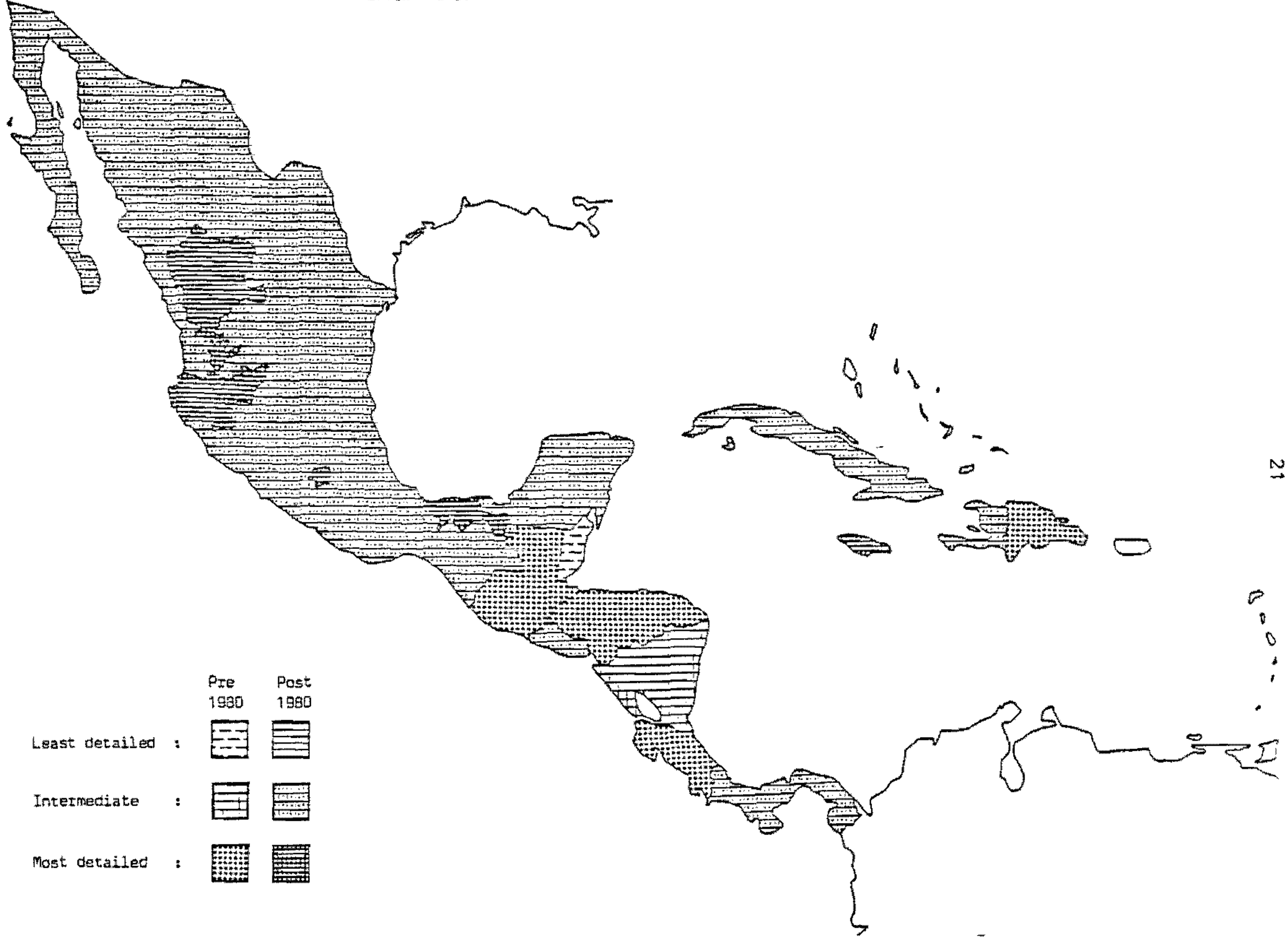
Table 3. Temperature effects on nitrogen efficiency.

	Low Nitrogen Area		High N Area	
	%	Ha	%	Ha
Warm	15	899,700	18	1,088,300
Medium	12	728,790	42	2,561,210
Cold	1	50,600	12	755,400
TOTAL	28	1,679,090	72	4,404,910

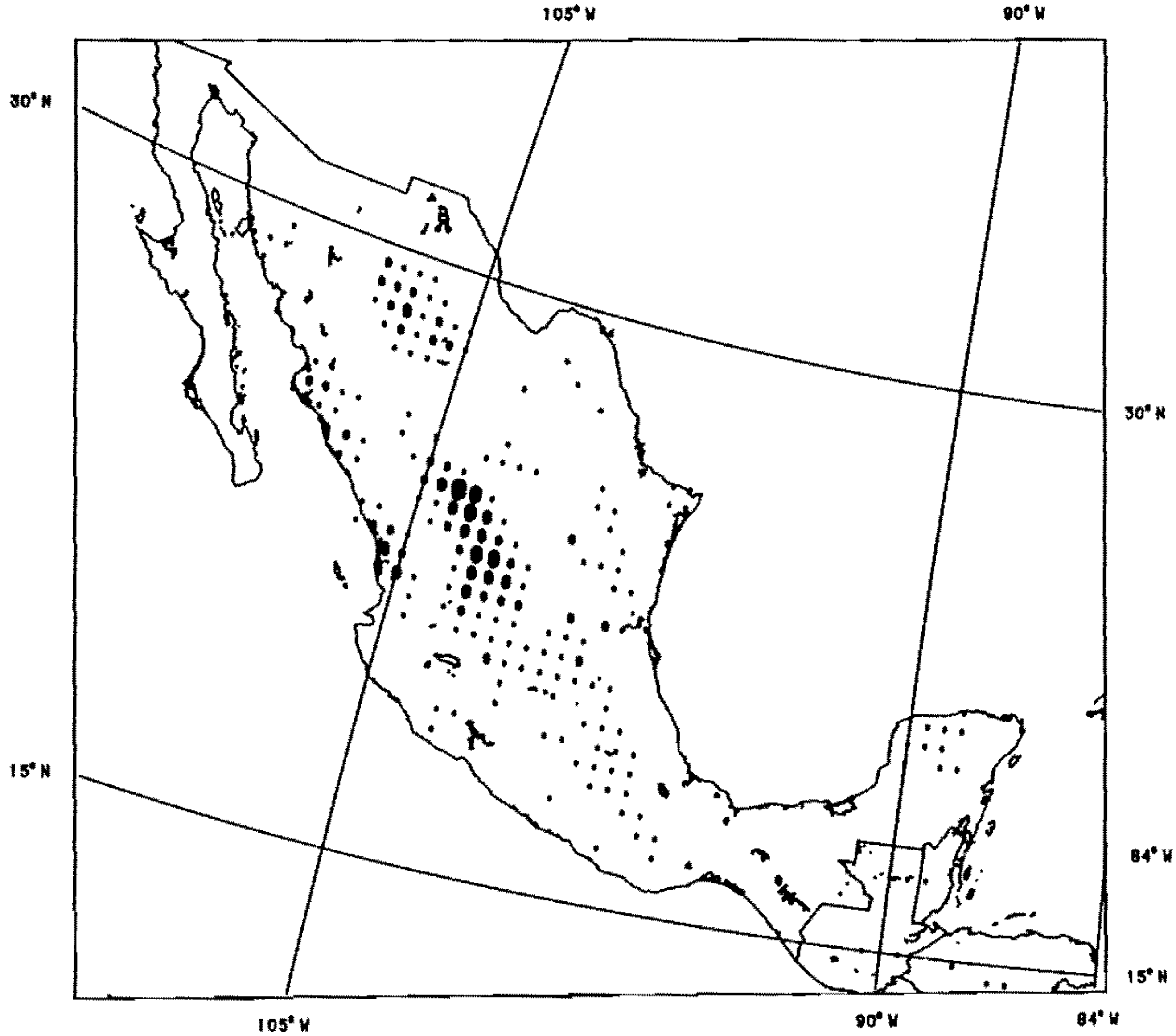
MAP 1   LATIN AMERICAN BEAN DISTRIBUTION MAP : THE NATURE OF THE INFORMATION



MAP 2 LATIN AMERICAN BEAN DISTRIBUTION MAP : THE NATURE OF THE INFORMATION



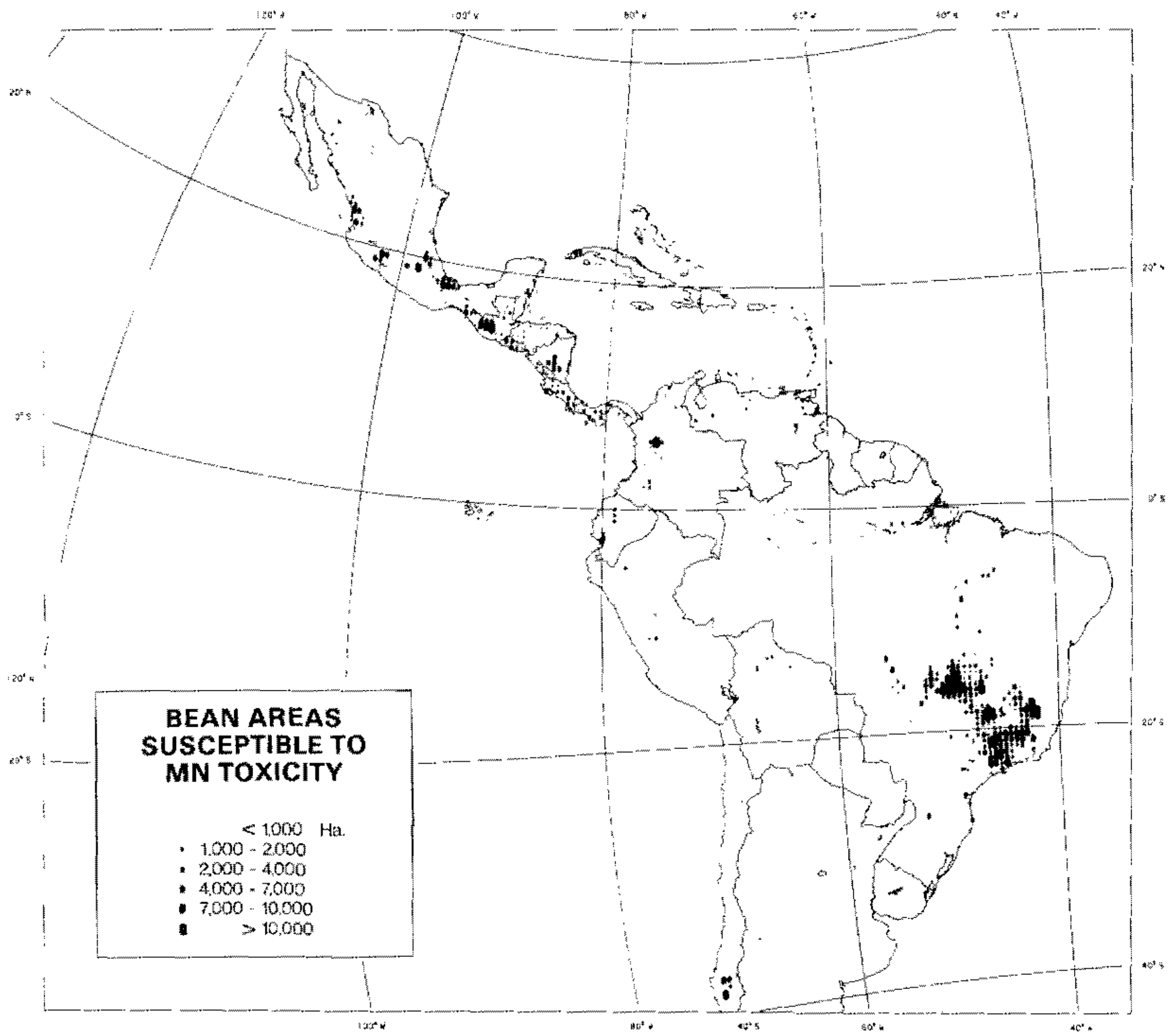
MAP 3



MEXICAN BEAN AREAS AT RISK OF DROUGHT

- < 1,000 Ha.
- 1,000 - 2,000
- 2,000 - 4,000
- 4,000 - 7,000
- 7,000 - 10,000
- > 10,000

MAP 4



BEAN AREAS SUSCEPTIBLE TO MN TOXICITY

BIOTECHNOLOGY

During 1988, activities of the Biotechnology Research Unit in *Phaseolus* beans comprised: a) development of *in-vitro* techniques for plant regeneration and micro-propagation; studies towards wide crossing and gametophytic screening; b) development of biochemical and molecular markers for the analysis of genetic variability. This work has been carried out in collaboration with scientists from the CIAT Bean Program and the Genetic Resources Unit, and through collaborative research projects with scientists in advanced institutes.

In-Vitro Techniques

With the exception of micropropagation through shoot tip culture, the development and utilization of tissue culture in *Phaseolus* beans has been constrained by the difficulty in achieving regeneration of complete plants from unorganized cell suspensions and callus. The grain legumes have traditionally been considered 'difficult' for plant regeneration; however, concentrated efforts have resulted in plant regeneration with pigeon pea, pea, moth bean, broad bean and soybean. In the case of *Phaseolus* beans, regeneration has been recently achieved with some wild *Phaseolus* spp, *P. acutifolius* and *P. coccineus*.

Plant Regeneration in Wild Phaseolus Species

Work initiated last year at CIAT demonstrated the formation of adventitious shoot primordia on a highly nodular callus derived from cotyledon nodes of one wild species. This year, the technique was successfully expanded to five species: *P. neglectus*, *P. scrabellus*, *P. xantotriclus*, *P. pedicelatus* and *P. glaucocarpus*, and culture conditions were developed to allow the growth of the shoot primordia into plants. The technique involves several steps starting with embryonic axes excised from embedded mature seeds: a) embryo axis *in-vitro* germination; b) after 8-10 days, excise cotyledonary node and culture in a callus induction medium; c) in 4-5 weeks, a nodular callus is formed on the explant, the callus can be maintained and propagated in the germination medium; d) after 2 weeks, shoot primordia begins differentiation from greenish nodules of the callus; e) upon transfer of nodular callus bearing shoot primordia, to a shoot elongation medium, rooted plantlets develop in 2-3 weeks (Fig. 1). Work now continues to assess the performance of regenerated plants in the field.

Plant Regeneration in Phaseolus Acutifolius

Collaboration between CIAT and the TCCP at Colorado State University, Fort Collins, has resulted in the application of a methodological approach to regenerate plants of tepary beans; and a search for conditions which can lead to regeneration in P. vulgaris has been initiated. The research used the P. acutifolius cv. Sonora 65 from Mexico and basically consisted of the following steps: a) callus induction on leaf explants from two week old seedlings germinated in-vitro; b) production of cell suspension cultures from 3 week old callus; c) three-four cell filtrations and selection of morphogenically competent cell clusters; d) maintenance of cell suspension cultures; e) transfer of cell clusters to regeneration medium; f) plant regeneration and growth. Callus with greenish cells was used to initiate cell suspensions. At the beginning the cell suspensions consisted of single isodiametric cells, elongated cells and clusters of rounded cells. The latter type is made up of relatively small cells with a dense cytoplasm and small nuclei; this type of cell were the most rapidly growing. The cell suspensions were filtered using a 500 μm filter and the filtrate of that was passed through a 250 μm filter. The cell fractions collected on the 500 μm and on the 250 μm, respectively, were cultured on a maintenance medium. The latter cell type clusters described above were plated on the regeneration agar medium. After 2-3 weeks, on this medium, some of the calli differentiated into globular, greenish, meristematic structures which subsequently developed into shoot primordia and plants (Fig. 2).

The basal medium which best supported cell growth and the proportion of densely cytoplasmatic cells was called L-6. L-6 medium deviates somewhat from the well known Murashige and Skoog (MS) medium and other common mediums in the types and relative amounts of nitrogen sources, sulfates and vitamins. The reduction of inorganic nitrogen increased calcium, and presence of the B5 vitamins and addition of casein hydrolyzate might have contributed to the observed results. The L-6 medium has also been shown to enhance regeneration in moth bean and pigeon pea. An important addition to the L-6 medium was sorbitol which enhanced embryogenic callus as well as helped retain the regeneration ability in long-term cultures. Callus induction best occurred with low levels of 2,4-D and Kinetin, while high concentration of 2,4-D or NAA and a low level of Kinetin were necessary for good cell suspension cultures. For maintenance, cell suspensions were transferred to medium with low 2,4-D and Zeatin. Regeneration occurred in L-6 medium with low Zeatin, BA and NAA.

The ability of the *P. acutifolius* cultures to retain regeneration potential for several months, makes them appropriate for genetic manipulation experiments.

Initial attempts to apply the tepary bean approach to two *P. vulgaris* cvs. resulted in the formation of suspension cultures with potentially embryogenic cell clusters reminiscent of the tepary bean. Further work in *Phaseolus* plant regeneration includes the following areas:
a) Test the cell suspension-regeneration approach with three *P. acutifolius* lines which have shown outstanding yield under drought conditions, and with a well known *P. vulgaris* cv. (e.g. Ica Pijao);
b) Rescue F1 embryos of Ica Pijao x best *P. acutifolius* line and culture to obtain germination and plantlet growth;
c) Induce callus from F1 embryos of Ica-Pijao x best *P. acutifolius* line, produce cell suspension cultures and proceed towards plant regeneration according to the tepary bean protocol.

Plant Regeneration in Phaseolus Coccineus

This work is part of the research on *Phaseolus* plant regeneration conducted at the Universita degli Studi della Tuscia, Vitebo, Italy in collaboration with CIAT. Using immature cotyledons smaller than 1cm as explants, the induction of shoots and somatic embryos followed by plant development has been observed in the cv. "Bianco di Spagna", but in low frequency. Seed of the regenerated plants was used to reproduce the technique. The regeneration frequency achieved increased to 37%. The culture medium used contains the inorganic salts of Munashige and Skoog, supplemented with BA, and 2iP.

The *P. coccineus* approach was tested with 20 accessions of *P. vulgaris* at Viterbo.

Multiple-Shoot Micropropagation of Phaseolus Vulgaris

An efficient micropropagation technique, through the induction of multiple shoots, can be useful for a) initial build up of sufficient number of plants from F_1 hybrids which show restricted seed production; b) treatment of shoot tips with mutagens and recovery of putative mutant plants through multiple shoot induction; c) rapid multiplication of valuable germplasm which is represented by only a few seeds.

Shoot tips comprising 2-4 leaf primordia were dissected from two-week old seedlings of cvs. Ica Pijao and Cargamanto, and cultured in the MS salt medium supplemented with the B5 vitamins, 3% sucrose, and varying levels of BA and NAA.

Cysteine (50 mg/l) and 0.8% agar was added to all the media. The inclusion of the hormones BA and NAA at low concentrations (0.7 - 1.0 and 0.09 - 0.1 mg/l, respectively) in the medium greatly enhanced the formation of multiple buds. While in the hormoneless medium only 3-4 buds were formed per shoot tip, with the hormones the number of buds increased up to 15 in Ica Pijao and 22 in Cargamanto (Fig. 3). Current work now focus on developing conditions for rapid shoot elogation, further in-vitro multiplication of shoots by nodal cuttings, rooting and transplanting to soil.

Embryo Development and Abortion in Interspecific Phaseolus Crosses

Provided that stigmatal pollen germination, intrastylar pollen tube growth and fertilization occur in interspecific crosses, the two major causes of failure in hybrid plant production are: a) the lack of, or restriction in hybrid embryo development after fertilization and b) lack of genomic integration leading to the loss of alien traits. In work done elsewhere, lack of hybrid embryo development has been overcome through the help of embryo rescue and culture, especially in some crosses of P. vulgaris x P. acutifolius and P. coccineus. It is proposed that interspecies genome integration can be enhanced by the induction of a callus stage using hybrid embryos, followed by plant regeneration. Since plant regeneration is an essential component of this approach, it may now be attempted with P. vulgaris x P. acutifolius crosses. Work in this subject has been initiated at the BRU in collaboration with Bean Program breeders.

Phylogenetically, P. lunatus is recognized as the most distant cultivated Phaseolus species from P. vulgaris. Hybridization attempts have failed due to embryo abortion even though fertilization had occurred. It seems that the genotype of the parental species plays a crucial role in achieving fertilization and early embryo development. On the other hand, compatibility exists between wild Phaseolus spp with P. vulgaris on the one hand, and with P. lunatus on the other. These intermediary ("bridge") hybrids can then be crossed with the help of embryo rescue and culture.

In collaboration with scientists from the Univ. of Gembleux and with GRU scientists work has been initiated this year to a) describe the abortion symptoms of P. vulgaris (P.v.) x P. lunatus (P.l.) crosses, b) to characterize the histology of P. vulgaris and P. lunatus embryo development in-situ, and c) to use crosses with wild Phaseolus species as "bridges" for the transfer of traits between P. lunatus and P. vulgaris.

While in the P.l. x P.v. crosses, abortion was total, in the reciprocal crosses (P.v x P.l.) there was 8% of pods reaching maturity (Table 1). Analysis of F_2 generation showed these pods formed due to contamination with P.v. pollen (i.e. selfing); thus the 19% aborted immature pods from cross P.v. x P.l. probably bore few hybrid embryos.
In order to characterize the events leading to embryo abortion in P.v. x P.l. crosses, it is necessary to follow the early stages of embryogenesis in P.v. and P.l. separately. In-situ histology and cytology of the ovaries one day prior to, and one day after, fertilization (selfing) showed no differences between P.v. and P.l. However, four days later, the rate of growth of the P.v. embryos is much faster than the P.l. embryos; by day 7 after pollination, the P.v. embryos have reached the torpedo-shaped stage, while the P.l. embryos are still heart-shaped. The large size attained by the suspensor cells in P.v. is noteworthy,in contrast to the less conspicuous suspensor of P.l. (Fig. 4). Obviously these differences in ontogeny will impinge upon the development of the P.v. x P.l. hybrid embryos.

Selection at Microgametophytic Level

The evidence that gene expression in pollen can be correlated to expression at the plant level suggests potential applications of microgametophytic selection in plant breeding. The intensity of pollen competition under stress conditions can result in a differential probability of fertilization and hence influence the quality of the sporaphyte. Both the number and growth rate of pollen tubes need to be considered in microgametophytic selection.

A study was initiated this year in collaboration with Bean Program physiologists and breeders to determine the extent of influence of microgamethophytic selection in common bean plants. Flowers and isolated pollen, obtained from a high temperature tolerant cv. (Jamapa) and non-tolerant cv (Calima) were exposed to one-hour treatments of increasing temperatures. Percent pollen germination was determined immediately after high temperature treatment of isolated pollen and 24 hrs. after the treatments of flowers. Pollen germination was carried out in a medium developed by Bean Program physiologists, at pH 7.3, comprising (ppm): 100 HBO3, 250 Ca (NO3)2. 4H2, 100 MgCl2, 100 KNO3, 200 CaSO4. 2H2O and 28% sucrose. There was a gradual drop in pollen germination from the control (25 C); the drop was most pronounced in the susceptible cv (Calima) reaching 0% germination at 70 C, while germination of Jamapa pollen (tolerant cv) remained stable around 10% after an initial drop (Fig.5). Pollen germination after high temperature treatment to excised flowers and to isolated pollen were highly correlated (r=0.84).

Pollen germination of Calima (non-tolerant) and Jamapa (tolerant) after treatment of excised flowers on the one hand and isolated pollen on the other was used to determine the differences in stress to high temperature of the two methods for assessing tolerance to high temperature at the microgametophytic level. Table 2 shows that high temperature treatment to isolated pollen is 15 times more sensitive than treatment to excised flowers, in the case of cvs. Calima and Jamapa.

From the range of temperatures tested, 37 C during 1 hr, was defined as the most appropriate treatment to isolated pollen; at 37 C, stress differences between the two genotypes were significant and still enough germinating pollen populations were available for conducting hand pollination in the field.

F_1 pollen of Calima x Jamapa was exposed to 37 and 49 C (with 25 C as control); then allowed to germinate and used for backcrossing to Calima. By means of a Jamapa seedling marker it was shown that the F_1BC1 progeny contains the trait of the Jamapa pollen stressed at 37 and 49 C.

This study has shown that it is possible to distinguish between a high temperature tolerant and a susceptible common bean cv. by the rate of <u>in-vitro</u> pollen germination after the isolated pollen has been exposed to high temperature treatment. Further work should provide information on the effect of temperature on the rate of pollen tube growth after deposition on the stigmata and the effect of pollen selection for high temperature on the agronomic and quality characteristics of the F_1, F_2 and backcross progenies.

Biochemical And Molecular Markers

Biochemical and molecular markers (proteins, isozymes and restriction fragment length polymorphisms) have special features that make them very useful in germplasm evaluation and eventually the genetic improvement of <u>Phaseolus</u> beans. These markers occur naturally, their expression (isozymes) or presence (RFLPs) is generally free of environmental and epistatic effects and they are inherited as single co-dominant alleles. Due to these features, molecular markers do not need to be artificially induced, patterns of these markers more faithfully reflect the genotype and thus can be used to assess the genetic variability in germplasm collections; their inheritance can be linked to the inheritance of economically important traits in early generations, without the need to wait for mature plants to express specific phenotypes.

Collaborative research with the Bean Program, the GRU and with advanced research institutes in the last two years has focused on developing biochemical/molecular markers in Phaseolus vulgaris for: a) analysis of evolutionary and germplasm dispersal pathways, b) characterization of genepool accessions and c) developing linkages to specific traits.

Phaseolin Markers

The variability in the electrophoretic pattern of the bean seed protein phaseolin has provided a useful tool for studying the domestication and dispersal of common bean germplasm. Several electrophoretic phaseolin types have been identified, e.g. S,T,C which are highly polymorphic and are related to the major common bean genepools.

a) Characterization of new wild populations of P.vulgaris from meso America and the Andes by their phaseolin molecular types requires clear cut differentiation of the seven types described so far as well as any new putative phaseolin type. Work this year in the BRU, on the phaseolin electrophoretic technique has resulted in an improved resolution of the polypeptide fractions comprising the phaseolin pattern. The changes in the technique included: reduction in the concentrations of the separation and stocking gels (13.86% and 3.42%, respectively) addition of EDTA and SDS to the separation and stocking gels and EDTA to the running buffer, and reduction of the sample for electrophoresis to 1 μl. These modifications allowed a better discrimination among the various known phaseolin types (Fig. 6).

b) In collaboration with GRU scientists a study of phaseolin in East African germplasm collections was finished this year. Out of 275 accessions from six countries, most of the accessions had the "T" phaseolin type, followed by the "S" and a few "C" types were also found (Table 3). No recombinants among the S,T or C types were found in this small sample of African material. The search for phaseolin recombinants should continue in view of the constraints to combine the higher productivity of small seeded ("S" types) with large seeded ("T" types) germplasm.

c) The main genepools of Phaseolus vulgaris have been confirmed by phaseolin types. The wild accessions from the meso-American genepool were found to be more variable than the Andean center. In the Andean center, phaseolin types (T, C, H, A) different from the meso-American center have been found, but their wild counterparts have not yet been fully characterized. In collaboration with GRU and Bean Program scientists, a collection of 24 wild P.vulgaris populations, from Peru and Bolivia, were screened for their phaseolin types. Most phaseolin types found were of the T and C types. Three new phaseolin types were identified and named "K" (from Peru), and two other were named "To" and "Ta" (from Bolivia) (Fig.6). These new types have not been described in the cultivated material yet. Additional work is needed to confirm the new phaseolin types found in Peru and Bolivia; two-dimensional gel electrophoresis should be helpful in confirming their identity.

Cotyledon Proteins

In a previous study we reported that electrophoregrams of cotyledon proteins can be used as cultivar "fingerprints" of accessions, within genepools displaying a particular phaseolin type. This year we found that the acid PAGE system utilized can even discriminate intra-accession variability, as for example in seed size and luster, as shown in the accession G04354 from the GRU. Hence, the technique should be useful to carry out inheritance studies of particular protein bands. In collaboration with Bean Program Breeders a study was initiated to determine the heritability of electrophoretic protein bands and their possible significance regarding morpho-agronomic characters of common bean lines from different genepools. Polymorphysm in protein patterns was detected in the following lines: Pinto UI 114 (from genepool 5) x ICA Tundama (genepool 8), Porrillo sintetico (genepool 2) x Tortolas Diana (genepool 10), and Carioca (genepool 3) x Porrillo Sintetico. In addition to acid proteins, basic extraction and SDS fractioning of proteins will be used in this experiment. Segregation of polymorphic bands will be monitored through F_1, F_2 and backcross generations.

Isozymes

In comparison to seed proteins, isozymes allow the analysis of gene products at a very early stage and offer a larger range of potential markers. In order to use isozyme analysis it is necessary to determine their level of polymorphism and their patterns of segregation in the common bean.

a) In collaboration with Bean Program breeders research was carried out to assess the variability in the electrophoretic patterns of 8 isozyme systems in 175 common bean accessions, native and cultivated, from a wide range of geographical distribution in Meso-America and the Andes. The electrophoresis technique utilized was reported earlier. A range of electrophoretic patterns was identified in the entire collection, i.e. slow (S), fast (F), null (N), unique (U), and intermediary (I) between S and F. Four isozyme systems (DIA, PRX, ACP and RUBISCO) presented high variability in the Andean germplasm, while in the Meso-American material only two systems (DIA and PRX) showed high variability.

The isozymes ME and EST presented low variability in the accessions of both centers; and whereas there was not any variability detected for SKDH and MDH in the Meso-American material, variability existed but at very low frequency in the Andean accessions (Table 5).

Under the restricted sample size utilized the results of this work indicate a higher isozyme variability in the Andean than in the Meso-American accessions; it is also suggested that the systems DIA, PRX, ACP and to a lesser extent RUBISCO, can be effectively used to seek polymorphisms within the Andean genepool and DIA and PRX within the Meso-American genepool.

b) The pattern variability of DIA, PRX and ACP can be potentially utilized to distinguish Meso-American from Andean accessions, as shown in Fig. 7. The small seeded accession BAT 477 displays a typical S pattern while the large seeded accession A 195 shows an F pattern in the DIA electrophoregram. Analysis of the F_2 generation between these two lines, shows approximately 1:2:1 segregation ratios for the bands at three loci (I,II,III). The segregating banding patterns suggests that DIA is present in three forms: as a monomer in locus I, dimer in locus II and tetramer in locus III. Except the hybrid H1, where hybridization has only occurred at loci II and III, all other hybrids (H2-H8) showed hybridization at the three loci, suggesting genetic linkage.

c) The approach described above can be extended to study the genetics of resistance or tolerance to important common bean pests and diseases and possibly to link such resistances to isozyme markers. Resistance to *Apion godmani*; one of the most important common bean pests in Central America, seems related to an antibiosis mechanism. The development of a quick, non-destructive, screening technique would greatly enhance current breeding approaches. In collaboration with Bean Program entomologists and breeders we have initiated work this year to develop a methodology, based on isozyme markers, to study the genetics of resistance to *A.godmani*.

As a first step, a set of 10 isozyme systems (EST, ACP, DIA, GOT, PRX, ME, MDH, SKDH, G6PDH and RUBISCO) were tested against extracts from a range of plant tissues: seed, root, stem, cotyledonary leaf, first trifoliar leaf, flower, immature pod, filling pod and mature pod, using the technique developed previously here for polyacrylamide and starch gels. We found that best isozyme system - plant tissue combinations were: 1) EST- first trifoliar leaf, 2) ACP- first trifoliar leaf and immature pod, 3) DIA- first trifoliar leaf and immature pod, 4) GOT- first trifoliar leaf and 5) PRX- stem and immature pod.

The next step is the evaluation of polymorphisms of the isozyme systems- tissues with each of the resistant (APN-18-1, APN-18, APN-43) and sysceptible (DOR-60-1, Desarrural, Roja de Seda) parental lines selected by bean breeding and entomology. Progeny and inheritance studies will then follow with the most polymorphic resistant and tolerant parental lines. Other backcross-selfed lines, F_1 plants and tolerant and susceptible parents and progenies which are currently available in the bean breeding program, will also be used.

d) Isozyme electrophoretic patterns can effectively complement morphological and immunological criteria for the characterization of pathogenic fungi. In collaboration with Bean Pathologists work was initiated this year to develop isozyme analysis of the various isolates (and geographical distribution) of the fungus Thanatephorus cucumeris, the causal agent of Web Blight in common beans. It is also proposed to correlate the isozyme patterns with the anastomosis groups of the fungus. Four isozyme systems have been tested (ACP, EST, DIA, PRX) with 64 isolates of the fungus, and ACP showed the highest discriminatory power among the isolates.

Restriction Fragment Length Polymorphisms (RFLPs)

In contrast to isozymes, RFLPs allow the analysis of variability directly at the DNA level, nuclear or cytoplasmic, and potentially an infinite number of RFLP markers can be studied in a single progeny. Using restriction enzymes, the plant DNA is digested into fragments of varying sizes, and when DNAs of several different lines are hydridized to selected probes (cDNA and genomic clones), a number of different alleles are often detected. These differences in the length of restricted fragments (polymorphisms) can be monitored through segregating populations, and jointly with isozyme markers linked to important qualitative and eventually quantitative trait loci. With the main objective being to construct a Phaseolus linkage map and tag genes for resistance to common bacterial blight (CBB) using isozymes and DNA-RFLPs, a collaborative project was initiated last year at the University of Florida, Gainesville under the leadership of

Dr. V.Vallejos. The following steps have been accomplished in this research:

1) variation between the parental lines (Calima, a susceptible cv. from Colombia and "XR-235-1" a line carrying resistance to CBB from P. coccineus) has been detected at a number of loci for 8 enzyme systems. At one loci: Glyceraldehyde-3-Phosphate Dehydrogenase (NADP), Glutamate Oxaloacetate Transaminase, Isocitric Dehydrogenase, Malate Dehydrogenase, and Shikimate Dehydrogenase; at two loci: Aconitase and Peroxidase; and at three loci: Esterase;
2) The parental lines, and F_1 and F_2 progenies, were inoculated with a local strain of *Xanthomonas campestris* pv. *phaseoli* and the response of each individual plant was recorded. The data suggested the presence of a single gene controlling for resistance to the pathogen;
3) Isozyme analysis in the F_2 progeny has been carried out, and DNA have been extracted from them;
4) A small cDNA library has been constructed and 20 cDNA clones, with insert sizes between 500 to 1800 base pairs, have been isolated. On the other hand, a larger genomic library (approx. 2000 clones), with insert size between 500 to 2500 base pairs, has also been constructed;
5) Genomic southern blots of the parental lines have been prepared using four restriction enzymes: Dra I, Eco RI, Eco RV and Hind III;
6) A few cDNA clones have been hybridized to the southern blots of both parental lines. As shown in Fig.8, polymorphism in the length of Calima and XR-235-1 DNA fragments is variable depending upon the restriction enzyme/cDNA clone (probe) combination. Comparing only two probes, probe I was able to reveal higher polymorphism than probe II and the restriction enzyme Dra I, followed by Eco RI, have yielded more variability in the length of DNA fragments between the two parental lines;
7) From the genomic library, some 100 random clones were isolated and 48 showed potential as probes. These are now being tested for their capacity to reveal polymorphisms between the parental lines, with each of the four restriction enzymes.

With sufficient restriction enzyme/probe combinations, it should be possible to saturate the genome with RFLPs and study the linkage of such markers with resistance to the disease.

Table 1. Abortion of reproductive structures following interspecific crosses of P.vulgaris (P.v.) with P.lunatus (P.l.)

Structures	Abortion (%)	
	P.v. x P.l.	P.l. x P.v.
Flower buds	38	65
Fertilized flowers	35	5
Immature pods	19	30
Total	92*	100

* Remaining (8%) pods grew to maturity.

Table 2. Pollen germination of two common bean cvs. after treatment with high temperature to excised flowers and isolated pollen, respectively.

Treatment	Excised flowers		Isolated pollen	
	Jamapa	Calima	Jamapa	Calima
T1 25 C	63.48	53.22	29.95	36.45
T2 90 C	12.95	9.78	16.22	9.03
Stress (%)*	76.60	81.62	44.54	72.22
Stress differential Calima vs. Jamapa	2.02%		34.54%	
Method differential	30.54/2.02 15/1			

* (T1-T2/T1)100

Table 3. Phaseolin electrophoretic types found in *P.vulgaris* germplasm from Eastern Africa.

Country of origin	No. of samples	Phaseolin types		
		"S"	"T"	"C"
Malawi	112	14	85	13
Zambia	78	21	55	2
Kenya	38	10	26	2
Uganda	21	2	18	1
Tanzania	18	12	6	-
Zimbabwe	8	4	4	-
Total	275(100%)	63(23%)	194(71%)	18(6%)

Table 4. Phaseolin electrophoretic types found in wild population of *Phaseolus vulgaris* in the Southern Andes

Regions	Known phaseolin types	New phaseolin types
Peru		
Cajamarca	I	
Junin	T1C	
Ajunimae	T1C	K
Cuzco	T1C1H	K
Bolivia		
Cochabanda	T1C	To
Chuquisaca	T1C	
Tarija	T	Ta

Table 5. Electrophoretic pattern variability of 8 isozymes in 175 common bean accessions from the Mesoamerican and Andean gene pools

Isozymes	Mesoamerica		Andes	
	variability	patterns*	variability	patterns*
Diaphorase (DIA)	very high	S F N U	high	S F N I
Peroxidase (PRX)	high	S F I	very high	S F N I
Acid Phosphatase (ACP)	very low	N	high	S F N
Rubisco	low	S F	high	S F
Malic Enzyme (ME)	low	S F	low	S F
Esterase (EST)	low	S F	low	S F
Shikimiate Dehydrogenase (SKDH)	none	-		
Malate Dehydrogenase (MDH)	none	-	very low	S F

* banding patterns: S (slow), F (fast), N (null), U (unique), I (intermediary)

Figure 1. Plant regeneration of wild Phaseolus species: P.scrabellus, P.neglectus, P.xantotriclus, P.pedicelatus and P.glaucocarpus.
Left: nodular callus from embryonic axis showing shoot primordia differentiation; Right: shoot proliferation and rooting of individual shoots prior to potting.

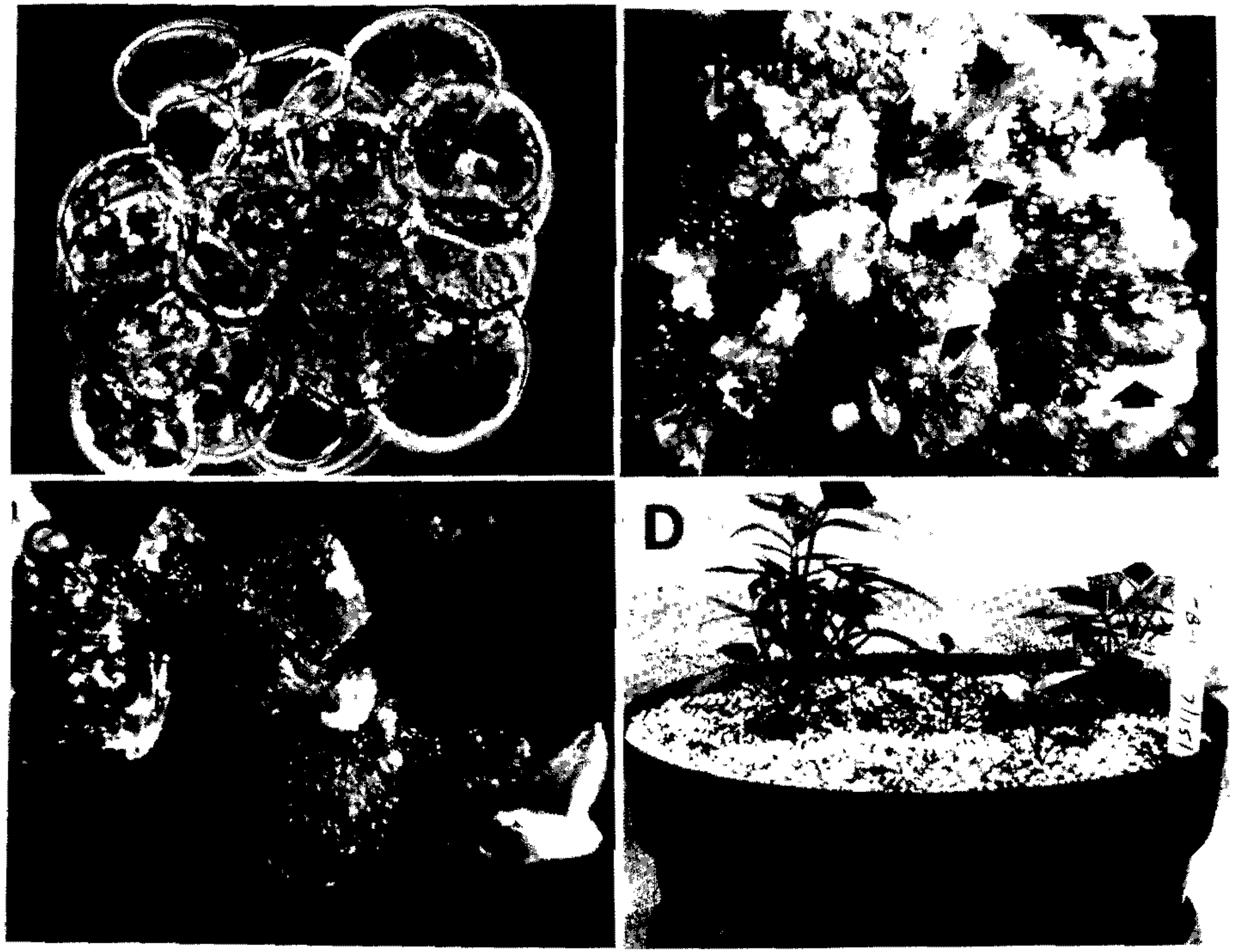


Figure 2. Plant regeneration of Phaseolus acutifolius: A. a potentially morphogenic cell cluster in suspension culture; B. organogenic callus from suspension culture; C. shoot differentiation from callus; D. regenerated plants.

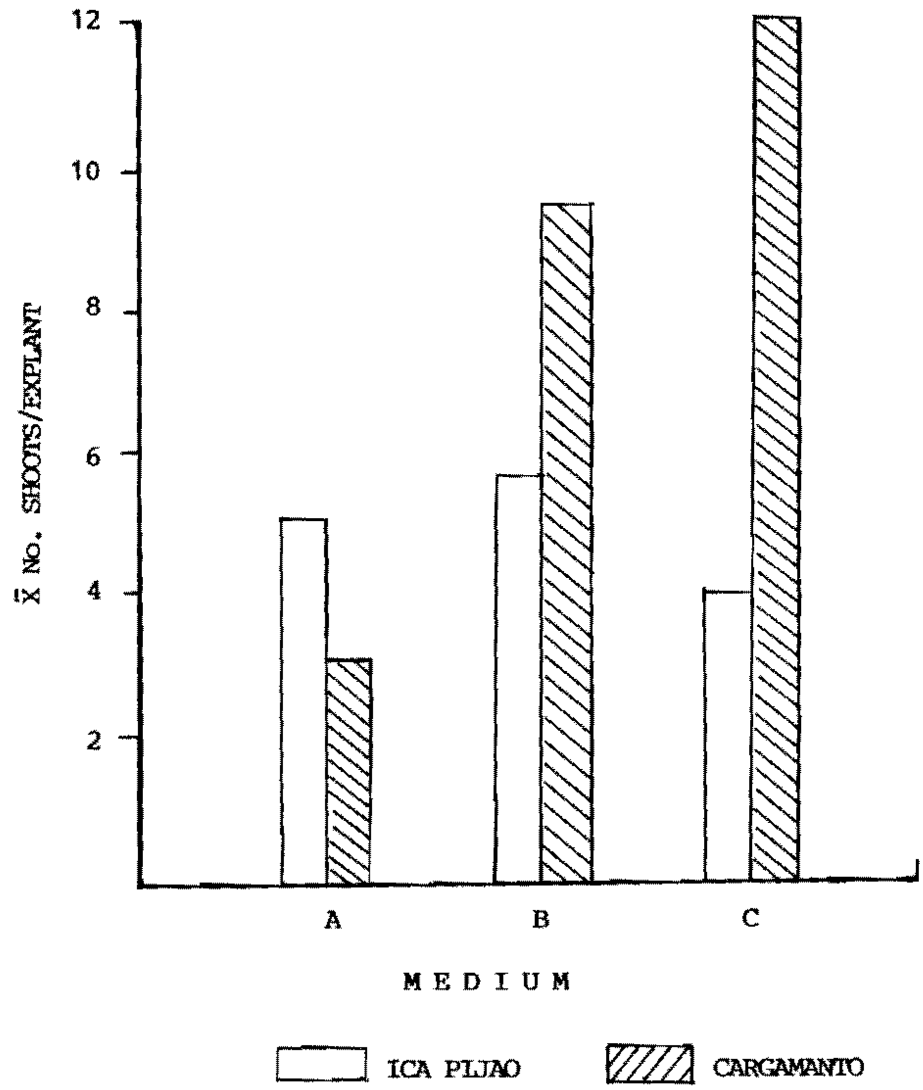


Figure 3. Multiple shoot induction from shoot tip cultures of common bean: Effect of media composition.

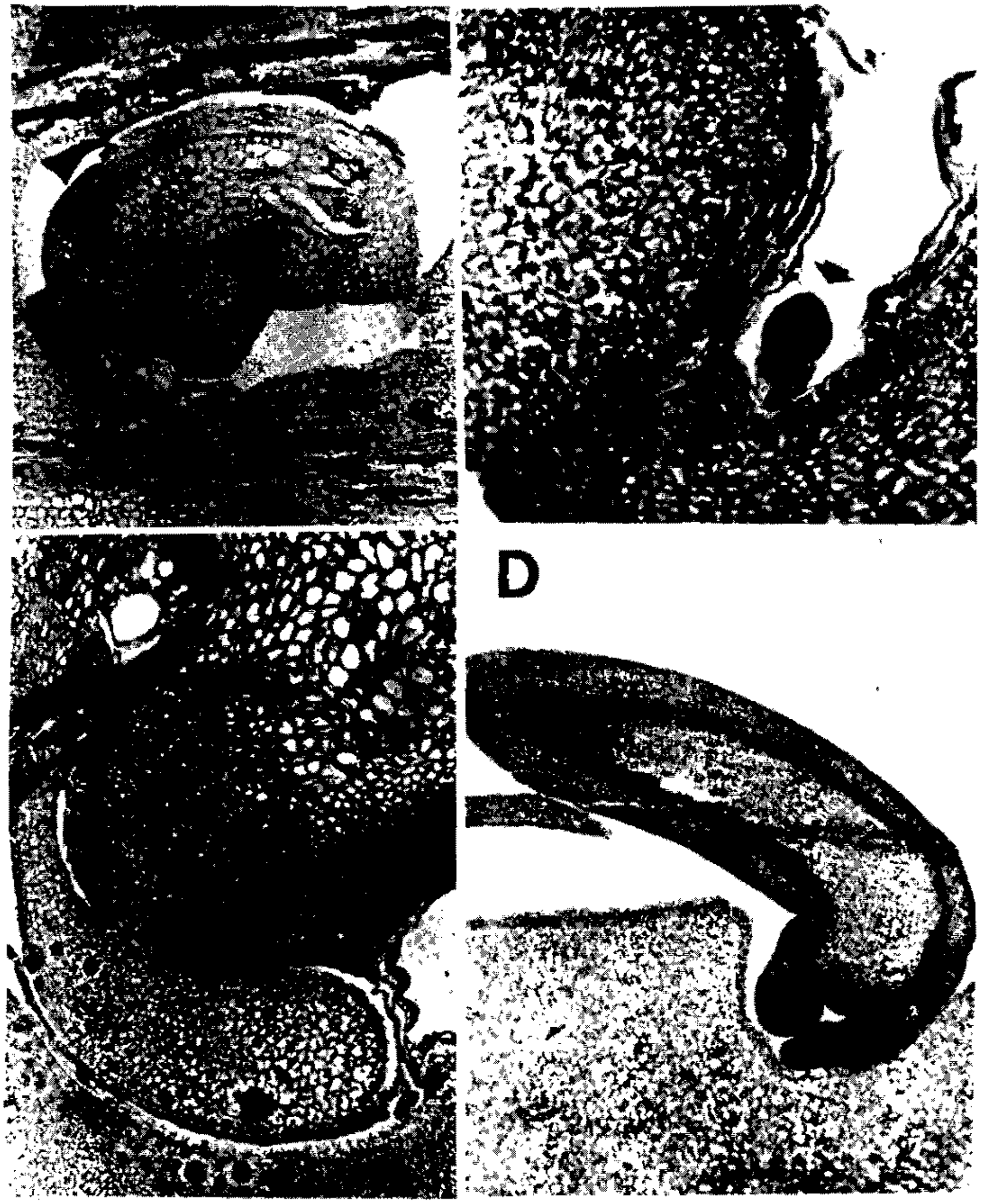


Figure 4. Early stage in *in situ* embryo development of *P. vulgaris* (P.v.) and *P. lunatus* (P.l.) : A. P.l. ovule one day prior to pollination. Note embryo sac with egg cell (arrow), synergids and antipodals; B. early heart-shaped P.v. embryo (arrow) 4 days after pollination; C. A torpedo-shaped P.v. embryo 7 days after pollination. Note conspicuous suspensor cells (arrow); D. A cotyledonary P.v. embryo 12 days after pollination. By this time, the P.l. embryo is still at the torpedo stage.

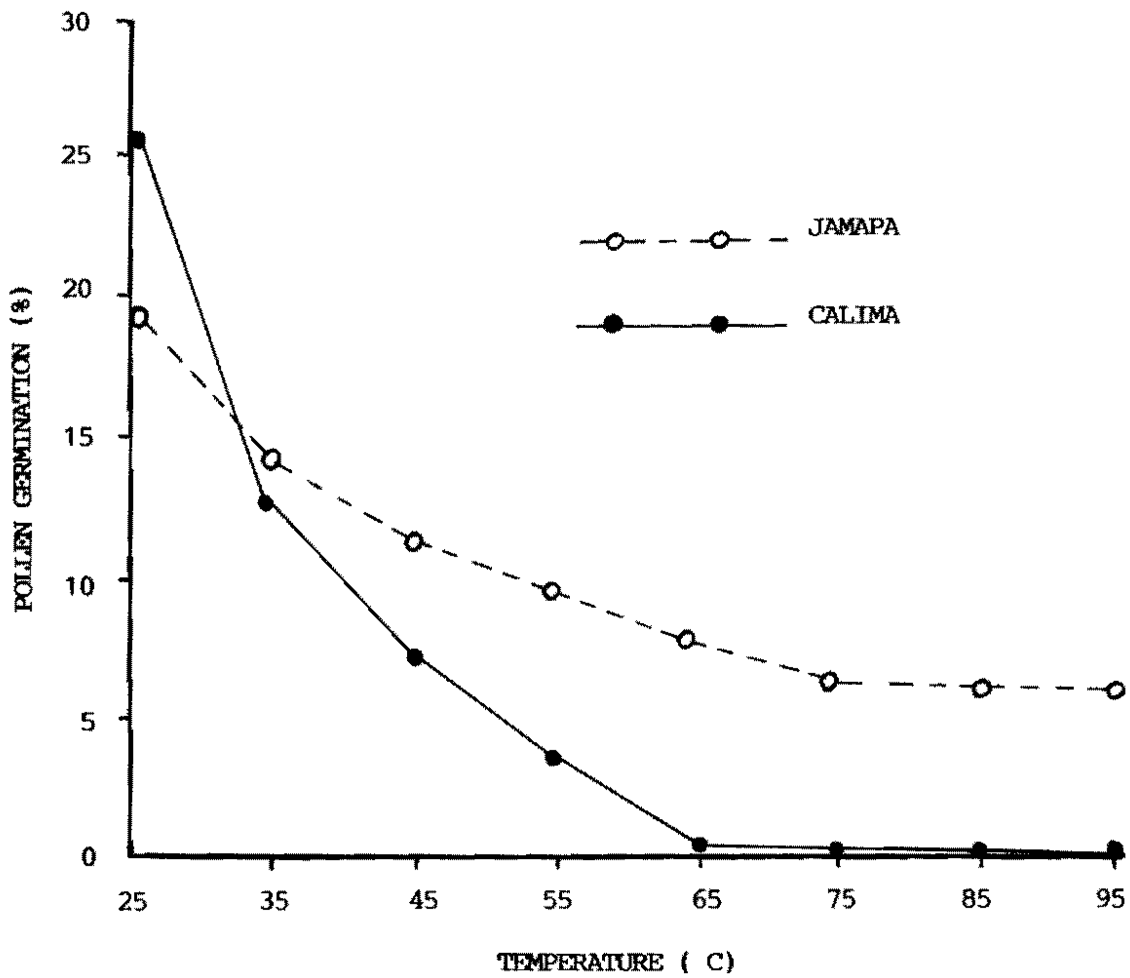


Figure 5. Changes in in-vitro pollen germination after treatment of pollen with high temperature.

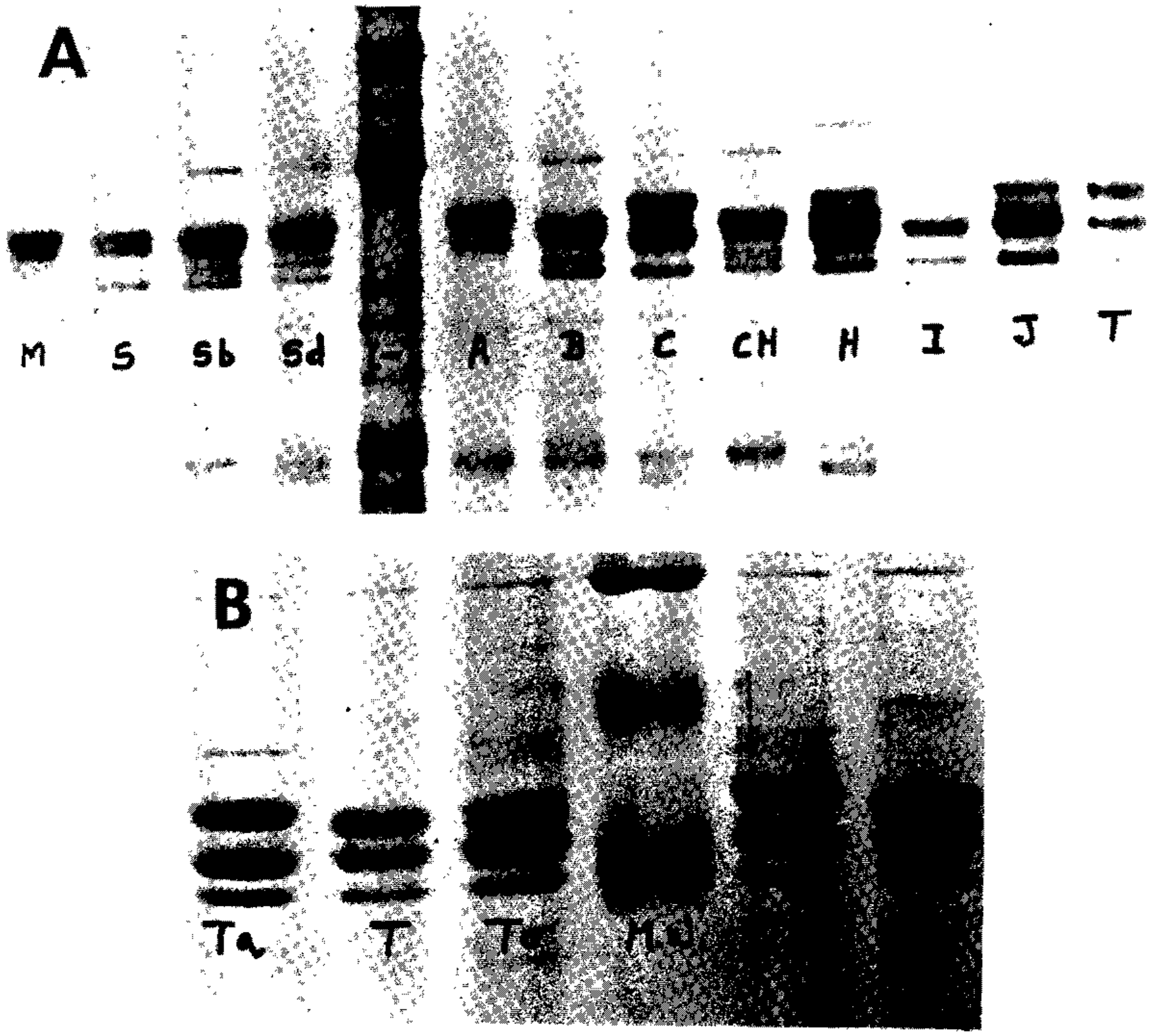


Figure 6. Variability in the phaseolin pattern of landraces and wild populations of Phaseolus vulgaris.

A. Discrimination of phaseolin types using a modified electrophoretic technique. In addition to the types S,T,C, B, N, A, Sb and Sd which occur in landraces, the wild populations also present the types: I, J, M and CH. (-) is a phaseolin-less mutant.

B. New phaseolin types found in wild populations of Peru (K) and Bolivia (Ta, To).

The known T (tendergreen) type is also present. MW (molecular weight marker).

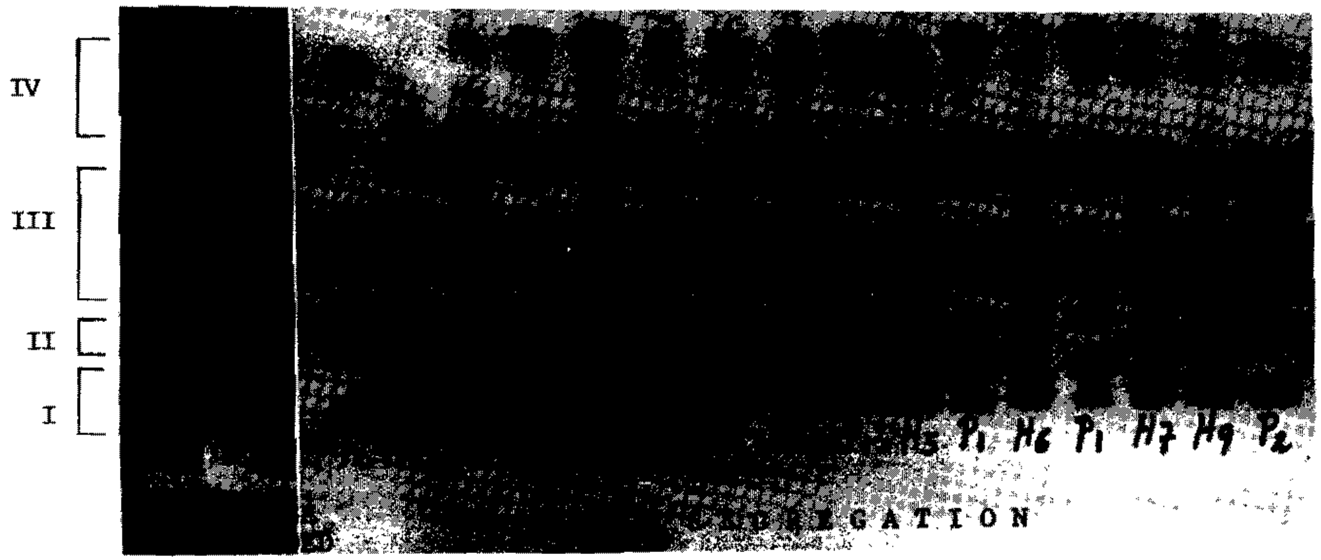


Figure 7. Analysis of F2 Diaphorase (DIA) pattern segregation of BAT 477 (P1) x A 195 (P2). Out of four loci, three have been analysed. Except H1, all others show hybridization at three the loci (I, II, III); segregation at each locus is approximately 1: 2: 1 (P1: Hybrid: P2) and suggests the presence of DIA in three forms: as a monomer (at locus I), dimer (at locus II)and tetramer (at locus III).

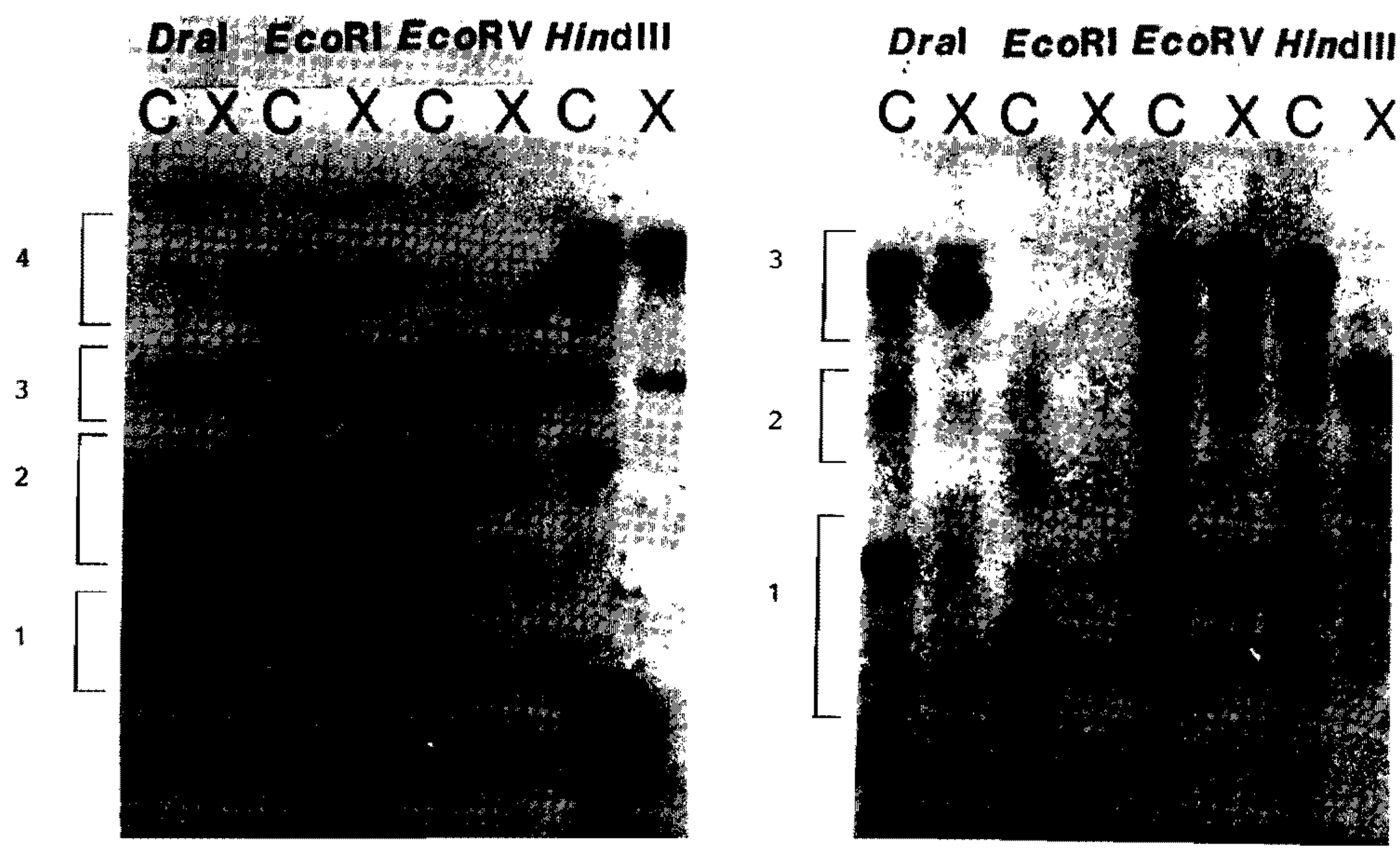


Figure 8. Hybridization patterns of two c DNA clones (I and II) to digests of CV. Calima (C) and line XR-235-1 (X) using four restriction enzymes. Clone I revealed more polymorphism than clone II and enzyme Dra I, followed by Eco R I, showed more variability in the length of DNA fragments between the two lines. (Foto: courtesy of Dr. E. Vallejos).

INTERSPECIFIC HYBRIDIZATION

The main objective of the CIAT/University of Gembloux project is to improve the common bean P. vulgaris L. through interspecific hybridization. The donor parents, P. coccineus L. and P. polyanthus Greenm., present useful characteristics poorly or not represented in the common bean primary gene pool such as: long and productive racemes; strong stem; and disease and pest resistance. The methodology includes the following activities: collection of P. coccineus and P. polyanthus lines; seed increase and evaluation of the material collected; selection of the best accessions according to the requests; crossing between the two species vulgaris and coccineus or vulgaris and polyanthus; multiplication and selection of the interspecific hybrids; and integration of the best advanced hybrid lines into the bean breeding program trials and nurseries(VEF and EP).

1. P. coccineus and P. polyanthus Multiplication and Evaluation

Multiplication

Because of the allogamy of the species, a special methodology is used, as described in former reports, in order to maintain the variability within each accession and to avoid mixtures between accessions.

The seed increase of the collection is going on in two different stations: at Rionegro (Antioquia, 2200msnm) in open field with hand pollination and racemes protected with paper bags, and Popayan (Cauca, 1750msnm) in meshcages with hand pollination.

At Popayan, the meshcages have a capacity for 1080 plants and an additional meshcage has just been built that can contain 360 plants. Table 1 shows the wild P. coccineus and natural hybrids between P. coccineus and P. polyanthus that have been planted at the beginning of September in order to be multiplied and evaluated.

During 1988, CIAT numbers have been attributed to 76 accessions. This brings up to 785 the number of P. coccineus and P. polyanthus accessions with CIAT numbers. Another 114 accessions are being multiplied and CIAT numbers will be soon attributed.

At Rionegro, 102 accessions with CIAT numbers were planted in the field for multiplication and preliminary evaluation.

Evaluation

During 1988, preliminary evaluation of the collection continued for both morphology and agronomy.

a.Morphology

As of this writing, 481 accessions have been partially evaluated for morphological characters and the results will soon be presented in a catalog.

The morphological evaluation of the collection is accomplished during the multiplication process, and concerns the following characters:

- type of germination
- hypocotyl or epicotyl color
- distance from cotyledons scar to primary leaves
- leaflet length and leaflet shape
- clear marking on primary leaves
- leaf anthocyanin
- leaf hairiness
- anthocyanin pigmentation on main stem
- growth pattern
- size and shape of the bracteole
- flower color
- shape of the stigma
- calyx, bracteole, and seed coat color
- weight per 100 seeds.

b.Agronomy

Evaluation for Ascochyta Blight Resistance

At Popayan, 40 accessions with 12 plants each have been planted in order to be evaluated for their resistance to Ascochyta during the first semester of 1988. Although the *P. vulgaris* check E1056 showed a very high susceptibility, the *P. polyanthus* species presented no lesions at all and *P. coccineus* was segregating. Results are presented in Table 2.

At Rionegro, *P. coccineus* and 20 *P. polyanthus* lines were planted in a two replications trial to be evaluated for their resistance to foliar diseases and their yield during the second semester of 1987. Because of the dry weather and the low disease pressure, no resistance evaluation was made but yield and days to flowering data of the best producing lines are reported in Table 3.

In order to made an evaluation with a better selection pressure, the same accessions were planted in April 1988 with the same trial design. Reaction to Ascochyta blight, Angular leaf spot, anthracnose, rust and powdery mildew were observed and are summarized in Table 4. All the *P. polyanthus* accessions evaluated showed a total resistance to Ascochyta and a very high level of resistance to other diseases. Within the *P. coccineus* lines, segregation occurred for Ascochyta and powdery mildew, with G35208 as best accession for Ascochyta resistance.

Other Evaluations

Additionally, accessions are included in other evaluation trials: bean fly resistance is tested at A.V.R.D.C.(Taiwan), Angular leaf spot at Quilichao(Cauca), bruchids and Bean Common Mosaic Virus are evaluated at Palmira. Table 5 lists the number of accessions sent for each objective.

Yield and Adaptation Nursery

The main objective of the nursery is to promote the productivity of *P. polyanthus* and *P. coccineus*
Other objectives are to evaluate under various environmental conditions the yield and adaptation of promising accessions of *P. polyanthus* and *P. coccineus*, to compare the accessions with the best local varieties (climbing *P. vulgaris* and *P. coccineus*) and to show the value of using the species directly rather than only as a source of interesting characteristics for the improvement of the common bean by interspecific hybridization.

The trial includes 12 entries: 10 *P. polyanthus* or *P. coccineus* accessions selected at Rionegro for disease resistance and productivity, and two local varieties planted as checks (*P. vulgaris* and/or *P. coccineus* according to the region) with three replications in a randomized design.

In the second semester of 1987, the nursery was planted at Obonuco (Pasto, Narino), including 10 *P. coccineus* accessions and 2 *P. vulgaris* checks. The results presented in Table 6 show that the checks produced better than the *P. coccineus* lines, but were later in flowering. Within the *P. coccineus* accessions, the best ones are G35393 and G35463, both from Mexico, with 1083 and 1250Kg/Ha respectively. No disease was observed because of the dry weather.

At Rionegro, the nursery included 10 *P. polyanthus* accessions and two *P. vulgaris* checks. Because of high weed competition, the *P. polyanthus* production was low and the *P. vulgaris* production not significant. As in Obonuco, no disease was observed, and the trial is now being repeated in order to make an evaluation with a better selection pressure. Results of the *P. polyanthus* lines production for 1987 are presented in Table 7.

2. Interspecific Hybridization

Crosses are made at the University of Gembloux according to the specific requests coming from the CIAT bean breeders. First priority is given to introduce Ascochyta and bean fly (*Ophiomyia* sp.) resistance from *P. coccineus* or *P. polyanthus* into Andean or African *P. vulgaris* varieties.

Another priority is given to upgrade the level of resistance to bean golden mosaic virus in Central American varieties of *P. vulgaris*. Finally the interspecific hybridization is also aimed at improving the plant architecture (long racemes, profuse podding, stout stems) or introgressing some cross-pollination mechanisms to the common bean.

Two kinds of crosses are undertaken: direct crosses are made using the cytoplasm of *P. vulgaris* and complex crosses combine genes of the requested *P. vulgaris* and *coccineus* parents on a wild *coccineus* or a *purpurascens* cytoplasm. Seeds of the F_1 are sent to CIAT in order to be multiplied at Popayan. The F_2 and further progenies are evaluated in different stations to select hybrid lines looking like *P. vulgaris*, with the *P. coccineus* or *P. polyanthus* desired characters.

Selection for Ascochyta Resistance

Popayan 1987B

During the second semester of 1987, F_1 seeds from 40 direct crosses as well as from 11 complex crosses were planted at Popayan for multiplication. The different combinations are listed in Table 8.

In more advanced progenies, evaluation was undertaken for *Ascochyta* resistance and 47 plants from 24 populations were selected in the F_2 progeny, 17 plants from 4 populations in the F_3, 15 plants from 11 populations in the F_4 and 48 plants from 13 populations in the F_5.

Popayan 1988A

During the first semester of 1988, selection was made in the F_4, F_5, and F_6 progenies as well as in some advanced lines selected at ICA-La Selva for their adaptation and productivity. These advanced lines did not present a good level of resistance to *Ascochyta*, excepted for some plants that showed some *P. polyanthus* characteristics like terminal stigma, but were very late and low productive. Within the F_4, F_5, and F_6 progenies, some 35 lines were selected for their resistance to Ascochyta and their adaptation. Some were still very similar to *P. polyanthus*, others had an architecture more like *P. vulgaris*. Specially resistant were in the F_6 ten complex hybrid lines [(NI889 x NI637) x

NI1015] X NI1007 and four [(NI889 x NI637) x NI1015] x A114 lines that did not show any Ascochyta symptom. The results of the F_4 and F_5 progenies are presented in Table 9.

Selection for Bean Fly Resistance

As selection pressure does not exist in Colombia, selection is made at A.V.R.D.C.(Taiwan) by Dr.Talekar.

During 1988, some 45 F_4 interspecific hybrids lines were selected for their resistance to bean fly and sent to CIAT. Particularly resistant were four complex hybrid lines: one (NI886 x G3807) x G35023 (0 larvae and pupae per 20 plants) and three (NI886 x G3807) x Canadian Wonder lines (0, 1, and 2 L+P/20 plants respectively). These lines are going to be planted in the field at Palmira in order to be evaluated for agronomical characters, and to be backcrossed with elite P. vulgaris lines resistant to bean fly, like ICA-Pijao, Argentino and BAT 1373.

On the other hand, seeds from 347 hybrid plants selected at Palmira were sent to A.V.R.D.C. in May 1988. They are F_9 and F_{10} progenies of direct hybrids P. vulgaris x P. coccineus. Parents combination are listed in Table 10.

VEF and EP

During 1987, some interspecific advanced lines were integrated in the VEF and the EP. The VEF lines included 3 complex hybrids in the F_4 progeny: two (NI886 x G3807) x BAC24 and one [(NI889 x NI637) x BAC24] x NI663. The EP lines were two Aete 1/38 x M7285A and two ICTA-Quetzal x M7285, all in the F_9 progeny. They present a good resistance to diseases as shown in Table 11. Nevertheless, segregation is still observed, almost in the F_4 progeny.

The lines integrated in the VEF 1988 included one P. vulgaris x P. coccineus F_5 line with red seeds (Mortiño x 88-1) and three P. vulgaris x P. polyanthus lines with cream/brown mottled seeds (Mortiño x X7 (F_5), Guate1008 x Piloy (F_5), and BAT450 x Piloy (F_6)).

Table 1. Wild *P. coccineus* and natural hybrid between *P. coccineus* and *P. polyanthus* accessions planted at Popayan in meshcages in September 1988.

Species	Origin	No. accessions
Wild *P. coccineus*	Mexico	20
	Guatemala	8
P. polyanthus (weedy)	Guatemala	1
Natural hybrids between *P. coccineus* and *P. polyanthus*	Colombia	7
Total accessions		36

Table 2. Reaction to Ascochyta of some *P. coccineus* and *P. polyanthus* accessions at Popayan during 1988A.

Species	Reaction to Ascochyta*	No. accessions
P. polyanthus	1	19
P. coccineus	1	2
	2	4
	3	8
	4	5
	5	2
P. vulgaris (E1056)	8	
Total accessions		40

* 1 to 9 severity and intensity scale, where 1 = totally resistant and 9 = susceptible.

Table 3. Productivity (Kg/Ha) and days to flowering of the best P. coccineus and P. polyanthus lines at Rionegro 1987B.

No CIAT	Species	Origin	Mean yield	Days to flowering
G35056	polyanthus	Mexico	2690	73
G35058	polyanthus	Mexico	1217	83
G35062	polyanthus	Mexico	1241	78
G35066	coccineus	Mexico	1421	91
G35074	coccineus	Iran	1090	68
G35181	polyanthus	Guatemala	1449	88
G35188	polyanthus	Guatemala	1502	82
G35245	coccineus	Puerto Rico	1240	102
G35246	coccineus	Puerto Rico	1045	82

Table 4. Reaction to some foliar diseases of 20 P. coccineus and 20 P. polyanthus accessions at Rionegro during 1988A.

Reaction to	Score (1-9 scale)	No accessions P. coccineus	No accessions P. polyanthus	Check[1]
Ascochyta	1		20	
	2			
	3	1		
	4	8		
	5	6		
	6	5		
	8			*
Angular leaf spot	2	13	20	
	3	7		
	4			*
Anthracnose	2	20	10	
	3		10	
	4			*
Rust	1	20	14	*
	2		6	
Powdery mildew	1	2	3	
	2	3	7	
	3	1	5	
	4	5	4	
	5	8	1	*
	6	1		

1 Cargamanto

Table 5. Number of *P. coccineus* and *P. polyanthus* lines that are being evaluated, and objectives.

Objective	Number of accessions *P. coccineus*	 *P. polyanthus*
Bean fly	31	17
Angular leaf spot	17	13
Acidity tolerance	50	50
Bruchids	125	111
BCMV	156	121

Table 6. Results of the *P. coccineus* nursery planted at Obonuco (Nariño) in 1987B.

No CIAT	Mean yield(Kg/Ha)	Days to flowering
G35392	600	98
G35400	907	98
G35422	170	98
G35446	370	105
G35501	270	103
G35508	573	99
G35393	1083	60
G35439	917	70
G35463	1250	57
G35470	570	62
Mortiño	1813	115
Frijolica032	1793	113

Table 7. Results of the *P. polyanthus* nursery planted at Rionegro (Antioquia) in 1987B.

No CIAT	Mean yield (Kg/Ha)	Days to flowering
G35516	501	81
G35521	165	99
G35522	545	81
G35527	351	91
G35545	528	85
G35559	405	86
G35560	467	84
G35544	493	97
G35549	345	87
G35556	236	88

Table 8. F_1 direct and complex crosses planted at Popayan in 1987B.

Cross combination	No crosses	No seeds
P. vulgaris x *P. polyanthus*	40	111
((Pc wild x Pv) x Pcp) x Pv[1]	9	27
((Pp x Pv) x Pcp) x Pv[2]	2	2

1 Pc wild = *P. coccineus* wild, Pv = *P. vulgaris*, Pcp = *P. polyanthus*
2 Pp = *P. purpurascens*

Table 9. Ascochyta reaction of the best F_4 and F_5 interspecific hybrid lines planted at Popayan during 1988A.

Cross combination	Parents identification	Prog.	Asc	No pop
P.vulg.x P.pol.	BAT1297xG35360	F_4	3	5
	BAT1297xG35360	F_4	2	2
	ZAV83008xG35360	F_4	3	2
	ZAV83008xG35360	F_4	2	1
	Antioquia8xNI757	F_5	2	2
	BAT1297xNI1015	F_5	2	2
	BAT1297xNI1015	F_5	3	1
	UrubonobonoxNI757	F_5	2	1
	A114xNI1015	F_5	1	1
(PpxPv)xPcp[1]	(NI552xICA-Guali)xNI757	F_5	1	1
((PcwxPv)xPcp)xPv[2]	((NI889xNI637)xNI1015)xNI1007	F_5	3	2
	((NI889xNI637)xNI1015)xNI1007	F_5	1	1

1 Pp = *P. purpurascens*, Pv = *P. vulgaris*, Pcp = *P. polyanthus*
2 Pcw = wild *P. coccineus*

Table 10. Interspecific hybrid lines sent to A.V.R.D.C. in May 1988 to be selected for Bean fly resistance.

Parents	Progeny	No of lines
BAT 338 x 46-1	F_9	275
Pasto x G35122	F_9	34
X23-3-6 Café x G35023(A)	F_{10}	14
X23866 Café x G35023(A)	F_{10}	24

Table 11. Resistance to diseases of some interspecific advanced lines integrated in the VEF and EP 1987.

(R = resistant, I = intermediate, S = susceptible; N = resistant, M = susceptible (mosaic)).

Identification	Rust	CBB H	CBB V	ANT H	ANT V	ALS H	ALS V	ASC	BCMV
EP									
P. vulgaris x *P. coccineus*									
Aete1/38 x M7689A	I	I	R	R	R	I	R		N
ICTA Quetzal x M7285	I	S	R	R	R	I	I		N
ICTA Quetzal x M7285	I	S	R	R	R	I	R		N
Aete1/38 x M7689A	S	I		I	R	I	R		N-M
VEF									
(PcwxPv)xPv[1]									
(NI886xG3807)xBAC24	R	R		R	R			R	N
(NI886xG3807)xBAC24	R	R		R	R			R	N
((PcwxPv)xPv)xPcc[2]									
((NI889xNI637)xBAC24)xNI663	R	R		R	R			I	N-M

1 Pcw = *P. coccineus* wild, Pv = *P. vulgaris*
2 Pcc =*P. coccineus*

PHASEOLUS DIVERSITY IN THE SOUTHERN ANDES

This year, the GRU/Bean Program Project on *Phaseolus* diversity focused its activities on the Southern Andes, one of the two major areas of bean domestication (the other being Mesoamerica). Work recently completed at the University of Wisconsin has shown that phaseolin, the major seed protein in *Phaseolus vulgaris* L., displays polymorphism and thus can be used as an evolutionary marker independent from selective pressures during domestication. Using that phaseolin variability, it was shown that the Southern Andes was a very important area from a genetic resources point of view. There, three major groups of cultivars with different phaseolin types 'T', 'C', and 'H' and a minor one with type 'A' (although only one 'A' accession is known so far, from Ayacucho) were domesticated. On the contrary, apparently only one group of cultivars with 'S' phaseolin was domesticated in Mesoamerica.

The Andean gene pool contributed to most of the Old World bean germplasm, either in Europe, or in Africa. In a research study conducted this year in collaboration with the BRU, it was demonstrated that 'T' phaseolin type was present in 71% of 275 landraces of 5 East African countries (Kenya, Malawi, Uganda, Tanzania and Zimbabwe). These results confirmed previous observations made on other African germplasm collections using either phaseolin or isozymes studies. On the other hand, it has been shown that several snapbean varieties, an expanding crop in several tropical areas, originated in South America.

This study on *Phaseolus* diversity explores the following questions:

1) What is the actual geographic origin of the materials cultivated in the Southern Andes? The assumption of an Andean origin was not obvious, because until very recently there were no wild bean germplasm collections to use as geographic markers (16 accessions for all of South America in 1985).

2) What is the extent of the Southern Andes? How was bean domestication concentrated within that range---in one single place or in many locations?

3) What are the consequences of this pattern of domestication on the formation of genetic variability in that region---and how does that affect current bean breeding programs?

Results

1) Germplasm exploration: collecting expeditions carried out in the Southern Andes for the last three years to further the world Phaseolus collection held at CIAT, especially for landraces and wild relatives, were continued.

This year, emphasis was put on Southern Peru and Bolivia after the collections made during 1985 to 1987 in Northern and Central Peru and Northwestern Argentina. Since the common bean materials from these regions were morphologically distinct, a transition was thus looked for in Southern Peru and Bolivia.

As it can be seen in Table 1, more complementary collections of landraces (61% of the total) were made because several materials (e.g. popped beans or nuñas) are rapidly disappearing.

Bean production and consumption does not vary much between areas of Peru and Bolivia---beans are grown in small plots on steep slopes; the crop is consumed on-farm; and planting and eating preference is given to maize and root crops. Three groups of beans are known in these areas--common beans, popbeans or nuñas, and chuies beans which are consumed only when all other food sources are depleted.

The consumption of native pulses is rapidly lessening in these highland areas of Peru and Ecuador, due to an increase in imported varieties, endangering the existence of popbeans and chuies. Ten and 14 collections were made of each group respectively, and more collections are planned for the future.

2) Field observations: as can be seen in Table 1, 35 weedy types of P. vulgaris were collected in the Cusco, Peru department and 2 in Tarija, Bolivia. These materials are morphologically intermediate between the true wild types present in natural vegetations, and the cultivated varieties; they are found in field borders and disturbed rural vegetation. These weedy types had been observed during previous explorations in 1985 - 87: in one place in Cajamarca, two in Junin, two in Apurimac and another one in Cusco.

This frequency of occurrence added to information provided by farmers in the area indicates the existence of a 'wild-weed-crop complex', where the weedy races arise from natural crosses with sympathetic wild forms. This complex has been observed in other cultivated plants such as maize, potato and chili peppers. The farmers noticed this phenomenon and used it in order to increase the genetic diversity of their mixtures. The next step will be to quantify the gene flow from the wild forms to see how it contributed (and still contributes) to the genetic variations in the landraces of the Southern Andes using on-going studies on phaseolin, isozymes and morphological traits.

3) Laboratory studies: since wild beans can be used as geographic markers, one dimension SDS/PAGE analyses of the total seed protein were performed on all available accessions of wild P. vulgaris. The results obtained in collaboration with the BRU at CIAT and independently at the University of California can be summarized as follows:

Two dimensional analysis is being carried out to determine if the phaseolin types 'Ta', 'To' and 'K' are new ones or variants of 'T' and 'C' respectively.The 'S' types found in Peru and Bolivia are of cultivated and introduced varieties with small seeds such as the Panamitos. These results suggest the following comments:

1) The Southern Andes were a place of bean domestication: the most common phaseolin types 'T', 'C', 'H' in traditional cultivars from that zone are also present in the wild populations of the same zone. However, 'C', once considered the result of a cross, has been shown to be a type of its own, present in wild populations of Southern Peru, Bolivia and Argentina.

2) The phaseolin types 'I', 'J', 'K', 'To', 'Ta' found in wild populations have not been found so far in any cultivated material.

3) This absence can be understood when taking the following into account:

- very few cultivated materials have been analyzed so far (Peru: 49; Bolivia: 5; Argentina: 6) when compared to the existing seed accessions at CIAT (Peru: 2357; Bolivia: 240; Argentina: 239). It is thus quite possible that other phaseolin types will be found in the cultivated landraces (the case of the 'A' phaseolin is quite illustrative of that possibility).

- the 'T', 'C', 'H' types are dominant in most wild populations, that is, they are displayed by a higher number of plants in a higher number of locations.

4) If it can be shown on a larger number of accessions, that the types 'I', 'J', 'K', 'Ta', 'To' are locally distributed and/or in low frequency, being present only in the wild, then just a few types were really domesticated and not the others. In this case, using a biochemical character that was not under direct domestication pressures, it

appears that there is more genetic diversity in the wild materials.

5) The dominant types 'T' and 'C' are present in a large number of wild populations extending from Junin (Junin) up to Tucuman (Argentina), that is an almost continuous distribution of 2300 km (possible gaps in Puno and Alto Chapare are still to be checked).

It is thus possible that domestication of native landraces took place in different parts of that range of distribution, that is, from different wild populations of Peru, Bolivia and Argentina. That range could thus constitute what we call the "Southern Andes".

6) At this stage of the analysis, the possibility that a single population (or just a very few) was domesticated somewhere in the Southern Andes where several phaseolin types would have been present, cannot be discarded. This situation occurs in certain populations (for instance 2259 from Peru; 2484 from Bolivia; 621 from Argentina), where 'T' and 'C' types were present as were up to three different phaseolin types. It would therefore be useful to consider another marker, such as mt DNA.

7) It is however possible that domestication took place in more than a single place, as indicated by certain traditions of the local farmers. In many places of Purimac and Cusco, farmers are still using wild and weedy races directly as food, and indirectly to increase the variation of their mixtures. That this genetic enrichment occurs today, simultaneously in several places in the Southern Andes, hints at a similar pattern in the past.

8) It has been demonstrated in this study that some phaseolin types are present with a low frequency in some wild populations (approx. 5%), making it necessary to run SDS/PAGE on up to 15 original seeds in order to find them. This study is thus a first step towards understanding the genetic structure of the wild populations; it will then be possible to improve methodology for both germplasm collecting and seed multiplication, wherein attention should be paid to the highest number of plants possible.

From these preliminary results, the following conclusions can be made:

a) The Southern Andes was a place of bean domestication, different from the Northern Andes and Mesoamerica.

b) For P. vulgaris, the Southern Andes include the interandean valleys from Junin, Peru (11^{o} lat. S) up to Tucuman, Argentina (27^{o} lat. S).

c) In several places of that range, crossing between wild forms or with cultivated materials resulting in the formation of weedy races has been observed. Folk people also noticed these weedy races and sometimes use them as an emergency food or include them in their mixtures. On the other hand, once fully characterized, the outcrossing mechanism will have important implications for bean breeding as well as for germplasm management.

d) At this stage of the analysis, bean domestication can be considered from two points of view: either the beans of the Andes were domesticated from a single wild population and then distributed in the area with a subsequent genetic enrichment from other wild and weedy races, or the beans were domesticated in several places from distinct wild populations and then enriched from subsequent crosses. Obviously, for the total genetic diversity, it is not the same result and it is worth knowing what happened.

e) In order to make further progress on this, it is necessary to analyze more cultivated and wild materials of Andean origin. More collections must be undertaken in areas not yet visited, specifically for wild materials.

Some of the conclusions outlined above were corroborated by a study done elsewhere on gene pools in P. lunatus, summarized below:

1) On the basis of morphological and phytogeographical evidence reported previously, and after a SDS/PAGE of the total seed protein (carried out with the CIAT Bean Entomology Department), there appear to be two different races of wild P. lunatus in the Southern Andes. One race with larger seeds (100 seed weight 17 g) is present in northwestern Peru; the Big Lima beans were domesticated from that race. A second one with smaller seeds (12 g) is distributed in the eastern foothills of the Andes and has apparently not been domesticated.

2) The wild materials (approx. 100 accessions) showed a higher variability than did the cultivated materials. More SDS/PAGE analysis on both kinds of materials (as well as additional collections for both of them) is necessary to show more precise patterns of bean domestication in P. lunatus.

Table 1. *Phaseolus* materials collected in 1988

Species	Collection Sites		
	Cusco, Peru	**Bolivia**	**Total**
P. vulgaris L.			
landraces	26	64	90
weedy types	35	2	37
wild forms	8	4	12
P. lunatus L.			
landraces	-	12	12
P. augusti Harms (wild)	10	7	17
Total	79	89	168

Table 2. Phaseolin types of *P. vulgaris* in the Southern Andes

Country/Department	Phaseolin types	
	Wild	Cultivated
Peru		
Cajamarca	I	T, C, S
Junin	T, C	T, C, H, S
Apurimac	T, C, K	T, C, H, S
Cusco	T, C, K, H	T, C, H, S
Bolivia		
Cochabamba	T, C, To	T, C
Chuquisaca	T, C	T, C
Tarija	T, Ta	T, C, S
Argentina		
Jujuy	T, C, J	T, H
Salta	T, H	T, H
Tucuman	T, C, H, J	--

YIELD PHYSIOLOGY

Nitrogen Use Efficiency:

Yield potential is related to the ability of a genotype to acquire and effectively utilize scarce environmental resources. Since nitrogen (N) is a limiting resource in many bean agroecosystems, a series of studies was undertaken with the objective of defining and evaluating a conceptual ideotype of optimal nitrogen use efficiency in bean. Here we report data related to N acquisition from the environment, N flux through the shoot, and seed N use.

Methods

Two experiments are discussed; the first an overview comparison of 16 legume taxa and the second a detailed study of 3 bean genotypes. The 16 taxa included soy, *Phaseolus lunatus*, cowpea, and the 13 bean genotypes listed in Figure 1. This trial was planted in Palmira in a lattice design with 4 replicates. At 42, 58, and 72 days after planting 2 m of row were harvested from each plot and divided into organ categories for dry weight and N determinations. Chlorophyll concentrations were chemically determined for young, fully-expanded leaves high in the canopy. In the second experiment BAT 477, G 5059, and Porrillo Sintetico were planted in Palmira in a randomized block design with 4 replicates. On 12 dates from flowering to physiological maturity 1 m of row was harvested as above for dry weight and N determinations. Yield was determined on subplots of 9 m^2. Data were locally smoothed by least-squares polynomial regression, numerically differentiated by Newton's divided difference method, and numerically integrated using the Trapezoidal Rule.

Results

N Acquisition

Significant differences in N content were observed in the 16 taxa (Figure 1). In the first 42 days after planting BAT 477 and BAT 332 were superior to the other materials; at 58 days after planting soy, *P. lunatus*, and the nonflowering (poorly adapted) Ancash 66 were superior, showing the effect of phenology on N uptake. N acquisition during the first period was not well related to N acquisition during the second period, suggesting that root growth and/or nodulation may have functional transitions during ontogeny.

Shoot N acquisition was studied in more detail in the second experiment. BAT 477 and Porrillo Sintetico reached maximum N flux at 53 DAP, corresponding with stage R8 (Figure 2).

After the peak, N flux in Porrillo Sintetico declined rapidly and remained relatively low thereafter. In BAT 477 the decline was more gradual, less severe, and late-season recovery more substantial than in Porrillo Sintetico. Enhanced N acquisition from 53 to 70 DAP in BAT 477 is an important positive attribute, since seed N demand peaks during this period (see below). G 5059 displayed very different behavior, having only moderate N flux until 70 DAP. This delay is partially explained by the fact that the phenology of this genotype was delayed 7 days relative to the other 2 genotypes. In all genotypes net N uptake continued well into physiological maturity, contrary to theories about root and nodule activity that have been advanced for other grain legumes.

A rapid screening technique for N acquisition was suggested by a strong relationship observed between total shoot N content and leaf chlorophyll concentration in 9 taxa during pod fill (Figure 3). Hand-held 'chlorophyllometers' are commercially available that purportedly permit rapid measurement of leaf chlorophyll density per unit leaf area in the field. We evaluated the usefulness of one such device available from Design Electronics. Initial field measurements gave poor correlations with chemical chlorophyll determinations. After modifications designed to correct for the effects of variable light and temperature on instrument readings, multiple regressions predict leaf chlorophyll concentration from instrument readings with an r^2 of 0.55, which is not adequate for routine screening. Because of the potential value of such a device, we are continuing our attempts to improve its utility for bean.

<u>N Duration</u>

N duration was calculated as the integral of N content over time, giving a measure of total N use during reproductive development. Total N duration was highest in BAT 477 and lowest in Porrillo Sintetico (Figure 4; in this figure the size of each pie chart is proportional to total N duration). Leaf N duration is particularly important since it is closely related to the photosynthetic potential of the plant. An efficient genotype would be expected to maximize leaf N duration at the expense of stem N duration and to some extent also seed N duration. Although high seed N duration is necessary for high N harvest index (final seed N vs. final total plant N; NHI), a pattern of delayed yet rapid seed N filling could expand leaf N duration while maintaining NHI. G 5059 had the greatest leaf N duration, followed by BAT 477, then Porrillo Sintetico. The three genotypes illustrate two routes to increased leaf N duration; G 5059 allocated relatively less N to seed development, while BAT 477 had greater leaf N duration than Porrillo Sintetico because of a larger total N budget. Differences in leaf N duration were associated with differences in leaf area duration rather than differences in leaf N concentration (Table 1). The greater N allocation to leaves in G 5059 may be related to its delayed phenology, and suggests that N use efficiency should be more common in late materials. Comparing N duration to yield as an index of overall N efficiency shows that Porrillo Sintetico was the most efficient genotype, with BAT 477 and G 5059 being roughly equal (Table 1).

N Remobilization Rates

N flux values during reproductive growth show that leaf and stem tissue largely exported or lost N while seeds imported N (Figure 5). In all three genotypes net loss of leaf N began 55 DAP. Leaf N flux decreased rapidly in Porrillo Sintetico, and decreased more gradually in BAT 477 and G 5059, respectively. Porrillo Sintetico was also earliest to begin stem remobilization, with BAT 477 showing a later but more rapid rate of remobilization. Gradual leaf and stem remobilization in G 5059 account for its relatively high leaf and stem N duration.

Seed N Concentration

Seed N loading peaked first in BAT 477, then Porrillo Sintetico, then G 5059, with Porrillo Sintetico having the lowest peak demand (Figure 5). Peak N loading corresponded with a period of zero net N acquisition in Porrillo Sintetico and low net N acquisition in BAT 477 and G 5059 (Figure 2), demonstrating that tissue N remobilization is necessary for seed N loading. Seed N concentration decreased gradually until 75 DAP, then increased slightly until 85 DAP (Figure 6). This late-season rise in N concentration merits further investigation, since theoretically an efficient genotype would preferentially load C into seeds before N. BAT 477 had the highest final seed N concentration. Seeds of both BAT 477 and Porrillo Sintetico efficiently extracted plant N, shown by high NHI (Table 1), although G 5059 was poorer in this regard. Seed N use is determined by seed N concentration and the duration and rate of seed filling. In soy, duration and rate of seed filling can be estimated from final Harvest Index (HI) and phenology data, since HI increases linearly with time. In these 3 genotypes HI also increased fairly linearly with time, indicating that this method can also be used in bean for rapid evaluation of seed filling parameters (Figure 7).

Summary

Genotypic variation was found for all parameters presumably related to N efficiency, with phenology playing a central role. BAT 477 was excellent in acquiring environmental N and partitioning it to seed production. N economy in BAT 477 may be limited by high seed N requirement. Porrillo

Sintetico had lower N acquisition, but because of lower seed N requirement and good NHI was an efficient yielder in terms of N. G 5059 had intermediate acquisition and good N allocation to leaves, but because of poor N remobilization to seeds was an inefficient yielder. Rapid selection criteria for N efficiency in bush beans might include N acquisition screening by leaf chlorophyll determination, leaf N duration screening by the HI method, and seed N mobilization screening by NHI.

Table 1.

Genotype	Leaf Area Duration m^2*day/plot	NHI	Seed yield (kg/ha)	Yield/N Duration (kg seed/kg N*day)
BAT 477	162.4	0.807	2053	0.248
G 5059	187.3	0.724	1701	0.243
P. Sint.	147.2	0.818	2137	0.316
s.d.	13	0.06	75	0.019

FIG 1: SHOOT N CONTENT IN 16 TAXA

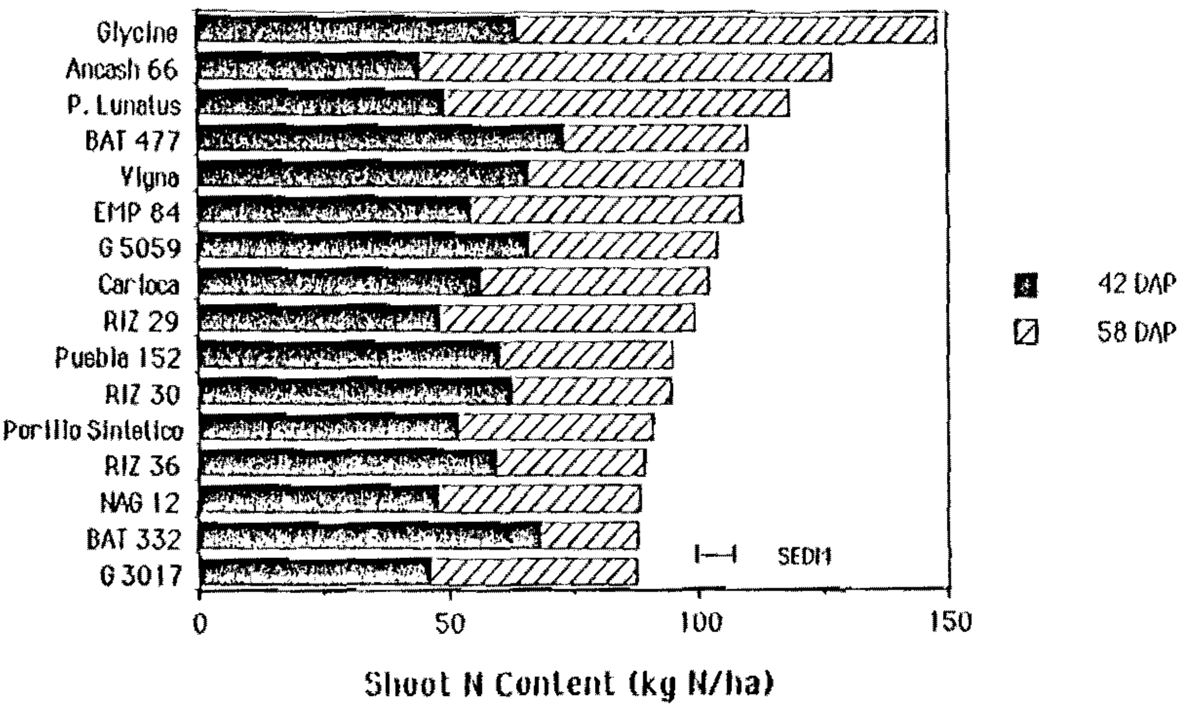


FIG 2: SHOOT N ACQUISITION BY 3 BEAN GENOTYPES

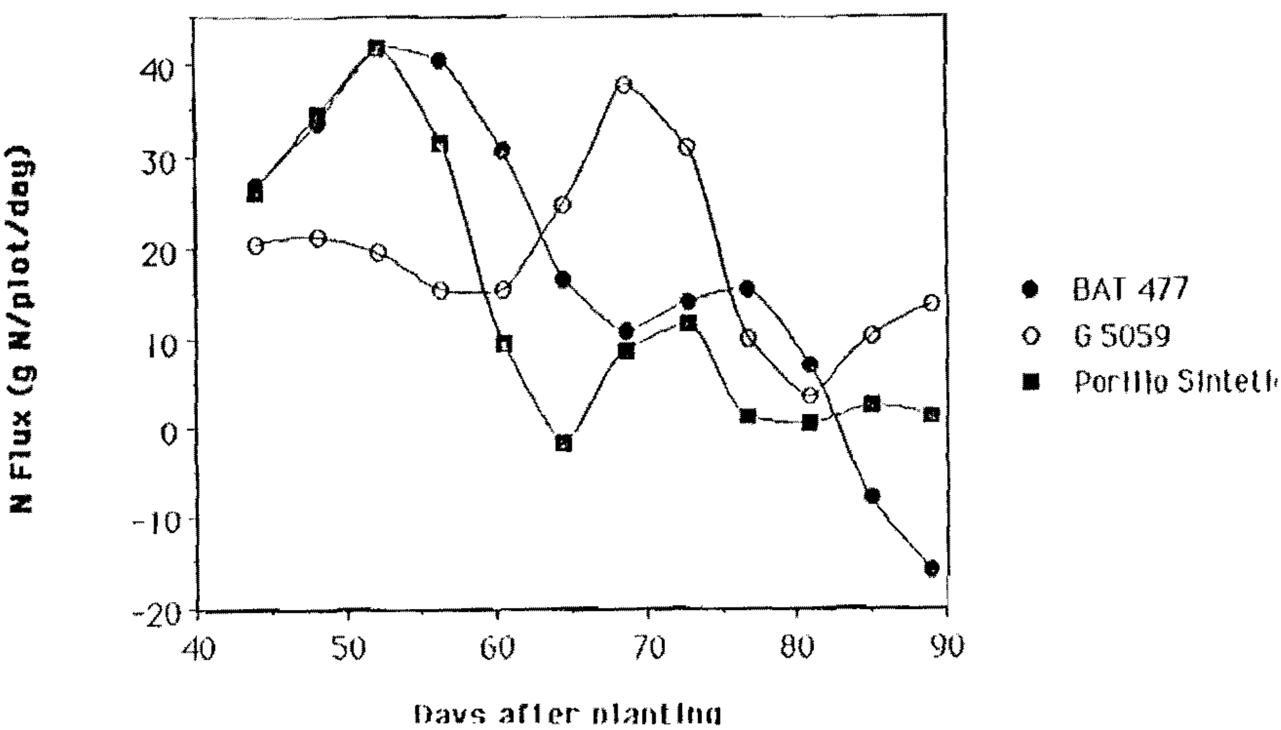


FIG 3: RELATIONSHIP OF LEAF CHLOROPHYLL CONCENTRATION WITH SHOOT N CONTENT

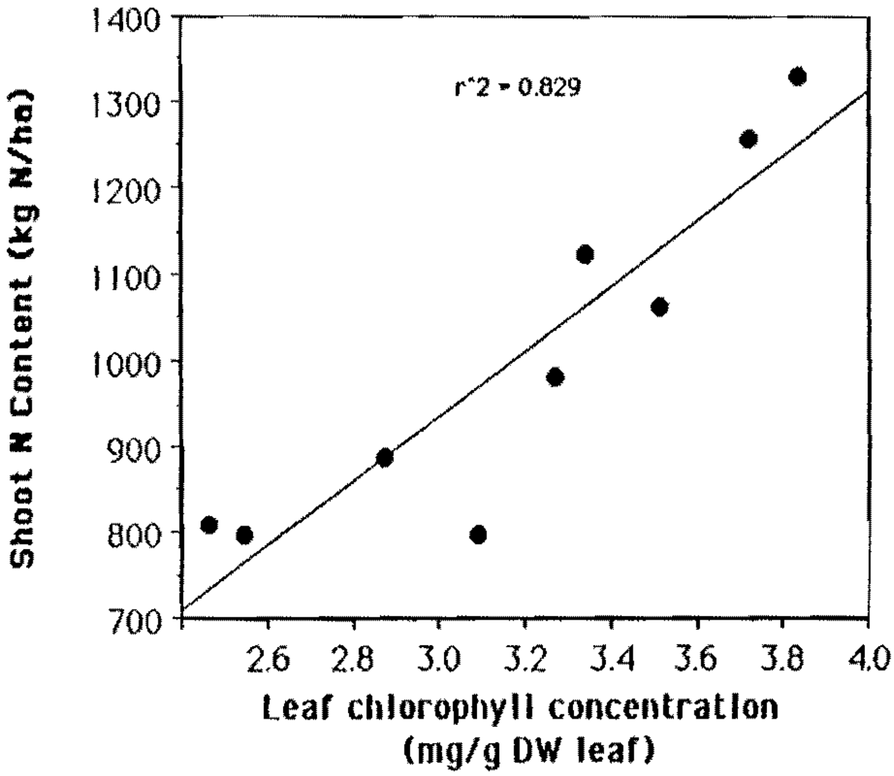


FIG 4: DISTRIBUTION OF N DURATION DURING REPRODUCTIVE GROWTH OF THREE BEAN GENOTYPES

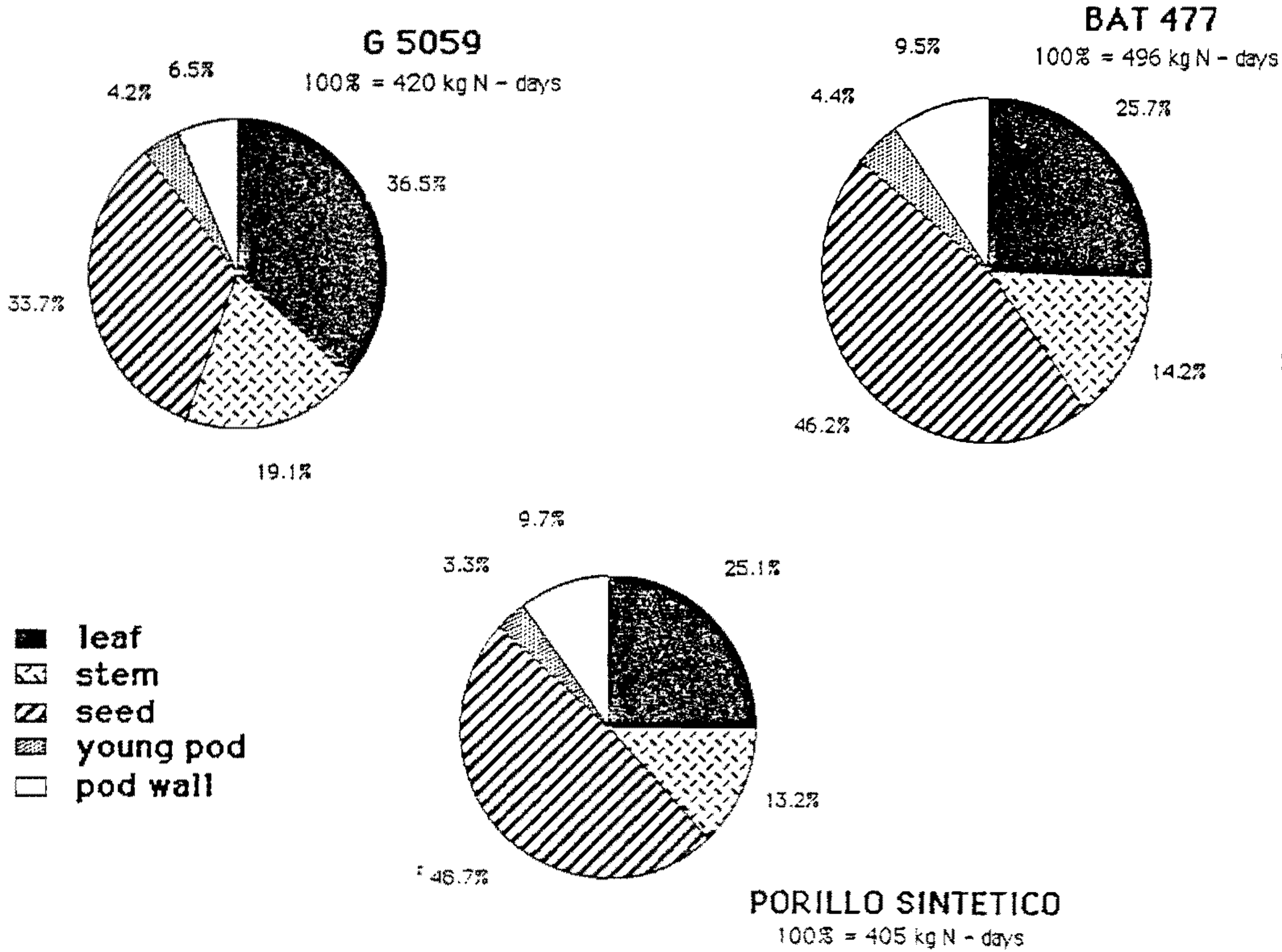


FIG 5: N FLUX IN 3 BEAN GENOTYPES

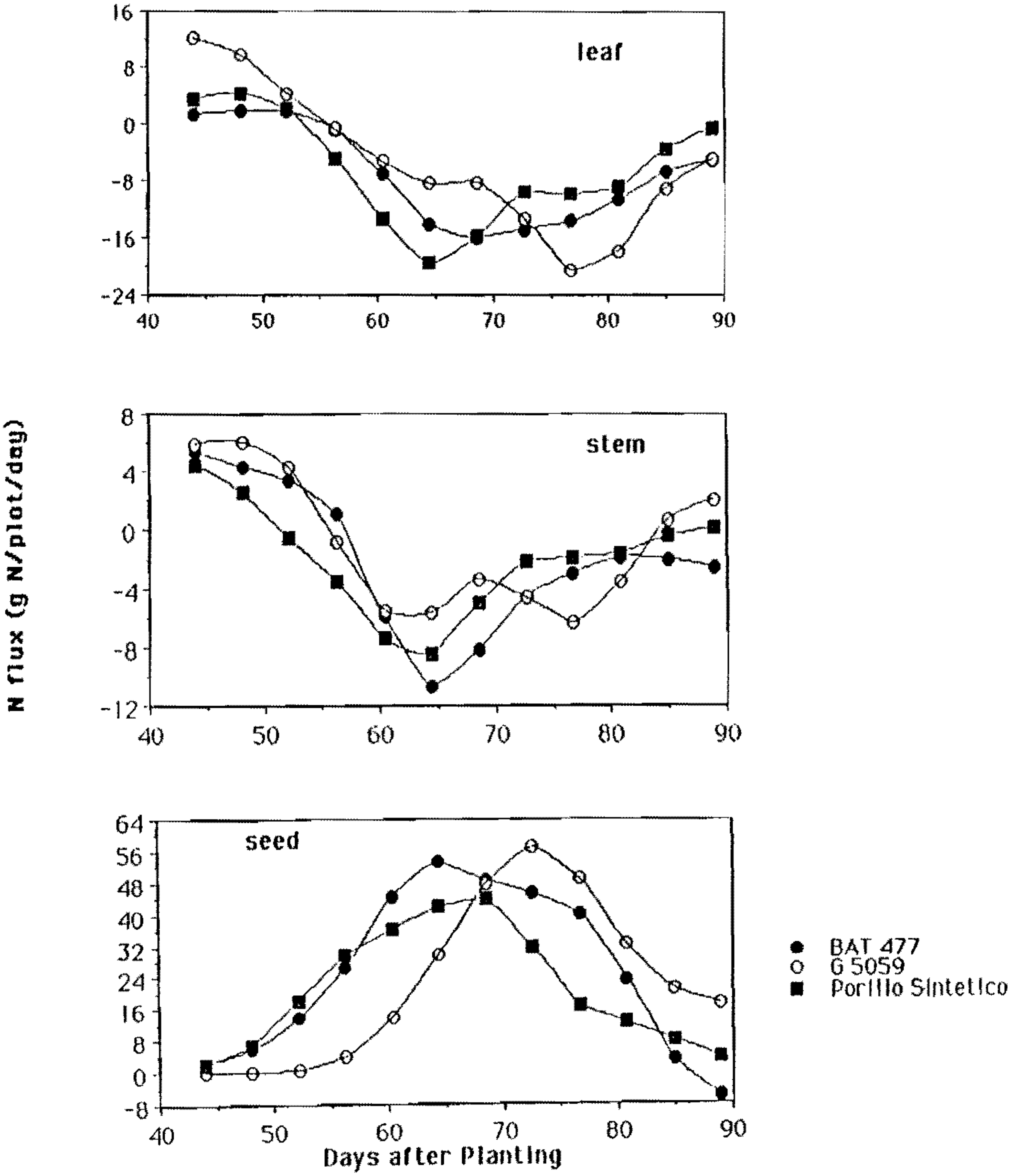


FIG 6: SEED N CONCENTRATION IN 3 BEAN GENOTYPES

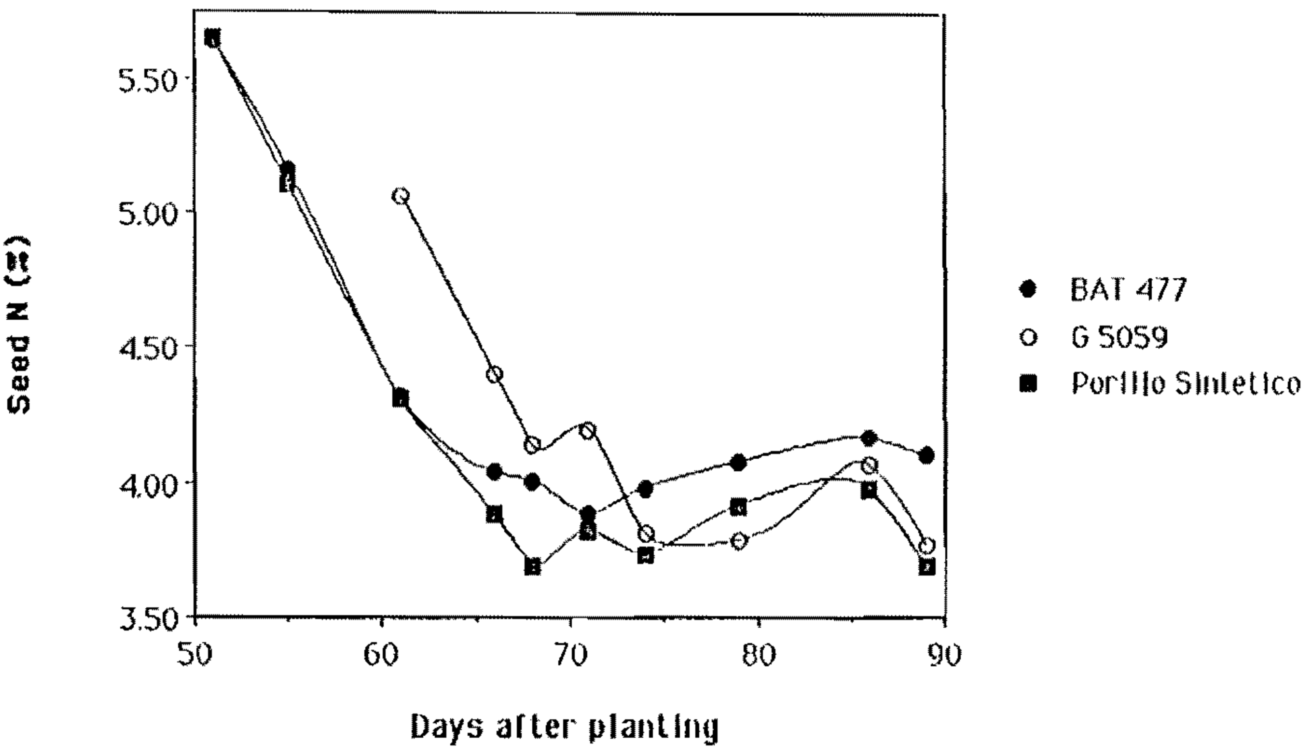
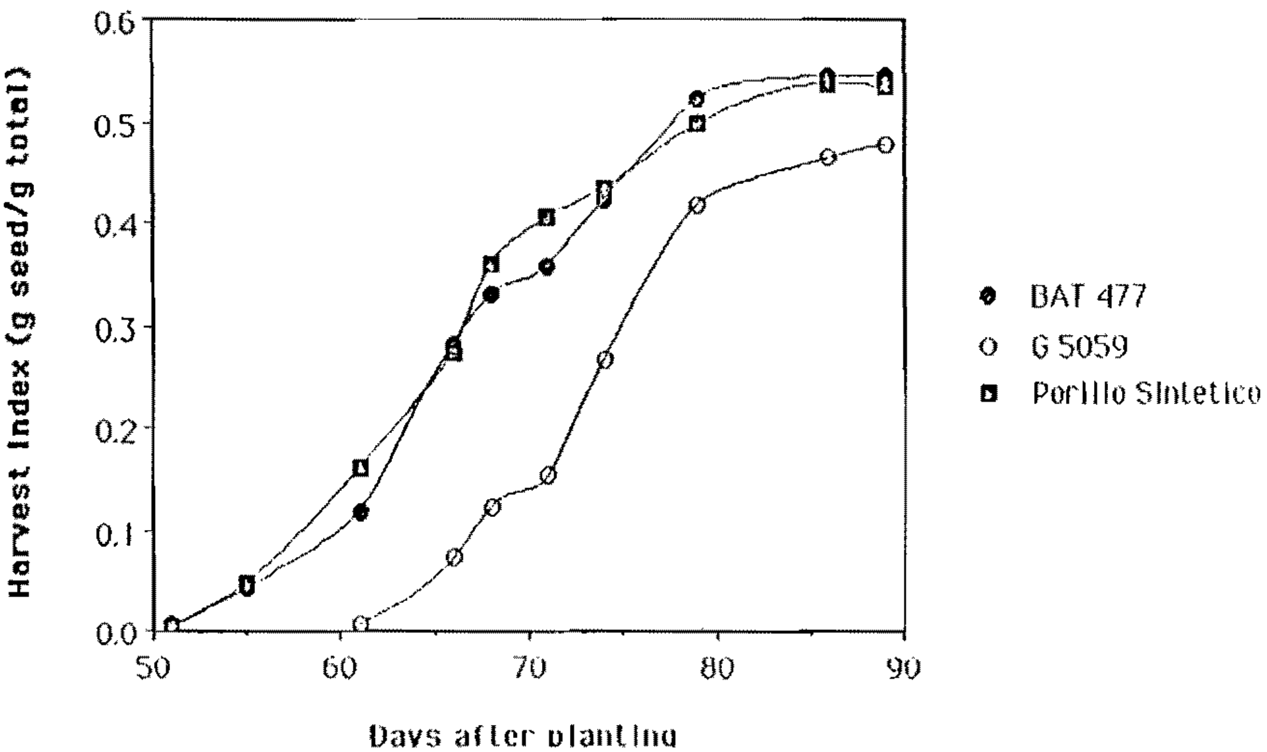


FIG 7: HARVEST INDEX IN 3 BEAN GENOTYPES



YIELD BREEDING

Studies on increasing bean yield through bean breeding were initiated or continued this year through investigations on the following topics:

The value of wild beans;

The variability for yield potential in the cultivated common bean;

The genetics of seed yield in the cultivated beans of the Andes;

The value of early generation testing, and

The effects of population density on selection for seed yield.

Summaries of each study are given below:

Value of Wild Bean Germplasm

Wild common beans are the immediate ancestors of all cultivated forms of Phaseolus vulgaris L. Wild common beans fall within the primary gene pool, i.e. crossing easily with cultivated types producing hybrid progenies which are fertile and normal. There is no indication of any genetic barrier between the cultivars and its wild relatives.

The discovery of bruchids resistance that was absent in cultivated forms but was found at its highest level (immunity) in some wild beans from Memo-American highlands,is the classic example of the "founder effect". Since it is possible that other useful genes might have been left out during domestication of the wild bean, a project was initiated in close collaboration with the University of California at Davis to look for them.

Over 40 different accessions of wild beans identified on the basis of phaseolin seed protein patterns and isozymes variation were selected. These represented a range of geographical distribution of wild bean from northern Mexico to the southern Andes in Argentina. The cultivar 'ICA Pijao' was chosen as a common tester parent because of its high yield, wide adaptation, and lack of dominant alleles; DL_1 and DL_2, that cause hybrid dwarfism in some crosses of cultivated bean from Meso-America and Andean South America. Crosses of ICA Pijao (as a female parent) with each wild bean accession were made during the year. For each of the crosses a minimum of 100 hybrid F_1 seed was produced.

Comparative yield trials for assessing yield potential will be conducted at CIAT-farms at Palmira and Popayan in 1989.

Variability for Yield Potential in Cultivated Beans

Over 44,000 accessions of Phaseolus species have been collected in the CIAT-germplasm bank thus far. Approximately 50% of these are available for evaluation and utilization by bean researchers. While it is absolutely essential that the remainder of the accessions are also processed through plant quarantine, their seed multiplied and made available. Useful genes for agronomic traits and their range of variation must also be identified from available germplasm, for utilization in improvement programs.

Eight seeds of each of 20284 accessions of common bean were supplied by CIAT-GRU. These were grown in hill-plots at CIAT-Palmira after initial grouping on the basis of seed characteristics representing all six races and 12 gene pools of Phaseolus vulgaris. Observations were recorded on growth habit, days to maturity, adaptation, and possible centers of domestication. In general, it was found that small-seeded beans of Meso-America (Race M) were better adapted than all other groups. The climbing beans from Andean America (Race P) were among those which mostly either did not flower or produced nothing. Of the latter origin, determinate type I (Race N) were among the best materials. While systematic and thorough evaluation of these materials will require several years of work, some very interesting early and late maturing bush and climbing bean germplasm, not known earlier, have been identified. All materials producing seed were harvested. Poorly adapted germplasm will be separated for evaluations at CIAT-Popayan in future. Seed of all accessions receiving adaptation scores 1 to 3 (where 1 = excellent and 9 = very poor) will be multiplied for further evaluations and yield assessments.

Genetics of Seed Yield in Common Beans of Andean America

After completing initial genetic studies of seed yield in Meso-American forms (reported in previous years),a similar study was undertaken on Andean American beans. Sixty-four germplasm accessions and improved lines representing a wide variation of growth habit, seed traits, geographical origin, etc., were selected for this purpose. These were divided into four sets of 16 parents. Within a set eight parents were used as female and the other eight as males to produce 64 F_1 crosses per set. All 256 crosses were completed during 1988. Seed from each F_1 hybrid was grown to advance to the F_2. The 256 F_2 populations will be evaluated in replicated yield trials at CIAT farms at Palmira and Popayan in 1989. Genetic variance, heritability, expected response from selection, and general combining ability of each of the parents will be estimated for seed yield.

Value of Early Generation Yield Test

From the genetic studies it was concluded that, among yield and its components, seed yield was the most effective selection criterion in crosses of common bean of Middle-American origins. Limited support for this was provided by the selection experiments conducted in high and low input environments at CIAT-Popayan (CIAT Annu. Rept. 1987). However, more convincing evidence was required.

Dr. R. Lepiz from INIFAP-Mexico joined CIAT in the middle of the year as a CIAT-fellow, and has undertaken to investigate this issue. He chose 33 F_2 hybrid populations from existing crosses, simply on the basis of seed availability. These along with three check cultivars were grown in a 6 x 6 partially balanced lattice design with two replications at CIAT farms at Palmira, Quilichao, and Popayan. While trials at Palmira were protected and subjected to minimum stress, those at Quilichao and Popayan were inoculated with CBB, angular leaf spot and anthracnose, subjecting these populations to our routine breeding activities. Data were recorded on seed yield, 100 seed weight and days to maturity at all three sites, and disease noted at Quilichao and Popayan.

Definitive conclusions must await the results of similar trials in the F_3 and F_4 generations and of the subsequent selection experiments, but from the F_2 data it was evident that:

(1) CIAT farms at Palmira, Quilichao, and Popayan provide contrasting environments,

2) that poor yielding crosses at any one given site were generally poor at all other sites,

(3) a common group of high and stable yielding crosses could be identified on the basis of their performance across sites (Table 1).

Effect of Population Density on Selection for Seed Yield

This experiment was initiated in 1982 at CIAT-Palmira. The F_2 seed of two crosses was divided into three equal parts and randomly assigned to low, intermediate, and high density selection environments. These three densities were represented by 4, 8, and 16 plants/linear meter, respectively, which gave effective populations of 66,400, 132,800, and 265,600 plants ha^{-1}. Single plant selections were made on the basis of visual appreciation of yield in the F_2 plants. In the F_3, plant-to-progeny rows were grown in replicated yield trials. Approximately 20% of high yielding family lines were saved for replicated yield trials again in the F_4 and F_5 generations. Single plant selections were again made in the highest yielding F_5 families. Thus six highest yielding F_8 lines selected from each density environment and each cross were included in a comparative yield trial along with 13 parents utilized in the two crosses. The first semester's data indicate that the mean squares due to origin of lines (i.e. density environments used for selection) was significant, indicating that effectiveness of selection depended upon the plant populations utilized, and that there were significant differences among selected lines and parents used. The trials will be repeated in 1989 for verifying these results.

Response to Visual Selection for Seed Yield in Early Segregating Generation

Visual selection for seed yield was done in the F_2 and F_3 generations of three crosses each of single, three-way, and modified-double types. Fifteen percent of the lines selected from each of the crosses were compared in the F_4 at CIAT-Palmira with bulks of those discarded in the F_2 and the F_3 along with 23 parents used in 9 crosses. A 14 x 14 partially balanced lattice design with three replications was used for evaluations. Each plot consisted of 3 rows 4m long. A net area of 6.3 m^2 was harvested, leaving head borders, for yield measurement. From comparison of the best line with the best parent of each cross it was found that visual selection for seed yield was not effective in any of the 9 crosses. Bean breeders interested in increasing production and productivity must investigate other, alternative strategies.

Breeding for Yield Potential in Large-Seeded Bush Beans

Medium to large seeded bush beans usually are of determinate growth habit (Type 1, CIAT's classification). These materials are characterized by having low numbers of nodes compared to small-seeded types 2 and 3, and the stem and branches end in a developed inflorescence. When the terminal inflorescence is formed the vegetative stage of growth ends and the plant enters the reproductive phase. The flowering period for determinate bush beans (DB) is short compared to the indeterminate bush beans (IB) and the pods generally mature at the same time. Because of this combination of characteristics, DB types are ranked the lowest in yield potential of the four major growth habits, and in terms of realized yield, DB types are more susceptible to yield loss when stresses occur during flowering since they do not have the capacity to recover and produce more vegetative growth and flowers as the IB types.

For these reasons, Bean Breeding III has embarked on a program to increase yield potential of large-seeded bush beans through the genetic manipulation of their growth habit. The objectives are to develop and contrast large seeded types 2 and 3 with traditional type 1 growth habits. However, the occurrence of medium to large IB types is infrequent in the bean germplasm collection housed at CIAT. Of the 22,042 accessions that have been evaluated, the following number of accessions have these characteristics:

Growth habit	Seed size (g/100 seed)	No. of accessions	Percent of total
2	>35	205	0.9
3	>35	1631	7.4
2	>40	157	0.7
3	>40	1141	5.2
1	>35	4343	19.7

Very few accessions having type 2 growth habit and medium-large seed (>35 g/100 seed) are available in the germplasm collection. The reason why this particular phenotype occurs so infrequently in the land races of P. vulgaris is unknown. However, studies are underway to determine 1) the inheritance and combining ability of medium to large-seeded IB, 2) the yield potential of these materials compared to DB, and 3) the stability of their yields over seasons and environments. At present over 60 breeding lines of medium to large IB are being evaluated for their yield potential and stability.

Evaluation of Isolines

The evaluation of isolines to study yield potential of medium-large seeded bush beans was carried out this year.Several medium-seeded IB lines were found segregating for growth habit in the VEF 87 evaluations. Individual plant selections were made within these lines for IB and DB types. Because the grain color and size were similar in both groups, the segregation in the advanced lines for growth habit, appeared to be conditioned by a single gene change. These lines were then considered to be near isogenic lines in that they were genetically similar except for growth habit.

The selections were increased in the field, and 42 isogenic lines corresponding to 4 crosses were planted in a yield trial in Palmira (Table 9).

The isogenic selections pertaining to the IB types in two lines, AFR 274 and AND 635, had yields that were significantly greater than their isogenic DB selections. In the other two materials, AND 632 and AND 636, no significant differences were detected between the IB and DB groups, though with these materials, the DB selections had higher mean yields than the IB types.

Days to maturity were similar in all comparisons except for the two groups of isogenic lines of AFR 274, where the IB had significantly longer maturity than the DB types, though seed size in the IB was also some what larger than in the DB types (Table 9).

These preliminary results indicate that there is potential for increasing yield using IB varieties without increasing days to maturity. However, the results show that the superiority of the IB types is genotype dependent and that IB types are not inherently better yielding than DB types. Breeding strategies are needed that an identify the superior IB segregants in crosses designed for this purpose.

Table 1. Mean seed yield (Kg/Ha) and disease scores for some high and low yielding F_2 populations of common beans in Colombia in 1988 A.

Entry	Popayan		Quilichao		Palmira		Mean
No.	Anthracnose	Yield	Angular leaf spot	Yield	Problem x	Yield	yield
34 (t1)	1	1341	5	2654	1	2036	2010
6	6	1355	6	1890	2	2501	1916
36 (t3)	2	1875	5	1420	1	2343	1879
20	2	1757	4	1711	1	1717	1728
14	1	1582	4	1420	1	2068	1690
17	3	1265	5	1494	2	2188	1649
2	2	1758	2	1520	2	1552	1610
15	5	1125	6	1311	2	2368	1601
12	8	264	6	1243	8	1670	1059
22	3	734	6	902	2	1301	979
29	1	265	2	1207	1	1429	967
23	5	497	8	828	4	1507	944
Mean	3	1066	7	1447	3	1744	1421
C.V. (%)		18.7		15.3		10.7	14.2
LSD (0.05)		474		527		443	344

Table 2. Comparison of near isogenic lines with indeterminate bush (IB) and determinate bush (DB) growth habits in four bean lines.

Bean line	Growth habit	Yield (kg/ha)	Days to maturity	Yield range	Wt. 100 seed	Seed color
AND 635	DB	1419 a[1]	74.2 a	1190-1759	35.7	7M5
	IB	1751 b	74.4 a	1556-2065	36.3	7M5
AFR 274	DB	1543 a	68.5 a	1348-1646	37.6	4M7
	IB	1802 b	72.2 b	1430-2018	39.1	4M7
AND 632	DB	1432 a	73.0 a	1288-1629	34.0	7M5
	IB	1189 a	74.4 a	995-1440	34.3	6M5
AND 636	DB	1424 a	73.5 a	1289-1586	34.2	7M5
	IB	1360 a	74.9 a	1073-1481	34.0	7M5

[1] Data within the same bean line and column with the same letter are not significantly different at P = 0.05 level (Duncan's Multiple Range Test)

NITROGEN FIXATION

Nitrogen deficiency limits production in many bean growing areas and different cropping systems. Research directed toward overcoming this constraint by increasing nitrogen fixation has emphasized improving both the plant genotype and Rhizobium strain components of the symbiosis.

Breeding for Enhanced Fixation

Two very significant facts have emerged from recent studies on the capacity of small seeded genotypes to fix nitrogen symbiotically: 1) The studies with ^{15}N have shown that almost all bean genotypes studied here were capable of fixing a significant proportion of their total nitrogen, from 30 to 50%, under Palmira and Santander conditions. 2) The best genotypes achieved good fixation levels through different mechanisms such as early nodulation, large maximum nodule mass, high specific nodule activity and efficient use of carbohydrate for fixation.

The search for bean germplasm excellent in one or more nitrogen fixation associated characters was the focus of much of this year's work. Variability in early nodulation has been reported previously and was central to the inbred backcross program for increasing fixation in Mutiki 2 and Rubona 5. The donor parents in this work were RIZ 23 and RIZ 29 and increased early nodulation was obtained; however very little germplasm had been evaluated for this character at the time those parents were chosen. A screening method, using trays of perlite in the greenhouse, was developed. Five trials were conducted. Among the approximately 100 small-seeded genotypes tested, several (DOR 164 and Chingo) have shown consistently better early nodulation than the best previously identified genotypes. Central American red-seeded land races nodulated especially well, although black-seeded commercial varieties tended to be poorer (Table 1).

A subgroup of these small-seeded Central American materials (approximately 40) was evaluated in Restrepo for late nodule senescence and two excellent genotypes were identified--- RAB 58 and Cuaranteño Managua. These were not later maturing than the majority of the materials evaluated.

Among the AFBYAN materials evaluated this year for the first time, G-12470 and AND-289 are very good nodulators (Table 2). Nodulation by T-3 again showed striking insensitivity to mineral nitrogen (repeat of 1987 results). Ikinimba and G13671 may also offer some potential for this character. G 12470 and G 2816 were the best of the materials in Table 2 for late nodule senescence.

We are continuing with our strategy, described in last year's report, of recombining these different components of BNF. In addition to crosses exclusively for BNF characters, we are putting some emphasis on combining BNF with stress tolerances (to drought and low P), in the expectation that these will be important in sustaining BNF under field conditions in many cases.

In Bean Breeding I an even broader strategy for BNF has been adopted. No nitrogen is being applied to breeding plots; both progeny tests and multi-locational F_3 population evaluations are being inoculated with a mixture of competitive, effective Rhizobium isolates. One semester's experience in both Restrepo and Santander de Quilichao suggested that this treatment resulted in acceptable vegetative development and therefore, reasonable conditions for selection. In these cases, selection is not practiced specifically for BNF characters, but rather for vigor and/or yield per se.

Rhizobium Strain Collection and Testing

Work on the bacterial component of the symbiosis is focused in three main areas: maintenance and characterization of the strain collection; screening for effective and competitive strains; and ecological studies on nodulation by inoculated Rhizobium.

Using the characterization system developed last year a set of 100 strains was described according to colony morphology and some physiological characters. In the group of 100 studied last year, none of the strains were able to grow at $10^{o}C$, however in this second group, 10 strains from Antioquia, Colombia demonstrated this ability. Ten good acid tolerant strains were also identified, CIAT 872-877, 611 and 895 - 897. All produce large amounts of gum, but one group is elastic and the other buttery in texture. Several strains that produce an alkaline reaction on the traditional yeast manitol medium and are able to nodulate Phaseolus vulgaris effectively, were described. Visiting researchers from El Salvador and Mexico characterized 10 strains from their respective countries. Of particular interest were the strains isolated from wild P. vulgaris collections made in 1985 in Nuevo Leon, Mexico. Eight of the ten strains nodulated BAT 76 effectively but showed unusual growth characteristics in culture media. They were all very sensitive to the pH indicator bromothymol blue.

The non-infective strains have yet to be tested on the original wild accessions to confirm that they are indeed Rhizobia.

P. vulgaris is a very promiscuous legume in that it nodulates with a diverse range of Rhizobium strains. It has been known for a number of years that CIAT 899, isolated in Colombia from P. vulgaris, is able to nodulate effectively with Leucaena sp. We tested 29 Leucaena strains and a number of Bradyrhizobium strains for nodulation and fixation in P. vulgaris variety Frijolica 03.2 and Leucaena leucocephala. The different patterns of response are shown in Table 3. Some "Leucaena" strains nodulate beans effectively, others nodulate ineffectively and others do not nodulate at all. This is obviously of some practical importance in bean- Leucaena alley cropping systems, especially if the legumes are being inoculated. A number of Bradyrhizobium strains from forage legumes induced ineffective nodules or root hypertrophies.

Three strain screening trials were conducted in soils from CIAT-Palmira and CIAT-Quilichao. Strains that have induced consistent plant growth responses in these soils are CIAT 652, 113, 274, 112 and 2. In one of the strain screening trials severe symptoms of "black tide" as described by workers in Chili, were observed. A new source of river sand, mixed with the soil to facilitate drainage, was very high in Fe (230 ppm) and under low N conditions the plants were severely affected. N-fertilized plants however were normal, a result consistent with observations in Chile where nitrogen fertilization has been shown to prevent the "black tide". Plants did not respond to calcium in our trial.

Several studies were conducted this year using ELISA, to measure nodulation by inoculant strains in soil environments. In one trial RIZ 29 was inoculated with strain CIAT 632 and nodulation was evaluated at three growth stages. Two soils were compared, CIAT-Palmira and limed Quilichao Soil (pH 6.1). In both soils the percent of nodules formed by the inoculant strain decreased over time from around 50% at 20 days after planting to between 10 and 20% by the 50 day harvest. This suggests that the principle problem with CIAT 632 is poor survival in the soil, so few nodules are formed by 632 after 20 days. This trial will be repeated next year and more strains will be tested.

Although the serological typing of nodules is working well with some strains, problems of cross reaction with native Rhizobium strains makes studies with some inoculants difficult (for example strain 652). Different culture media and rabbit immunization schemes are being tested to see if more specific antisera can be obtained without resorting to monoclonal antibodies.

Table 1. Early nodulation of a number of genotypes used actively in Bean Breeding I. (Differences significant at P 0.05, DMRT).

Identification	Principal character	Color	Number of nodules
DOR 164	Earliness	6	109
Chingo	Earliness	6	104
BAT 271	Tolerance, low P	8	97
DOR 60	BGMV	8	94
Orgulloso	Earliness	6	91
BAT 477	Drought	2	90*
Roxinho	Commercial variety	7	88
San Cristobal 83	Drought	6M	84
Centa Izalco	Commercial variety	6	84
RAO 27	Web blight	6	81
DOR 364	BGMV	6	78
G-2	Commercial variety	5	76
ICA Pijao	Commercial variety	8	75
FT 83-120	Commercial variety	8	73
Carioca	Commercial variety	2R	72
Rio Negro	Commercial variety	8	64
Porrillo Sintético	BGMV	8	60
ICACOL 10103	Commercial variety	8	58
DOR 41	Commercial variety	8	58
RAB 404	Tolerance, low P	6	57
XAN 90	Common blight	6	35

* Material of known good nodulation

Table 2. Total nodule duration (area under the curve of red nodule number vs. time), and growth habit of 29 genotypes with importance for Africa. (Differences significant at P 0.05, DMRT) (Popayan 1988A).

Genotype	Growth habit	Nodulation
G-12470, Peru 14-2	I	2710
TOSTADO	I	2328
AND-289	I	1535
CAROLINA	III	1535
KILIYUMUKWE	III	1371
A-197	I	1343
ZPV-292	II	1276
CALIMA	I	1268
IKINIMBA	III	1250
NAIN DE KIONDO	III	1247
DORE DE KIRUNDO	II	1159
T-3	III	1117
G-1821	III	1114
RUBONA 5	I	1094
LUSAKA BEAN	III	1059
PVA-880	I	1052
G-2816	III	1040
MUHINGA	II	1035
NATAL SUGAR	II	1016
PVA-1272	I	998
KABANIMA	I	982
PVA-563	I	948
XAN-76	II	912
G-13671	III	869
A-262	II	839
T-23	I	838
A-410	II	836
CARIOCA	II	635
URUBONOBONO	III	541

Table 3. Nodulation of *P. vulgaris* and *Leucaena leucocephala* by Rhizobium strains from different host legumes.

CIAT #	Host Plant Origin	NODULATION *P. vulgaris* Infective	*P. vulgaris* Effective	*L. leucocephala* Infective	*L. leucocephala* Effective
899	P. vulgaris	+	+	+	+
166	P. vulgaris	+	+	+	+
652	P. vulgaris	+	+	-	-
632	P. vulgaris	+	+	-	-
1967	L. diversifoli	+	+	+	+
1922	L. leucocephala	+	+	+	+
42	L. leucocephala	+	-	+	+
4478	L. leucocephala	+	-	+	+
3101	Centrosema sp.	+	-	-	-
420	Macrotilium sp	+	-	-	-
71	Stylosanthes sp.	-	-	-	-

TOLERANCE TO ACID SOILS

Little progress can be reported this year in tolerance to acid soils at headquarters, due to the loss of all yield trials in Santander de Quilichao to drought. However, the International Phosphorous Trial, formation of which was reported last year, was harvested in two separate plantings in Restrepo and one in Palmira. It was also planted under high and low phosphorous conditions in CNPAF, Goiania, Brazil. No meaningful results can be reported until data are available for comparison over sites.

Evaluation of low phosphorous tolerance was initiated in Popayan in the second semester after an initial study was planted to determine what level of P fertilization induce an acceptable level of stress.

In the second semester, yield studies were initiated in Santander de Quilichao on the effect of ammonium polyphosphate (APP) as a foliar applied source of phosphorus. Similar studies were planted in CNPAF, Goania, Brazil. APP has the advantage of being a particularly concentrated form of phosphorus with a low ionic charge, thus making it possible to apply appreciable quantities of P to the plant without foliar burning. APP also costs a fraction of traditional P fertilizers.

DROUGHT TOLERANCE

Studies on drought adaptation have continued following three lines of research: routine screening, studies of adaptation mechanisms, and studies of the inheritance of adaptation.

Drought Screening

Evaluations of three tepary bean (P. acutifolius) accessions had indicated that this species exhibits outstanding drought adaptation both at Palmira and Quilichao. Early maturing materials had also shown particular promise, so the stage I and II nurseries were organized using a large proportion of tepary beans and lines from projects for early maturity.

Under mild drought stress at Palmira and Quilichao, 91 tepary beans in stage I nurseries gave average yields approximately double those from a similar number of common bean materials (Fig. 1). Previous studies had suggested that maturity and seed size differences (typically 120 mg per seed vs 200 to 250 mg for small seeded common bean) might explain part of the spectacular superiority of the teparies, so effects of these parameters were tested with simple regression analyses. The results indicated that there was no effect due to differences in maturity or seed weight (Table 1).

Based on these results, P. acutifolius by P. vulgaris crosses have been programmed with the Biotechnology Unit. In addition, lines from existing interspecific hybrids are being multiplied for drought testing in 1989.

Studies Of Mechanisms

Besides analyses of screening nurseries for evidence of drought escape through early maturity, the main line of research on drought adaptation mechanisms concerned drought avoidance through greater root growth or efficiency of water uptake.

To determine whether simple visual evaluations of root morphology in the field would relate to drought performance, thus permitting rapid selection of promising genotypes, 100 genotypes were evaluated for length of the hypocotyl, persistence of the primary root, and overall fibrosity and abundance of secondary roots. None of these parameters showed any relation with yield. The four P. acutifolius accessions tested did not differ from the P.

vulgaris lines. However, three of them did show greater biomass at 56 days (with mean maturity occurring at 68 days).

In a final test of the relative importance of root and shoot genotype in determining drought adaptation, four genotypes were examined in a grafting study at Quilichao. As in previous studies, there was a large effect of root genotype but no effect of shoot genotype (Tables 2 and 3). Effects of grafting and a graft by genotype interaction were detected, so these results were less conclusive than those from the four previous studies. The graft effect was thought due to a combination of poorer quality of grafted plants for transplanting and of transplant shock associated with root rots. In subsequent trials, greater care is being taken to avoid these problems.

Since visual evaluation of root morphology showed no promise, more detailed studies are being undertaken on the basis of differences in root growth and function. An important first question was to determine how early in the growth cycle differences in root growth may be detected using the laborious but reliable method of extracting soil cores and washing out the root samples. Figure 2 compares root growth of BAT 477 (drought adapted) and BAT 1224 (drought sensitive) at 33, 45, and 60 days after planting. BAT 477 had greater growth at all stages, but the most spectacular differences occurred at 60 days. In terms of screening, the greater growth of BAT 477 at 45 days in the upper soil layers also merits further attention to determine whether it represents a consistent trend.

Inheritance Of Drought Adaptation

In the absence of screening parameters besides yield, there is a need to understand the inheritance of yield under drought stress. Of particular interest is to know whether genotypes selected in one region contain desirable characteristics not found in drought adapted materials from other regions. This question is of special importance when considering crosses between regions as contrasting as Colombia and the highlands of Mexico since materials selected in one of the regions are generally poorly adapted in the other.

Preliminary results of a collaborative inheritance study between researchers at INIFAP and CIAT indicate that crosses between Mexican and CIAT materials produce populations superior to crosses among parents from a single region. In evaluations of a diallel of 36 F_2 populations derived from crosses and grown under stress at two sites in Mexico (parallel trials in Colombia including an irrigated check are also being conducted), crosses of materials of contrasting origin produced the largest proportion of high-yielding populations (Table 4).

Table 1. Analysis of variance for multiple regression testing for effects of days to maturity and seed weight on yield from stage I screening at Palmira and Quilichao, including 91 entries of *P. acutifolius*.

Source of variation	DF	Mean square of indep. variable	
		Days to maturity	Seed weight
Location	1	33410000**	33410000**
Species	1	96690000**	96690000**
Location x species	1	454600*	454600*
Independent variable	1	41660	89520
Species by I. var.	1	260000	13780
Location by I. var.	1	11540	242900
Location by species by I. var.	1	154400	24080
Error	383	90802	90490

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

Table 2. Seed yields of grafted and normal plants under drought stress using four genotypes at Quilichao, 1988A.

Root genotype	Plant type	Seed yield per shoot genotype			
		BAT 1224	BAT 477	Carioca	VABRA 332
		$kg\ ha^{-1}$			
BAT 1224	Grafted	470	890	600	670
BAT 477	Grafted	910	940	880	830
Carioca	Grafted	350	610	530	290
VABRA 332	Grafted	940	1080	1130	1080
BAT 1224	Normal	720			
BAT 477	Normal		1120		
Carioca	Normal			950	
VABRA 332	Normal				1110
$S.E._D$		180			

Table 3. Analysis of variance for yields from grafting experiment described in Table 2.

Source	DF	MS	V
Rep.	3	112881	
Graft	1	377345	5.77*
Genotype	3	456423	6.98**
Graft x genotype	3	202576	3.10*
Grafted materials	3	98361	1.50
Misc.	9	325576	4.98**
Graft	1	568384	8.69**
Root genotype	3	1148571	17.56**
Shoot genotype	3	470001	0.72
Ungrafted genotype	3	142640	2.18
Root x shoot	9	68805	1.05
Residual	53	65391	

*,** Significant at the $p = 0.05$ and $p = 0.01$ levels, respectively.

Table 4. Yields of parents and F_2 populations of diallel evaluated under drought at Aguascalientes and Durango, Mexico by INIFAP.

Identification		Origin of material	Site: Aguascalientes	Site: Durango
			kg ha^{-1}	kg ha^{-1}
BAT 477		CIAT	420	1140
V 8025		CIAT	510*	1150
G 4830		CIAT	290	1090
SAN CRISTOBAL 83		CIAT	370	870
APETITO		Mexico	210	1390
BAYO CRIOLLO		Mexico	360	1530*
BAYO RIOGRANDE		Mexico	150	1330
DURANGO 222		Mexico	460	1450
BAT1224		Sensitive	380	1080
BAT477	V8025	CC[1]	390	1240
BAT477	G4830	CC	490	1200
BAT477	SCRIST83	CC	380	1300
V8025	G4830	CC	510*	1420
V8025	SCRIST83	CC	430	1330
G4830	SCRIST83	CC	500	1240
BAT477	APETITO	CM	610*	1420
BAT477	BAYOCRIL	CM	480	1400
BAT477	BAYORIOG	CM	490	1420
BAT477	DUR222	CM	560*	1520*
V8025	APETITO	CM	520*	1460*
V8025	BAYOCRIL	CM	510*	1330
V8025	BAYORIOG	CM	500	1490*
V8025	DUR222	CM	540*	1510*
G4830	APETITO	CM	480	1290
G4830	BAYOCRIL	CM	480	1620*
G4830	BAYORIOG	CM	500	1470*
G4830	DUR222	CM	590*	1390
SCRIST83	APETITO	CM	440	1270
SCRIST83	BAYOCRIL	CM	520*	1450
SCRIST83	BAYORIOG	CM	360	1360
SCRIST83	DUR222	CM	470	1450
APETITO	BAYOCRIL	MM	330	1260
APETITO	BAYORIOG	MM	110	1340
APETITO	DUR222	MM	400	1380
BAYOCRIL	BAYORIOG	MM	320	1560*
BAYOCRIL	DUR222	MM	430	1430
BAYORIOG	DUR222	MM	380	1430
BAT477	BAT1224	CS	480	1330
V8025	BAT1224	CS	450	1260
G4830	BAT1224	CS	380	1140
SCRIST83	BAT1224	CS	420	1200
APETITO	BAT1224	MS	420	1350
BAYOCRIL	BAT1224	MS	470	1500*
BAYORIOG	BAT1224	MS	390	1450
DUR222	BAT1224	MS	430	1380
Check 1		L. Check	420	1430
Check 2		L. Check	500	1440
Check 3		L. Check	440	1250
Check 4		L. Check	320	1360
MEAN			430	1350
S.E.$_D$			67	131

[1] CC, CM, MM, CS, and MS are crosses of CIAT by CIAT, CIAT by Mexico, Mexico by Mexico, CIAT by drought sensitive, and Mexico by drought sensitive.

* Yields greater than 500 and 1450 kg ha^{-1} respectively for Aguascalientes and Durango.

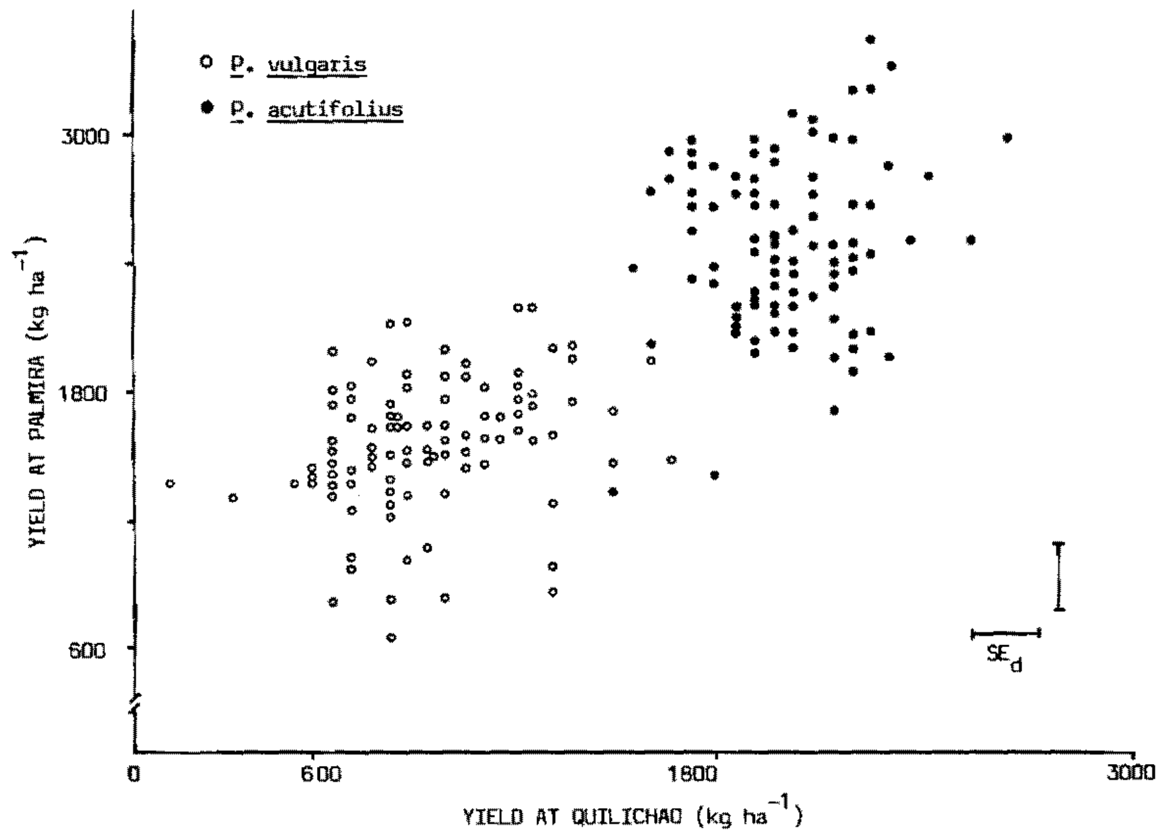
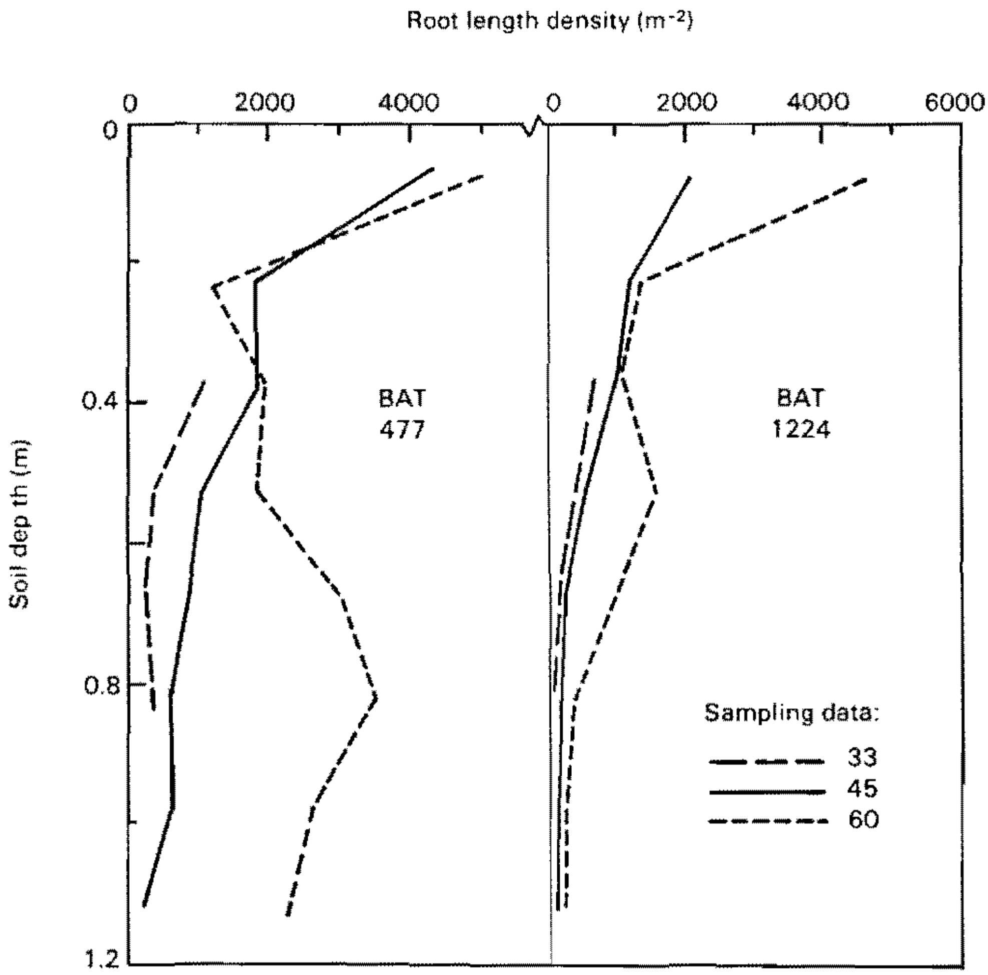


Figure 1. Yields of <u>Phaseolus</u> <u>vulgaris</u> and <u>Phaseolus</u> <u>acutifolius</u> lines under mild drought stress at Palmira and Quilichao.

Figure 2. Comparison of root growth of BAT 477 and BAT 1224 under drought stress at CIAT Palmira at three sampling dates.



CULTIVAR DEVELOPMENT

Blacks

Another set of black-seeded genotypes was selected in 1988 for distribution as an Adaptation Nursery in 1989. Selection in the first semester of 1988 was performed in Santander de Quilichao under drought and fertility stress. Rhizobium was applied but no additional nitrogen or phosphorous was utilized. Plots used had been fertilized several years ago with rock phosphate. It was very interesting to note that under these conditions the superior genotypes were from parents with both drought and low P tolerance in their pedigrees.

In early generations, some 450 F_2 black-seeded populations were prescreened in CIAT and 140 of these were mass-selected for further study in F_3 multilocational yield tests. Different populations combined parents for: resistance to anthracnose and CBB; tolerance to low P; earliness; and drought.

Small Reds/Pinks/Light Purples

In preparation for the distribution of yet another Adaptation Nursery in 1989, a progeny test of red-seeded genotypes was planted in Restrepo with Rhizobium inoculation and native soil phosphorous (no additional N or P was utilized). Wide variability in response to moderately-low fertility conditions was observed. Although commercial red-seeded types with I-gene BCMV resistance have been available for several years, this group of selected lines represents wider genetic variability in commercial types than previously available. Under these conditions in Restrepo, several early genotypes were outyielding the early check, Desarrural.

In the purple and pink classes, commercial grain type with BCMV resistance was obtained only last year. This year we have initiated an extensive crossing program between these and sources of resistance to CBB, BGMV, and anthracnose.

Yellows

It was explained in last year's report that the areas of greatest demand for these grain types- coastal Mexico and coastal Peru - are served by national programs active in breeding. Therefore this class has relatively lower priority than other grain classes. However, in other areas there is a small but often lucrative market for these classes, and genotypes with broader adaptation and disease resistances could be very useful. In 1988 a group of agronomically superior genotypes of this class was selected in CIAT, all with I-gene BCMV resistance. These will be organized in an Adaptation Nursery for 1989, and have already been programmed for another cycle of crosses to introduce other disease resistances.

Small Seeded Cream and Cream Striped

The second breeding cycle of these commercial bean types was completed this year with approximately 79 lines being developed. Each of these lines showed resistance to BCMV and anthracnose in fields at Popayan. In addition, most of these possessed intermediate level of tolerance to common bacterial blight and to angular leaf spot at CIAT-Quilichao. These beans were made available for testing and utilization to other bean researchers within and outside of CIAT. The third breeding cycle will be initiated in 1989.

Early Maturity

About three years ago the project on breeding and genetics of earliness in common beans of Middle-American origin was undertaken. Nineteen early maturing accessions (landraces) from Central America, the highlands of Mexico, and Brazil were crossed to a common late maturing tester parent--A 301. From the preliminary analysis of data on parents, F_1, F_2, and backcrosses it was found that earliness was partially to completely dominant and its inheritance was controlled by one or two major genes.

From some of the same and additional crosses 16 early maturing ($\leq$ 70 days to maturity at CIAT-Palmira and Quilichao) lines resistant to BCMV and of cream (mulatinho), cream striped, pinto and large red grain type were developed. These were the first group of bred lines (coded as PEF lines) from this project. Evaluation and selection from remaining crosses made in the first breeding cycle is continuing.

NUTRITIONAL QUALITY

The nutritional quality laboratory routinely monitors materials produced in the EP and carries out nutritional research in specific areas as well. Evaluations of EP materials were carried out using the routine acceptability parameters of cooking time, water absorption and crude protein content. Table 1 compares this year's data with data from the last 6 years. In addition, research was conducted on the following specific topics this year:

Interference by cotyledon components of beanmeal flour with the extraction of condensed tannins:

When tannins were extracted from wholemeal bean seed flour an effect, resulting from the interactions of the dissolved tannins with the cotyledon components (protein, carbohydrates, and minerals) was found.

Searching for a simple methodology to measure the capacity of condensed tannins to bind proteins and starches:

Radial diffusion in agarose media containing different concentrations of each one of the nutrients considered, makes it possible to measure the binding capacity of the condensed tannins. This measure is a simple method for predicting the biological effect of the tannins in foods as well as their nutritional effects.

The relationship of water absorption capacity to common bean mosaic virus resistance:

The "isogenic" materials resistant and susceptible to the BCMV were evaluated for water absorption. The resistant materials were found to absorb significantly less water than the susceptible materials.

Accelerated storage to predict the hard-to-cook phenomena that develops in beans under normal storage conditions:

Accelerated storage conditions at 45^o and 80%RH for three weeks reproduced the hard-to-cook phenomenon seen in beans stored under normal conditions for much longer periods. Each week of accelerated storage equalled six to eight weeks of normal storage, in terms of increased cooking time needed for stored beans.

Seed characteristics that control some textural measurements:

Knowledge of the optimum time for cutting raw seed is a valuable tool in textural measurement assessments. Seed weight, seed shape and thickness of seedcoat were found to be the most important variables in this study.

Table 1. Group analysis of beans conducted in the nutritional laboratory 1982-1987.

Group # 10 - Small-seeded black bush bean

Year	82	84	85	86	87
Variables:					
NTC	31.0	9.0	32.0	35.0	60.0
MTC (min.)	21.8	23.8	26.0	22.7	19.1
SDTC	3.1	3.3	1.2	2.0	2.9
NABS	31.0	9.0	32.0	35.0	60.0
MABS (%)	102.8	96.2	99.0	103.7	102.7
SDABS	9.4	4.8	2.0	2.3	4.4
NPC	31.0	9.0	32.0	35.0	60.0
MPC (%)	23.0	22.8	21.6	24.0	23.0
SDPC	1.1	1.6	1.1	1.1	1.8

Group # 20 - Small-seeded red bush bean

Year	82	83	85	86	87
Variables:					
NTC	34.0	45.0	45.0	33.0	108.0
MTC (min.)	17.4	25.1	25.8	21.8	16.5
SDTC	2.7	4.2	5.9	3.8	2.1
NABS	34.0		46.0	33.0	108.0
MABS (%)	95.4		92.7	98.5	99.9
SDABS	12.0		18.5	7.3	12.5
NPC	34.0	60.0	46.0	33.0	108.0
MPC (%)	23.2	23.6	27.8	25.7	25.7
SDPC	1.5	1.7	1.9	1.4	1.6

Group # 25 - Large-seeded red bush bean

Year	82	84	85	86	87
Variables:					
NTC	53.0	135.0	73.0	136.0	199.0
MTC (min.)	21.8	27.2	27.1	25.7	19.9
SDTC	4.2	6.1	5.3	4.4	2.8
NABS	53.0	146.0	76.0	136.0	199.0
MABS (%)	96.5	92.6	102.3	108.5	107.4SDABS
16.1	22.2	16.3	8.5	5.6	
NPC	53.0	146.0	76.0	136.0	199.9
MPC (%)	21.3	23.4	27.1	23.6	23.9
SDPC	1.7	2.3	1.9	1.4	1.8

Group # 30 - Small-seeded white bush bean

Year	82	84	85	86	87
Variables:					
NTC	11.0	32.0	37.0	44.0	46.0
MTC (min.)	19.6	23.9	29.4	22.5	19.1
SDTC	2.6	4.1	4.5	2.4	2.0
NABS	11.0	32.0	37.0	44.0	46.0
MABS (%)	90.2	94.0	99.2	100.2	
SDABS	8.5	5.7	3.4	5.4	5.9
NPC	11.0	32.0	37.0	44.0	46.0
MPC (%)	24.2	25.8	28.7	25.1	25.6
SDPAC	1.0	2.0	2.0	1.4	2.0

Group # 35 - Medium-seeded white bush bean

Year	82	84	85	86	87
Variables:					
NTC	13.0	10.0	7.0		
MTC (min.)	23.8	22.1	35.3		
SDTC	4.7	4.1	14.6		
NABS	13.0	10.0	7.0		
MABS (%)	101.1	97.2	105.7		
SDABS	7.7	13.0	7.8		
NPC	13.0	12.0	7.0		
MPC (%)	23.3	24.1	27.0		
SDPC	1.9	2.1			

Group # 40 - Coastal and Pacific bush beans

Year	82	84	85	86	87
Variables:					
NTC	23.0	20.0	28.0	21.0	8.0
MTC (min.)	19.7	24.8	28.8	22.7	21.6
SDTC	4.6	7.9	3.7	3.6	2.0
NABS	23.0	20.0	28.0	21.0	8.0
MABS (%)	101.1	99.4	101.3	106.0	104.7
SDABS	8.4	4.2	4.8	5.3	7.8
NPC	23.0	25.0	28.0	21.0	8.0
MPC (%)	23.7	25.8	23.3	24.2	23.1
SDPAC	2.1	1.8	2.0	1.4	2.4

Group #45 - Bush beans from the Mexican Plateau

Year	82	84	85	86	87
Variables:					
NTC	18.0	13.0	4.0	138.0	
MTC (min.)	21.2	25.2	29.3	19.5	
SDTC	5.2	5.0	2.5	2.3	
NABS	18.0	13.0	4.0	138.0	
MABS	101.8	96.3	96.5	104.2	
SDABS	9.9	8.6	3.8	14.8	
NPC	18.0	13.0	4.0	138.0	
MPC	23.9	25.6	23.6	24.5	
SDPC	2.2	2.5	1.6	1.8	

Group # 50 - Brazilian bush bean

Year	82	84	85	86
Variables:				
NTC	56.0	16.0	24.0	14.0
MTC (min.)	20.7	27.5	26.1	24.4
SDTC	2.9	6.8	3.9	3.0
NABS	56.0	16.0	24.0	14.0
MABS	98.8	86.5	98.9	102.1
SDABS	8.0	7.2	6.6	11.9
NPC	56.0	16.0	24.0	14.0
MPC	22.5	25.5	23.5	26.0
SDPC	1.7	2.5	1.4	1.8

Group # 60 - Black climbing beans--high temperature

Year	82	84	85	86
Variables:				
NTC	2.0	5.0		
MTC (min)	27.0	23.4		
SDIC	4.2	2.9		
MABS	2.0	5.0		
MABS	101.3	90.7		
SDABS	5.7	5.0		
NPC	d2.0	5.0		
MPC	24.6	23.9		
SDPC	1.4	1.9		

Group # 65 - Black climbing beans--low temperature

Year	82	84	85	86
Variables:				
NTC	7.0			3.0
MTC (min.)	18.6			30.3
SDIC	2.9			1.2
NABS	7.0			3.0
MABS	101.1			96.6
SDABS	3.0			4.3
NPC	7.0			3.0
MPC	26.4			24.0
SDPC	1.6			0.2

Group # 70 - Red climbing bean--high temperature

Year	82	84	85	86
Variables:				
NIC	16.0	24.0	27.0	62.0
MTC (min.)	27.9	26.5	28.7	23.7
SDTC	4.2	4.6	5.0	4.1
NABS	16.0		24.0	27.0
MABS	100.6	83.6	96.2	102.2
SDABS	6.1	7.9	10.1	6.4
NPC	16.0	24.0	27.0	62.0
MPC	23.7	21.7	24.4	26.1
SDPC	2.1	1.5	1.8	1.4

Group # 75 - Red climbing beans--medium-low temperature

87	Year	82	84	85	86	87
220.0	Variables:					
19.4	NTC	22.0				
2.6	MTC (min.)	20.9				
22.0	SDTC	2.4				
101.3	NABS	22.0				
8.3	MABS	101.7				
220.0	SDABS	9.6				
25.3	NPC	22.0				
1.8	MPC	26.9				
	SDPC	2.8				

Group # 80 - High temperature climbing beans (other colors)

87	Year	82	84	85	86	87
	Variables:					
	NTC	8.0	32.0			
	MTC (min.)	27.0	26.3			
	SDTC	3.5	7.9			
	NABS	8.0	32.0			
	MABS	97.7	87.1			
	SDABS	5.8	25.2			
	NPC	8.0	33.0			
	MPC	23.5	22.6			
	SDPC	2.0	1.6			

Group # 85 - Low temperature climbing beans (other colors)

87	Year	82	84	85	86	87
	Variables:					
	NTC	7.0	15.0	20.0	48.0	
	MTC (min.)	19.6	23.7	31.5	25.3	
	SDTC	2.8	7.9	5.5	4.4	
	NABS	7.0	15.0	21.0	50.0	
	MABS	101.5	92.7	88.8	92.0	
	SDABS	8.0	5.1	20.2	22.5	
	NPC	7.0	15.0	21.0	50.0	
	MPC	26.6	25.2	24.1	25.6	
	SDPC	2.4	2.7	1.2	2.1	

N = sample number, M = mean value, SD= standard deviation,
87 TC = cooking time, ABS = water absorption, PC= andeprotein

62.0

P. LUNATUS L.

As part of the collaboration between CIAT and the faculty of Gembloux (Belgium) a research project was begun in May 1986 on the *P. lunatus* (Lima bean) collection held by CIAT.

Seed Increase

The first priority was to increase the entire collection of 2833 samples. Multiplication was started in two meshhouses in Palmira with previously unmultiplied accessions as well as with some increased accessions which had only produced a few seeds. The number of accessions planted specifically for multiplication of seed during these two years represents 21% of the entire CIAT collection (see Table 1).

Accessions increased at the Popayan site in the last two years included those which did not bloom abundantly at Palmira or which presented seed germination in the pods (Peruvian materials). These were mostly accessions from Peru (Cajamarca), from Colombia (Nariño) and some wild types from Costa Rica. In addition, some Peruvian accessions presenting seed germination in the pods even before maturity, were sowed at Popayan to study the effect lower temperature has on stopping seed germination in pods.

A few wrinkled white seeds were recently harvested from a wild Mexican Lima bean (G25713). Once fixed, this trait will be crucial to the study of intra- and interspecific hybrids. Seeds have been planted for further population studies and for preservation of this special characteristic.

Morphoagronomic Evaluations

Two trials were sown in the heterogeneous soils of Dagua in July 1987 and March 1988. Ninety-nine climbing accessions of different origin and altitude preference, were planted in a completely randomized design with 16 replicates of one control, for evaluation of the influence of this heterogeneous soil.

Five accessions (G25217, G25521, G25579, G25753 and G03393) having intermediate growth habit (a habit between bush and climbing types) were sown. This intermediate type is potentially very valuable, as climbing types need expensive or unavailable staking materials for supports, and bush types are not optimally adapted to tropical conditions. A Bolivian accession of intermediate growth habit (G25579-Bermejo) showed great promise by taking only 47 days to flower, and producing two tons/ha yield.

A great variability among the varieties planted was evident--the range of days to flower was from 47-123 days, and yield ranged from 0.02 tons/ha to 6.21 tons/ha.

Large variability was observed between accessions and within accessions for number of nodes/raceme(1 to 29), raceme length (0.5 to 35cm) and number of pods/raceme (0 to 14).An average finding of two pods/raceme generally located in the first nodes, was observed. However, racemes loaded with more than 10 pods were also seen. It was also noted that some accessions produced more than two flowers/node in a raceme and in a second flowering these nodes initiated other buds.

A repetition of the trials described above was sown at Palmira in October 1987 and November 1988. The statistical analyses for the first trial are not yet available but some observations on pests and diseases can be made. Pests and diseases at the Dagua site (red spider mites, leafworms, leafminers or pod borers, and Macrophomina were not a serious problem, but they were very serious at the Palmira location. An intense attack of leafhoppers facilitated a screening of the accessions, and the following showed degrees of tolerance (G25102, G25319, G25411, G25418 and G25826). Symptoms of BCMV were also observed, and the following eight accessions (G25288, G25297, G25411, G25579, G25804, G25821, G25826 and G25828) showed resistance. With the collaboration of CIAT virologists, these *P. lunatus* accessions will be subjected to more intensive BCMV resistance screening.

Catalogue of the Accessions

Currently the catalogue comprises passport and collection data. Passport data are completed, and 67% of the collection data is in. The compilation of this information allowed the weeding out of duplicate accessions numbers--i.e. those accessions, which for various reasons, have been assigned up to 5 different identification numbers from various institutions.

Data on the collection shows that 900 accessions received from IITA in Nigeria are of unknown origin; 18% of the remainder of the collection is also of unknown origin, 17% come from markets, 26% have an indefinite origin and 39% have a precise one.

Data about the type of materials received (pure line, mixture or segregating) is also being collected. This information is very important to the management of *P. lunatus*, a partial allogamy crop.

Seedborn BCMV

All of the first 200 accessions tested showed susceptibility to BCMV but only very weak symptoms presented under greenhouse conditions. Preliminary studies were conducted in association with CIAT virologists and pathologists to determine if the bean common mosaic virus could be seed transmitted.

Five accessions were planted in three repetitions with two check repetitions. These accessions were inoculated by the more virulent race of BCMV on P. vulgaris L., but no seed harvested to date has evidenced seed transmission. However, many more repetitions using different morphotypes of P. lunatus and different races of BCMV must be carried out, before it can be certain that BCMV is not seed born in Lima beans.

Electrophoresis Study

The recent discovery of a new wild Lima bean by a IBPGR-CIAT collector was received with great interest as other wild forms of beans have demonstrated a remarkable natural resistance to bruchids due to the presence of special proteins (like arcelin). The protein variability in both wild and cultivated forms of Lima beans is being studied in collaboration with the CIAT Entomology program.

The methodology involves extracting the crude proteins from seeds of Lima beans from different origins, and then analyzing them by one-dimensional sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS/PAGE).

Although only 96 accessions have been analyzed (82 cultivated and 14 wild forms) it appears that:

1) Two major familial patterns can be identified among the cultivated materials and traced back to two different wild ancestors: one distributed from Jalisco (Mexico) up to Salta (Argentina) along the eastern slopes of the Andes , and another one in Cajamarca (Peru). These results support the idea of separate and geographically distinct domestication for Lima beans.

2) There is an intermediate pattern displayed by only one accession: a wild form from Panama.

3) Variability as shown in seed storage proteins should prove to be (through more testing) greater in Peru and surrounding highlands, since the Big Limas and their wild ancestors displayed more variable patterns there, than in Mesoamerica.

4) The Big Lima seed morphotype is frequently associated with the Peruvian origin, while the Sieva and Potato morphotypes are associated with Mesoamerica. Although it is not a strict one, this morphotype correlation is good with seed size; it is weak with seed shape and non-existent with seed color.

5) The lack of a strict correlation is shown by G25872 (DGD-1336) from Nariño (Colombia), a black-seeded type close to a Big Lima that shows more similarity to the Mesoamerican type. This material was indeed segregating and produced three different seed colors. Moreover the three familial patterns (Peru, Panama and Mesoamerica) were found in the original seeds and in the first generation as well (Figure 1).

This case of natural introgression would indicate that we are dealing with a single species, but one that arises from two very separate gene pools. It is of interest to look into breeding Lima beans in this part of Colombia.

The preliminary results outlined above should be tested against a larger sample, especially for studying the possible origin of the small Limas. Results from experiments outlined above, however, have shown that all wild forms tested to date were resistant to the bruchid *Acanthoscelides obtectus* but displayed several protein patterns; this indicates that the mechanism(s) involved are not the same as those found in *P. vulgaris*.

Embryogenesis Study

The introgression of certain desired characteristics from one species to the other through interspecific hybridizations is very important. This transfer is often difficult due to the high rate of abortion of hybrid embryos, especially in crosses between *P. lunatus* and *P. vulgaris* .

Although both species are normally fecund, all embryos obtained abort at an early stage. Research is ongoing to better understand the reciprocal cross differences between these species, the early hybrid embryo development, the genotypic effects on embryo growth and the effects of culture medium on hybrid survival.

In collaboration with the CIAT Biotechnology Unit, a embryogenesis study has been started on Lima beans and common beans to pinpoint the stage of the embryo at the moment of abortion. A preliminary study of the parents shows that embryonic growth is slower in Lima than in common beans, and is evident immediately after pollination. Still, variability exists between and within accessions in embryo size of equal age.

The methodology for transplanting the plantlets obtained by embryoculture in a non-sterile soil was improved. A system using perlite and a nutritive solution facilitates the transplantation of younger ones, but the embryo loss is still high because of malformations during growth in test-tubes. These malformations (like witches-broom) appear at the first node of the stem, and is possibly due to too little light. These observations will be investigated in more detail this year.

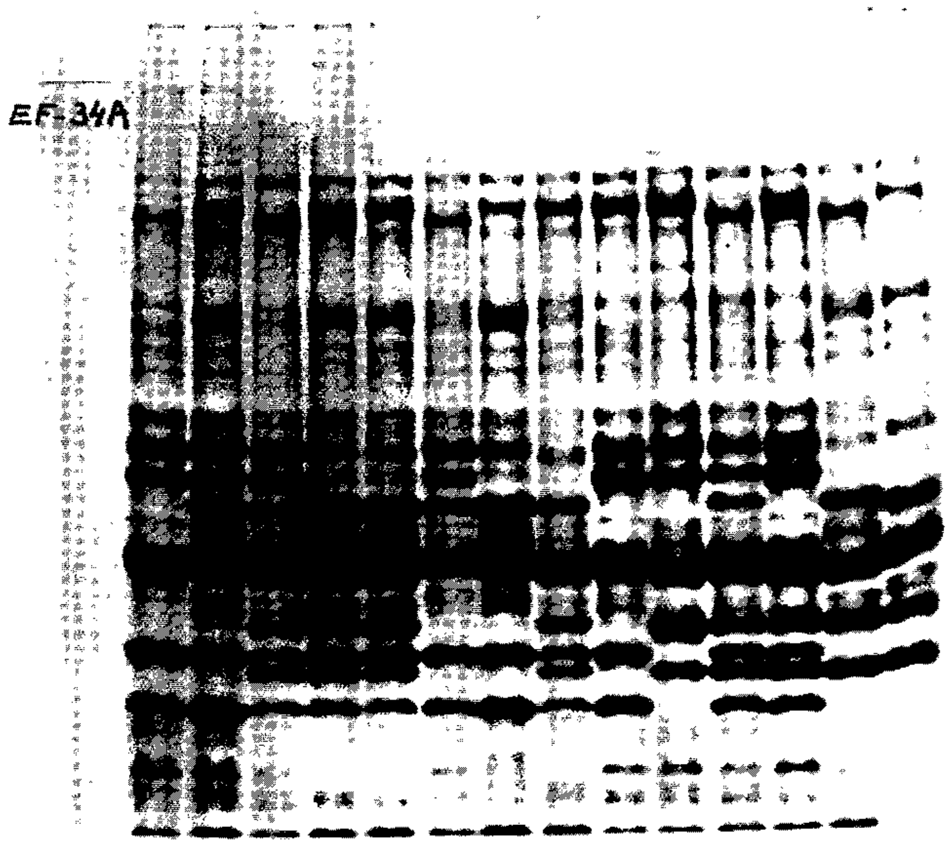
Table 1. *P. lunatus* seed increase in Palmira and Popayan over two years.

Site-Years	No. of accessions sowed	incre-ased	in multi-plication	No germi-nation	% segrega-tion	Accessions with seed germination
Palmira						
86-88	305	171	80	54	42.8	17.5
88-89*	200	40	130	30	30.0	8.0
Popayan						
87-88	91	49	38	4	7.7	0.0
88-89**	46	-	-	-	-	-

*Accessions still in harvest

**Accessions just sowed

Fig. 1 : A segregating case in P. lunatus L.



G25916	ORIGINAL SEEDS	2d GENERATION			G25704
	G25872	G25872A	G25872B	G25872	

POPBEANS

Nuñas are a group of varieties of the common bean, Phaseolus vulgaris L., which like popcorn, burst when heated. They may be cooked either dry or in oil. The effect is less dramatic than popcorn and the resulting product is soft and tastes somewhat like roasted peanuts. All nuñas are climbing varieties with the foliage located at the top of the plant. They form a non-homogeneous group with respect to color and seed size, but are generally spherical and opaque.

From northern Peru to central Bolivia, nuñas are commonly cultivated by highland Indians in plots above 2100 m. At these altitudes, water boils at such low temperatures that normal beans take a long time to cook, consuming a lot of fuel. Nuñas, however, can be cooked economically at high altitudes.

An obvious advantage in cultivating nuñas is that toasting nuñas requires less fuel than boiling beans. This is an important economical and ecological issue in regions (such as central Africa) where firewood is scarce. Nuñas have the potential for becoming a dependable source of cheap, high-quality protein that require relatively little fuel for cooking.

In addition to its nutritional and energy saving virtues, nuñas could be a nutritious snack food in industrialized nations. Their pleasant taste and texture should make them marketable in North America and Europe.

Research Plans for Nuñas

The structure and composition of nuñas and other bean seeds are being studied to identify the components, such as carbohydrates, micronutrients, and moisture, which might determine the capability of the bean to pop. To date, however, no single factor has been shown to be markedly different between nuñas and normal dry beans in laboratory tests (Table 1). Information on factors influencing popping in maize, rice and other grains, will be obtained in order to compare their popping mechanism to the nuña's mechanism.

The second important factor that will be studied is the effect of the environment on seed structure and composition. It has been observed that nuñas grown at locations which have different climatic conditions from those of the Peruvian sierras, lose their ability to pop.

Once the popping mechanism and the effect of the environment is established, the genetic control of the popping mechanism will be studied in the progeny of hybrids. The aim will be to determine whether control is monogenic or polygenic, and in the latter case whether genes controlling different aspects of the mechanism are linked or inherited independently. The association of the popping mechanism with other characteristics such as the climbing growth habit and the opaque seed color will also be studied in the progeny in glasshouse and field experiments.

These studies will provide the basis for transferring the popping mechanism to varieties having diverse genetic backgrounds adapted to different regions and systems of cultivation.

Table 1. Laboratory analyses of seven nuñas and three normal common bean varieties[1]

Identification	% Humidity	% Protein	% Fat	% Starch	Total Sugar	Density g/ml	% Seed Coat thickness
Nuña Poroto Blanco	10.27	22.5	1.90	38.5	1.53	1.21	.114
Nuña Angel Poroto	10.02	21.0	1.92	38.5	2.97	1.23	.110
*Nuña Pava	10.48	20.0	1.82	34.5	2.89	1.59	.120
Nuña Mani Roja	10.35	18.9	3.36	34.5	3.15	1.38	.104
Nuña Frontina Colorada	10.30	21.1	1.91	36.0	2.57	1.34	.117
Nuña Frontina Ploma	10.11	19.8	2.63	31.0	1.28	1.03	.105
Nuña Coneja	10.06	19.8	2.60	33.0	4.33	1.21	.108
Mean	10.23	20.4	2.31	35.1	2.67	1.28	0.115
Checks							
Calima	10.09	21.52	2.84	39.5	2.72	1.05	.109
Mortiño	10.19	20.46	1.79	38.0	2.15	1.41	.110
Pajuro	10.57	19.77	2.28	35.5	2.78	1.24	.105
Mean	10.28	20.6	2.50	37.7	2.55	1.23	0.108

[1] Mean of two replications

SNAPBEANS

Snap beans, the young green pods harvested from Phaseolus vulgaris, have long been a part of Asian diets and are becoming increasingly popular with consumers and growers in Africa and Latin America. Economists in CIAT's Bean Program have undertaken a major study of the economic potential for snap beans in developing countries.

The following studies are in progress:

1. Pest management --Information from several Latin American and Asian countries collected through case studies has shown that alarming quantities of chemical controls are being used in snap bean cultivation (up to 15 applications per crop). It was found that snap bean cultivators would refuse to consume their own (contaminated) crop! Consequently, a collaborative project was begun by CIAT and ICA to evaluate the ecological, economical and toxicological aspects of pest management in snap bean cultivation. This study in the Usagasuga area of Colombia will describe the present pest management situation, and look for alternative strategies to recommend for Colombia and other LDCs suffering from similar chemical control (mis) management practices.

2. Seed quality --The availability and quality of snap bean seed are crucial factors influencing input costs, disease and pest susceptibility, and yield. Major European and North American seed companies have consistently supplied snap bean seed that is not adapted to the climatic conditions of the tropics, thus contributing substantially to poor domestic seed production and distribution. A study to define the world vegetable seed market, and to assess the impact of international seed exports on domestic seed production within developing countries is underway. The Colombian snap bean seed industry is being analyzed in depth to assess the potential for increased self-sufficiency, and to improve current methodologies for releasing new seed.

3. Case studies --Economic case studies are still in progress for Costa Rica, Taiwan and Turkey. A specific interest or problem in each area is receiving special emphasis, as in Turkey, where the merits of bush versus climbing snap bean varieties are being measured. Data already in from China has shown that this country produces 3 million tons of snap beans annually, and that peri-urban yields can reach 22 tons per hectare. The potential for snap beans in this huge market of 1.1 billion Chinese people demands an in-depth analysis and case study in the near future.

Preliminary Results from Economic Studies

Production costs: Snap bean production is typically a small farm activity, as shown by micro production data from several country case studies (Table 4). In Latin American countries, the average farm size (2-5 ha) is substantially larger than those for Asia (1-3 ha) or Africa (.2-.5 ha), and the area per farm allocated for snap bean cultivation in Latin America is less than 15%. This is due, primarily, to snap beans being a high input, high output crop with random fluctuating market prices, and secondarily, to the fact that small farmers are risk-averse. They are not willing to devote too much of their land to a crop that requires substantial labor, capital and other inputs, and generates an unknown return. Between 25-50% of total production costs goes to labor. From a farmer's point of view, snap bean production is labor constrained, however, from a macro point of view, it is employment generating. Future production strategies should be directed towards minimizing labor needs in snap bean cultivation, to allow the crop to compete favorably with other vegetables. Most other production costs comprise chemical control (10-14%) and fertilizer costs (11-20%). High inputs by Asian snap bean farmers bear results in yields of up to 22 t/ha.

In both Latin America and in Asia, snap bean cultivation is a profitable small farmer enterprise providing a much needed source of cash.

Perishability and marketing constraints: The high perishability of the crop and the (often) high number of intermediaries in the marketing channel are the major reasons for relatively high marketing margins; from a low 53% in Indonesia to a 320% in Sri Lanka. The marketing channel in most Chinese urban centers is very efficient, since either the producer takes the crop to the (free) retail market or the stall owner collects his produce directly from the producer. Consequently, even when vegetable wholesale markets play a (minor) role, the Chinese urban retail price incorporates only three pricing points at most, while in Colombia this may be five to seven.

African snap bean market: In contrast to dry beans, Africa demonstrates an insignificant snap bean consumption. However, snap beans have been produced as a profitable export product by Kenya, Senegal, Burkina Faso, Ivory Coast, Cameroon, Rwanda and Egypt for the European off-season fresh market. Some 100,000 metric tons of (extra)-fine and "Bobby" snap beans are air-freighted to major European cities each year. A study conducted in Rwanda to evaluate the crop's potential as a foreign exchange generator for the country, found that profits can be made by the French export companies on yields of 3.5 tons per hectare. Current real average yields of 1.2-3.7

tons/ha for snap beans grown on poor soils gives Rwanda a foreign currency inflow that could be substantially increased by planting more hectares of better soil to snap beans.

Consumption studies: Snap bean consumption in most developing countries is income dependant. In general, higher (urban) income households consume more of this vegetable than do lower income households. To a certain extent, the opposite holds true for cabbage, a typical "poor man's" vegetable.

However, a division needs to be made between (predominantly) animal-protein consuming LDCs (Latin America) and (predominantly) vegetable-protein consuming LDCs (Asia). For example, Chinese urban consumption of cabbage is some 37 kg/capita/year, but this figure is expected to decrease as more disposable income becomes available for the purchase of more expensive protein-containing vegetables. However, in Colombia, household survey data shows that people increase their consumption of cabbage, snap beans or any vegetable, when incomes improve. This increase is due to urbanization and health consciousness, and because much less distinction is made amongst vegetables in Latin America, where they are a side dish, than in Asia, where they are the primary components of the meal. It is expected that the Asian market will demand increases in snap bean production more than will the Latin American market.

In addition to snap beans, yard-long beans (*Vigna sesquipedalis*) form an important part of the Asian diet, whereas in Latin America and Africa the cultivation and consumption of this vegetable is insignificant. This probably will not change much in the future. Consumption depends on availabilty by climate (more temperate for snap beans, more (sub) tropical for yard-long beans) and popularity in traditional dishes.

Snap beans are often described as being a green, slightly curved, smooth and cylindrical/round shaped bean. Whereas the Europeans and North and South Americans (except Brazil) definitely prefer this type of snap bean, there are many other types of snap beans found in Asia and the Middle East, ranging in color from white to almost black, and in all shapes and forms. The type of bean that will bring a top price in Paris or Bogota, would sell poorly in the markets of Turkey and China. Asians prefer more mature snap beans which may partly explain the high yields in some Asian countries.

Demand Characteristics of Dry Beans Versus Snap Beans

Research strategies are not only determined by production, but also by market and consumption characteristics. Snap bean and dry bean market and consumption characteristics were compared using Brazilian and Colombian data. Results show that research objectives for snap beans have to differ from those for dry beans.

Income and urbanization differences between snap and dry beans were striking as were seasonality and market integration differences. The nature of the differences and the implications for research will be discussed briefly.

Income and Urbanization

The 1982 DRI-PAN Colombia-wide survey provides data on per capita consumption for both snap beans and dry beans across different income strata in rural and urban environments.

While dry bean consumption levels are very comparable across rural and urban environments, snap bean consumption is strongly concentrated in urban areas, where it is growing with increased urbanization. It was also seen that snap bean consumption depends more strongly on appropriate marketing than does dry bean consumption.

Dry bean consumption has very low income elasticities. In the urban areas, consumption increases with income in the three lowest income strata, but levels out afterwards. In the rural areas the consumption increase in the lowest income strata is slightly larger.

On the other hand, snap bean consumption was shown to be very income dependent. Wealthy people eat on average 5 to 6 times more of it than poor people, in the urban as well as the rural environment. While dry beans are a very important food product for the urban poor, snap beans do not have a comparable role. An important objective of dry bean research can be to decrease acquisition cost of the poor urban consumer. For snap beans considerations of consumption by lower income quintiles are less relevant. In a Latin American situation snap bean research should focus on increasing small farm income, probably through emphasizing quality.

Seasonality

Monthly wholesale price data from 1980 to 1985 for 12 state capitals of Brazil were analyzed, both for dry and for snap beans. In dry beans on average 22% of the variability in prices could be explained by seasonal factors and in seven towns seasonality appeared to be significant and stable. In snap beans 56% of price variability could be explained by seasonality factors and in 10 out of 12 towns stable seasonal patterns were observed.

The average monthly deviation of snap bean prices was 18% and of dry bean prices only 4%. Seasonality appears to be more of a constraint for snap beans than for dry beans. Research on seasonality constraints including snap bean storage would be very useful.

Market Integration

The same monthly wholesale data for dry beans and snap beans in Brazil were used to study market integration. These data show that there is very little correlation between snap bean prices across Brazil, which suggests that the price formation in different markets takes place independently. The average level of correlation between 12 state capitals was only 23%. Dry beans wholesale prices are more strongly correlated showing an average level of 76%.

Within the high correlation coefficients between dry bean wholesale markets, three clusters can be discovered. The first cluster contains 5 towns in the south (Rio de Janeiro, Sao Paulo, Curitiba, Florianapolis and Porto Alegre). The second cluster contains three cities in the center and the southern part of the North East region (Belo Horizonte, Salvador and Recife). The third cluster contains three cities more towards the Northern part of the North East (Natal, Joao Pessoa and Fortaleza). Only Belem in the extreme north could not be included in any clusters. The correlation coefficient among towns within the same cluster is more than 90%.

In the Brazilian snap bean market, it is more difficult to group towns together. In fact the correlation coefficient between the towns clustered for snap beans is lower than the average correlation between the not-clustered towns for dry beans.

The evidence suggest that dry bean markets are rather well integrated. If productivity is raised in a particular area of the country, the resultant cost reduction will be This was not the case for snap beans.

Snap bean research needs to be aimed at a widespread and diffuse area of production regions, whereas dry bean research can take more of a national focus, concentrating on the areas where the crop has comparative production advantages.

Table 1: Consumption of dry beans and snap beans in Colombia, 1982 by income and urbanization strata (kg/capita/year)

Income Stratum	Dry Beans		Snap Beans	
	Urban	Rural	Urban	Rural
V	6.74	8.44	5.57	1.87
IV	7.44	8.49	3.99	2.05
III	7.34	7.53	3.32	1.77
II	6.20	6.40	1.97	0.67
I	4.76	3.64	1.15	0.31
Average:	6.78	6.17	3.52	1.06
Income elasticity:	0.16	0.42	0.86	0.95

Note I lowest income quintile

V highest income quintile

Source: Encuesta DRI-PAN 1982

Table 2: Dry bean and snap bean wholesale price - variability, 12 towns, Brazil, 1980-1985.

	Dry Beans	Snap Beans
Variability explained by seasonality	22%	56%
Number of towns with stable seasonality patterns	7	10
Average monthly deviation of prices caused by seasonality	4%	18%

Source: Snap beans. COBAL: Quantidades comercializadas por produto no SINAC, Database, Brasilia.

Dry beans. Ministerio de Agricultura. Precos nos mercados atacadistas, various years, Brasilia.

Table 3: Market integration parameters for dry beans and snap beans in Brazil, 1980-1985

	Dry beans prices	Snap beans prices
Average correlation between towns	76%	23%
Number of market clusters	3	2
Number of towns included in the clusters	11	9
Average correlation between towns within clusters	0.91	0.66
Average correlation between towns in different clusters or outside clusters	0.68	0.05

Source: Snap beans. COBAL: Quantidades comercializadas por producto no SINAC, Database, Brasilia.

Dry beans. Ministerio de Agricultura. Precoz nos mercados atacadistas, various years, Brasilia.

Table 4. Snap bean production statistics for selected developing countries.

	COLOMBIA	BRAZIL	RWANDA	PHILIPPINES	INDONESIA
Average farm size (HA)	2 - 5	5 - 20	.2 - .5	.5 - 3	.2
Average yield (MT/HA)	10	3	2	17.5	11
Average farm price (US$/MT)	270	200	120	153	95
Net value of production (US$/HA)	832	-	500	751	997
Labor costs (% OF TOTAL COSTS)	39	28	16	35	52
Seed costs (% OF TOTAL COSTS)	7	8	10	7	6
Chemical control costs (% OF TOTAL COSTS)	9	13	10	11	9
# of chemical applications	11	16.5	7	6	6
Fertilizer costs (% OF TOTAL COSTS)	12	20	14	20	11
Return to costs	1.3	-	1.2*	1.6	1.46

* Returns to costs for export firm.

FUNGAL AND BACTERIAL PATHOGENS

The principal activities of bean pathology during 1988 continued to be concentrated on disease research, investigation of cultural practices, and training activities.

Research emphasis this year was placed on working with disease resistance to bean pathogens. Cultural practices were also studied in connection with the most important and widespread bean diseases: anthracnose, angular leaf spot (ALS), common bacterial blight (CBB), and rust. Other diseases receiving less research emphasis included those that are either very important or very widespread but not both. These are web blight, ascochyta blight, halo blight, Rhizoctonia root rot and Fusarium wilt.

Disease resistance research centered on:

1. Identification of new, better or different sources of resistance that can be utilized in breeding and that will result in a broader and more stable bean genetic base. Here, the emphasis continues to be on diseases caused by pathogens exhibiting extensive pathogenic variation, i.e. races, such as those causing anthracnose, ALS, rust, halo blight, and Fusarium wilt.

2. Characterization and monitoring of the variation present in populations of the principal bean pathogens. Highly variable pathogens are emphasized.

3. Studies of disease resistance mechanisms, aimed toward using resistance more effectively for enhanced stability over time and space.

4. Additional complementary studies including inheritance of resistance, induced resistance, and biocontrol.

Cultural practices were studied for web blight and ascochyta blight, two diseases for which breeding for resistance is very difficult. To date, only somewhat resistant parents are available for the management of these diseases and the need for an integrated disease management strategy has prompted increased research toward this end.

Bean pathology training of scientists from Latin American and African national programs has increased substantially during the last few years. In 1988, eight visiting scientists received post graduate training in Bean Pathology at CIAT, each for a minimum period of 3 months.

This year's pathology report will concentrate on a few diseases that were not emphasized in previous years.

Web Blight

In the past, most of the web blight (WB) research has been conducted in Central America (primarily in Costa Rica) in very close collaboration between the CIAT regional program for Central America and the Caribbean, and scientists from the Costa Rican national program. Results obtained from this collaborative effort have been very instrumental in the management of WB, a most serious disease in this area. Some of the most salient results involve the use of cultural practices in the management of the disease, These practices found to be effective include mulching, and/or planting on ridges, both of which limit the splashing of the pathogen inoculum onto bean plants.

In Colombia, WB is a very important disease in the coffee zone between 1200-1600 masl. Results from trials conducted here suggest that WB epidemiology in Colombia varies from that of Costa Rica, in that mulches and ridges may not be efficient or useful cultural practices for WB management in most locations or years in Colombia. Therefore, a study was initiated in the second semester of 1987 to further investigate the epidemiology and management of web blight in the Colombian coffee zone. This study is a collaborative effort between the pathology sections of CIAT and Cornell University. The study is still on-going, but the following is a summary of preliminary results:

***In a survey of WB in most of the bean producing regions of Colombia, the disease was found to attack bush as well as climbing beans in 12 departments. Observed severe WB outbreaks were associated with increasing precipitation, as in Costa Rica; however, in Colombia the disease occurred in areas with much lower temperatures (averaging 16-18 C^{o}).

***In addition to WB, severe root and hypocotyl rot, caused by *Rhizoctonia solani* was also associated with bean plants under these conditions. No previous reports associate high WB severity with *Rhizoctonia* rot. The WB and root rot pathogen is also *R. solani* (telemorph= *Thanatephorus cucumeris*); however it is generally accepted that most isolates causing WB belong to anastomosis group 1 (AG1), and those causing root rot are AG 4; but this is a generalization. The isolates from Colombia, obtained from roots (root rot) or from leaves (web blight) were mostly multinucleate, the majority belonged to AG 1 and AG 4, in equal proportions, showed a very broad morphological variability, all formed sclerotia and there were no differences in virulence between these isolates. In most cases, virulent isolates grew very fast, were brown to dark brown, and originated either from roots or leaves. Under greenhouse and laboratory conditions, the most virulent isolates originating either from roots or leaves, produced more severe symptoms on both leaves and roots and the less virulent ones produced the least severe symptoms on both plant parts. One isolate from Popayan (1700 masl) obtained from roots with Rhizoctonia root rot symptoms and one from Manizales (2000 masl) obtained from leaves with WB, were binucleate and both caused severe symptoms on roots and leaves under greenhouse conditions. Binucleate Rhizoctonia-like fungi have been generally associated with foliar blight of cereals, grasses and sugarbeets.

***The small round foliar lesions caused by basidiospores were the most common type of lesion encountered, suggesting that basidiospores are the most important component of WB dissemination in Colombia. Hymenium layers were found very often, supporting the hypothesis that in Colombia, the sexual state (basidiospores) are more important than the asexual state (mycelia and sclerotia) in secondary disease dissemination. The basidial state has been seldom found in Central America.

***This very important difference in inoculum type (asexual vs sexual) between Costa Rica and Colombia may be due to differences in temperature and amount of rain. The coffee zone in Colombia is at a much higher altitude than the low land tropical areas of Nicaragua, Costa Rica, Panama and consequently the temperatures are also lower. In addition, the coffee zone generally has less precipitation and thus there is much less chance of inoculum splashing from the soil. The aerial nature of the inoculum of the WB pathogen in Colombia, suggested that many of the cultural practices useful in Costa Rica and elsewhere in Central America and the Caribbean for WB management are not going to be as useful in the Colombian coffee zone. These practices only impede the path of initial inoculum present in the soil toward the bean plants, but do not affect the transport of aerial inoculum; however, it has been also observed, that in Colombia in certain areas or years when there is abundant precipitation, rain-splashed inoculum is important in disease initiation.

***Experiments were conducted to study the effect of mulches and ridges on the amount of web blight in two bean varieties, BAT 1155 (very susceptible) and BAT 1297 (of intermediate resistance). Three types of mulches, made of sugarcane leaves, plantain leaves and of weeds, were compared with a treatment with no mulch. No statistically significant differences were observed during two years between the no mulch treatment and the other three treatments with mulches (Figures 1 and 2). Similar results were observed when ridges were used (Figures 3 and 4). The disease progress curves for WB severity were similar in all treatments; however, there were significant differences on the WB severity between the very susceptible variety (BAT 1155) and the intermediately resistant (BAT 1297). This suggests that in most years in the Colombian coffee zone, where it rains less than in Central America and where the aerial inoculum is very important in disease dissemination, the use of resistant varieties is going to be a much more important strategy than mulches or ridges for WB management.

***The population dynamics of Thanateporus cucumeris in two bean varieties grown with mulches and in ridges were also studied. The same two bean varieties mentioned above were used. The results show that the fungal propagules (sclerotia and mycelia) were present mostly in the upper (2 cms) of the soil layer. Populations density of the pathogen propagules in the lower (next 8 cms) layer were significantly more reduced than in the upper layer (see Figure 5 and 6). There were no significant differences in amount of propagules between varieties. A low amount of inoculum was observed at planting, but this increased with time, reaching a maximum at flowering and declining to low levels at harvesting.

Fusarium Wilt

Fusarium wilt or yellows, caused by Fusarium oxysporum f. sp. phaseoli (Fop), is a bean disease that is becoming increasingly important in several areas of Latin America: e.g. in Santa Catarina and Pernambuco states of Brazil; in the state of Zacatecas, Mexico, and in Nariño, Colombia. The disease is known to be more severe under stress (drought, flowering) conditions and Fop is reported to have 2 races; therefore, a variety resistant in one location may be susceptible in another. The literature reports that isolates from Holland and the United States belong to one race, while isolates from Brazil belong to another race. Results from bean trials conducted in cooperation with scientists from Brazil and Colombia suggested that isolates from these two countries were pathogenically different.

In order to identify sources of resistance that may be useful on both countries, the pathogenic variation of the Fop isolates had to be studied. Isolates from some regions of these two countries were collected, isolated and grown on acidified PDA and inoculated on a common series of bean varieties. In all cases, seeds of the bean varieties were planted on sterile sand, and after 8 days dug up, the roots washed and the terminal ends of the roots cut. The roots were then immersed for two minutes in a suspension containing 1×10^6 spores/ml of Fop. Seedlings with cut roots immersed in water served as checks. Inoculated seedlings were then transplanted into pots containing sterile soil and placed on a greenhouse bench.

The results clearly show that the isolates from Colombia are pathogenically very different from those from Brazil (Table 1). Bean varieties Mortiño, Calima and Tib 3042 had no reaction (were immune) to the isolates from Brazil, but were very susceptible to those from Colombia. On the other hand, bean varieties IPA 1, RIZ 30 and A 211 susceptible to the isolates from Brazil were immune to the isolates from Colombia (Table 1). Bean lines HF 465-63-1 and BAT 477 were resistant to both groups of isolates. These results also suggest that all isolates from a given country belong to the same race (Table 2).

Common Bacterial Blight

During 1988 we continued the evaluation of bean germplasm for reaction to *Xanthomonas campestris* pv. *phaseoli*, the common bacterial blight (CBB) pathogen, with the objective of identifying better or different sources of resistance. The evaluation of accessions from the germplasm bank continued to be of primary concern, bringing the total number of accessions evaluated to approximately 15,000. As in previous evaluations, high levels of resistance in *Phaseolus vulgaris* to the CBB pathogen were very rare. Initially, all germplasm was evaluated under greenhouse conditions. Some of the accessions with the best levels of resistance were: G 19195 (PI 325761, an indeterminate genotype of Pompadour grain type), G 18168 (Red Kidney Noailles), G 18443 (Ojo de Cabra ST del Rio) and G 18836 (PI 209481, a Central American red-seeded genotype). This is the first time we observed CBB resistance in a medium-sized grain genotype from highland Mexico gene pools; i.e. in G 18443. Other genotypes with only intermediate levels of resistance were G 18443 (Cornell 1040 Bulk), G 17353 (N.Y.-82-707), and G 17645 (Cal 77102). We also evaluated a number of accessions reported in the literature as showing resistance in the United States. Under greenhouse conditions most of the lines tested had a susceptible reaction similar to our susceptible check BAT 41. Some of the accessions here included are: G 292 (PI 169830), G 815 (PI 197687, G 215, PI 169 727), G 309 (PI 169854), G 167 (PI 165422), G 885 (PI 204603). The exception was G 1320 (PI 207262) which had intermediate levels of CBB resistance under greenhouse conditions. A similar evaluation was conducted for 20 bean lines reported resistant in Bulgaria. Only six lines (174-1-1-1-1, 174-1-8-2-8, Oreol, Maritza 45704, 112204-1-1 and 115084-1-3) had intermediate levels of resistance both under field and greenhouse conditions.

This year the field technique for plant-by-plant inoculation was further improved over the surgical blade method described previously (CIAT Ann. Rept., 1981). The blades and the sponge were mounted opposite each other on the arms of ordinary kitchen tongs, thus allowing the inoculation to be done with a single hand. This leaves the other hand free to manipulate the leaf, and is thus less cumbersome and more rapid. The reservoir of inoculum is the wetted sponge which is held within a small metallic cup. However, to insure uniform inoculum distribution, inoculated plants are also misted with inoculum late in the afternoon, after manual inoculation is completed.

Other Diseases

Routine evaluations of advanced bean breeding nurseries (VEF and EP) for their reaction to the most important diseases under field conditions were also conducted this year. The evaluations were conducted in Palmira for rust and bacterial blight; Santander de Quilichao for angular leaf spot and common bacterial blight; and, in Popayan for anthracnose and ascochyta blight. The results are presented in another section of this report (see Uniform Nurseries). Similarly, the most important International Bean Disease Nurseries (anthracnose, angular leaf spot, common bacterial blight and rust), were also evaluated at each of these locations for three semesters with the objective of identifying resistance to a broad spectrum of pathogens. This is particularly important in view of the need to have sources with resistance to two or more diseases. Since this semesters' results are not yet completed, these will be presented next year. However, it is worth mentioning that preliminary results show that only a very small number of sources had resistance to all four pathogens but many were resistant to at least two.

Two major inheritance of resistance studies have been completed during this semester, but the statistic analyses are not completed. One study included the inheritance of resistance of the newly identified sources of anthracnose resistance: G 811, G 894, G 2333, G 2338, AB 136, Princor and CIAT improved lines A 193, A 252, A 475. Cornell 492 42, the well known source of the ARE gene for anthracnose resistance was included and all were crossed to A 316 (a line susceptible to anthracnose). The other study included the newly identified sources of resistance to the angular leaf spot pathogen: G 1805, G 2676, G 5173, G 3991, and the CIAT improved lines A 75, A 235, A 339, BAT 76 and BAT 332. The line JALO EEP 558 known for its ALS resistance in Brazil was also included. All were crossed to susceptible line BAT 304.

A very important activity that took place at CIAT during 1988 was the first Latin American Bean Anthracnose Workshop. Bean pathologists and breeders participated from Brazil, Colombia, Costa Rica, Mexico, Nicaragua and Peru. This meeting was extremely important for the dissemination of recently generated information on anthracnose to and between researchers. Some of the information and data generated in different countries, particularly in the area of pathogenic variation of *Colletotrichum lindemuthianum*, is not comparable because different researchers have used different differential varieties, as well as different rating systems. During this workshop much information was presented on pathogenic variation of the anthracnose fungus in different bean producing regions of Latin America, on sources of resistance, other management strategies and plans for the future. The papers presented, as well as the conclusions reached, will be published in a separate document.

The participants agreed on a common set of 12 differential bean varieties for studies of pathogenic variation of _Colletotrichum lindemuthianum_. These varieties will be increased and distributed by CIAT. It was also agreed that a new numerical system of nomenclature will be used for the designation of races (Pathotypes) of _C. lindemuthianum_. This designation is derived from the spectrum of pathogenicity of _C. lindemuthianum_ isolates in the 12 differential varieties. To designate a race the differential varieties are always arranged in a fixed order and each variety is given a value used only when the variety is susceptible. The varieties in their fixed order (and values) are:

No.	Differential Variety (Value)	No.	Differential Variety (Value)
1.	Michelite (1)	7.	Mexico 222 (64
2.	Michigan Dark Red Kidney (2)	8.	PI 207262 (128)
3.	Perry Marrow (4)	9.	TO (256)
4.	Cornell 49242 (8)	10.	TU (512)
5.	Widusa (16)	11.	AB 136 (1024)
6	Kaboon (32)	12.	G 2333 (2048)

For instance, a race that attacks varieties Michelite, Michigan Dark Kidney, Cornell 49242, Widusa and Mexico 222 will be designated as race 91, which results from the addition of 1 + 2 + 8 + 16 + 64, the values of the susceptible varieties. On the other hand, a race that attacks Perry Marrow, Cornell 49242 and PI 207262 will be designated as race 140. This system of nomenclature facilitates the interpretation of any race, because only odd numbered races are pathogenic on the first differential variety Michelite. In addition, a race denominated 140, for instance, is not pathogenic on Michelite-- and 140 can only be obtained by adding 128 + 8 + 4 which implies that race 140 is pathogenic only on Mexico 222, Cornell 49242 and Perry Marrow.

Table 1. Reaction of selected bean lines to 2 isolates of *Fusarium oxysporum* f.s. *phaseoli*: from Brazil and 2 isolates from Colombia.

	DISEASE REACTION[1]					
	BRAZIL			COLOMBIA		
	FOP-5-BR	FOP-24-BR	water (control)	FOP-26-CO	FOP-28-CO	water (control)
TIB 3042	1.0	1.0	1.0	9.0	9.0	1.0
Mortiño	1.0	1.0	1.0	8.4	9.0	1.0
Calima	1.0	1.0	1.0	8.7	7.0	1.0
Frijolica 03.2	1.0	1.0	1.0	7.0	8.8	1.0
IPA 1	8.1	9.0	1.0	1.0	1.0	1.0
RIZ 30	8.7	8.9	1.0	1.0	1.0	1.0
A 211	4.0	8.5	1.0	1.0	1.0	1.0
BAT 477	-	1.0	1.0	-	1.0	1.0
HF465-63-1	-	1.0		-	1.0	1.0

Scale 1-9: 1= no visible symptoms; 9= severely diseased inoculum concentration 1.0×10^8 spores/ml.

Table 2. Reaction of bean variety IPA 1 to isolates of *Fusarium oxysporum* f. sp. *phaseoli* from Colombia and Brazil.

Isolate	Origin	DSR[1] (1-9)	Isolate	Origin	DSR 1-9	Isolate	Origin	DSR (1-9)
FOP # 2	Colombia	1.0	FOP # 6	Brazil	8.8	FOP # 14	Brazil	9.0
FOP # 9	Colombia	1.0	FOP # 7	Brazil	8.8	FOP # 16	Brazil	9.0
FOP # 5	Brazil	9.0	FOP # 11	Brazil	8.0	FOP # 22	Brazil	9.0

[1]DSR = Disease reaction based on a 1-9 scale where 1= no visible symptoms; 9= very severe symptoms.

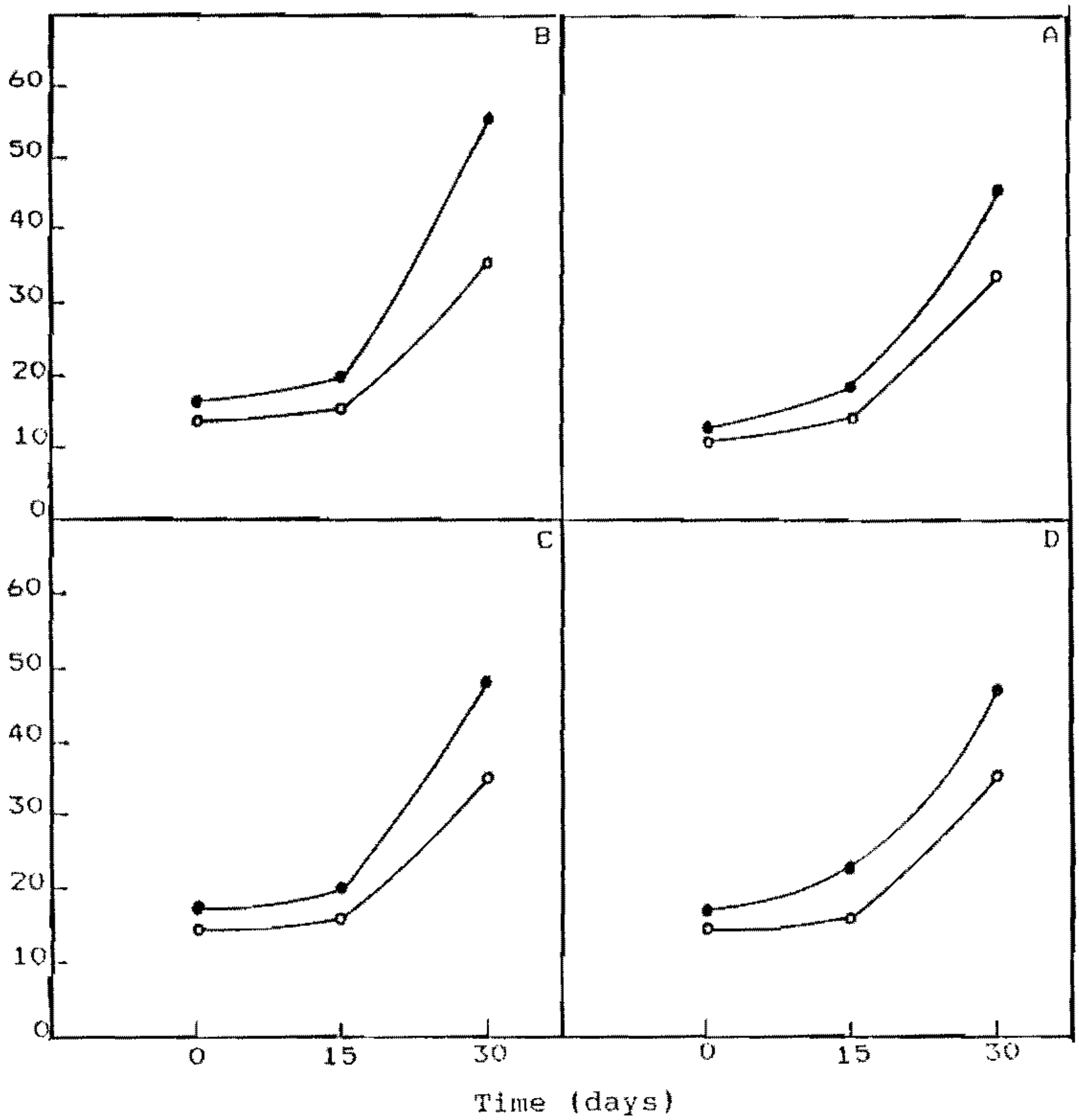


Figure 1. Web blight disease progress curves on bean varieties BAT 1155 (-●-) and BAT 1297 (-o-) grown in the following treatments: no mulch; B,C, and D, mulches of sugarcane residue, plantain leaves and weeds, respectively. Darien, 1987B.

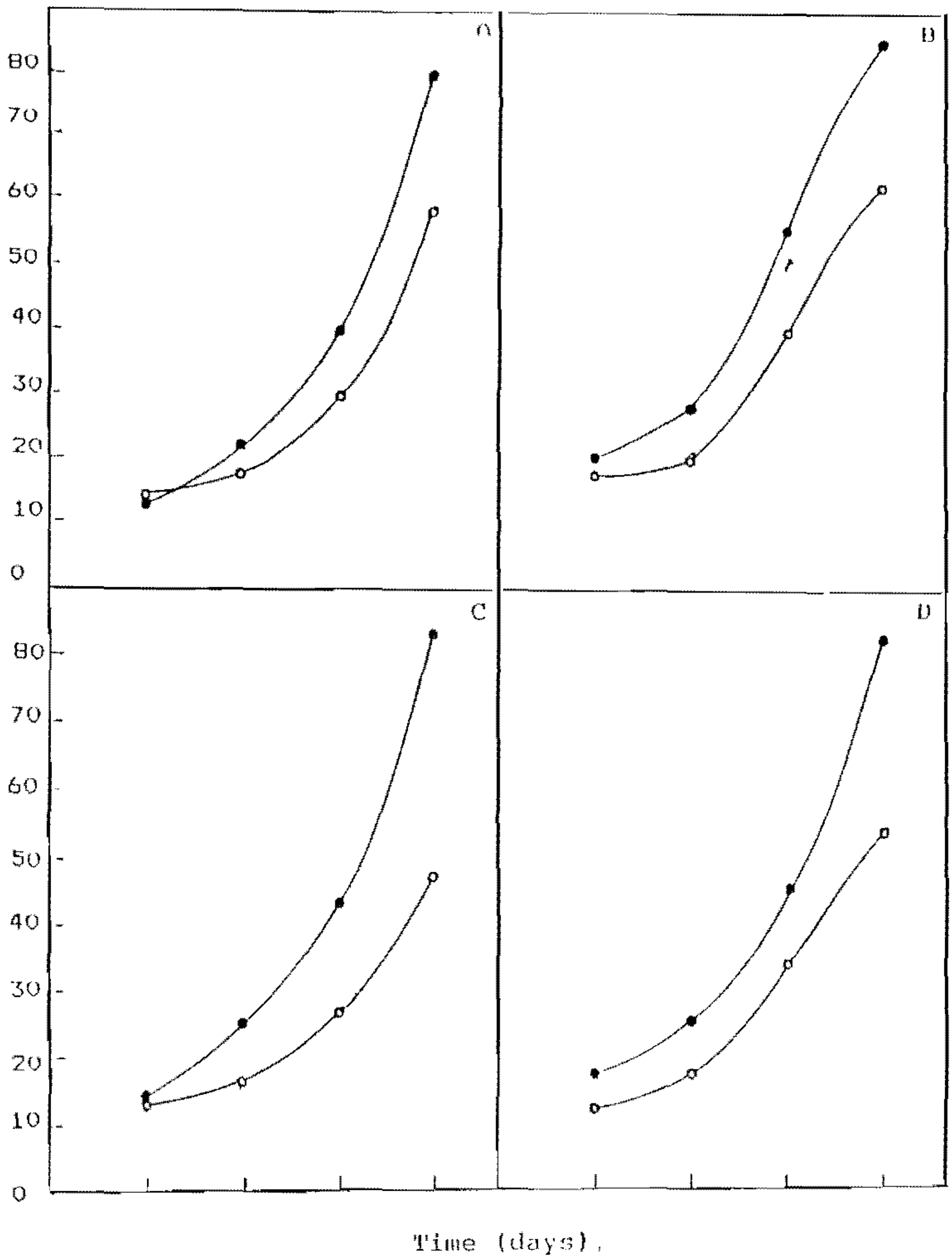
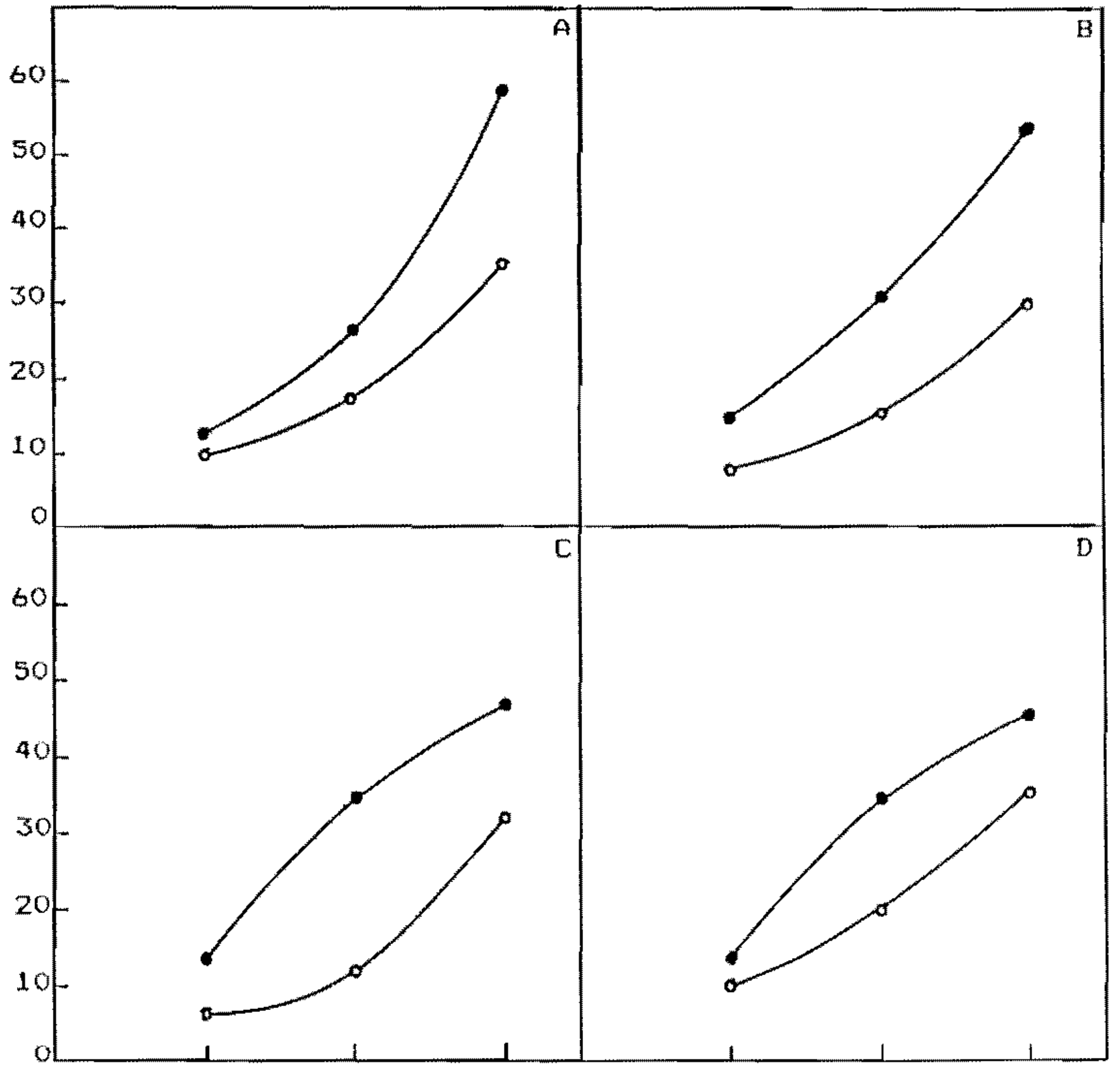


Figure 2. Web blight disease progress curves on bean varieties BAT 1155 (-●-) and BAT 1297 (-o-) grown in the following treatments: no mulch; B,C, and D, mulches of sugarcane residue, plantain leaves and weeds, respectively. Darien, 1988B.



Time (days)

Figure 3. Web blight disease progress curves on bean varieties BAT 1155 (-●-) and BAT 1297 (-o-) grown in A) ridge; B) ridge plus mulch; C) flat soil; D) flat soil plus mulch. Darien, 1987B.

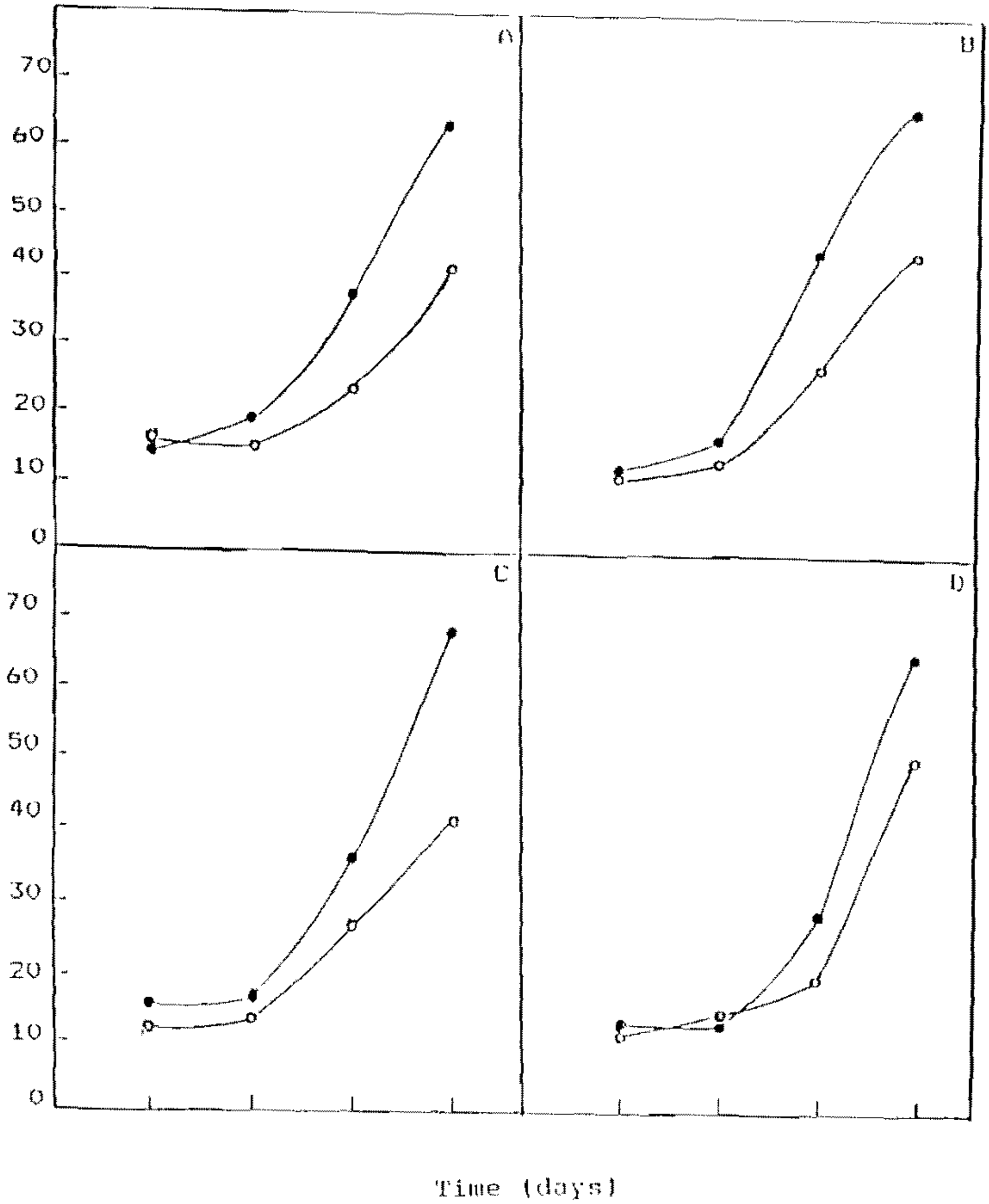


Figure 4. Web blight disease progress curves on bean varieties BAT 1155 (-●-) and BAT 1297 (-o-) grown in A) ridge; B) ridge plus mulch; C) flat soil; D) flat soil plus mulch. Darien, 1988A.

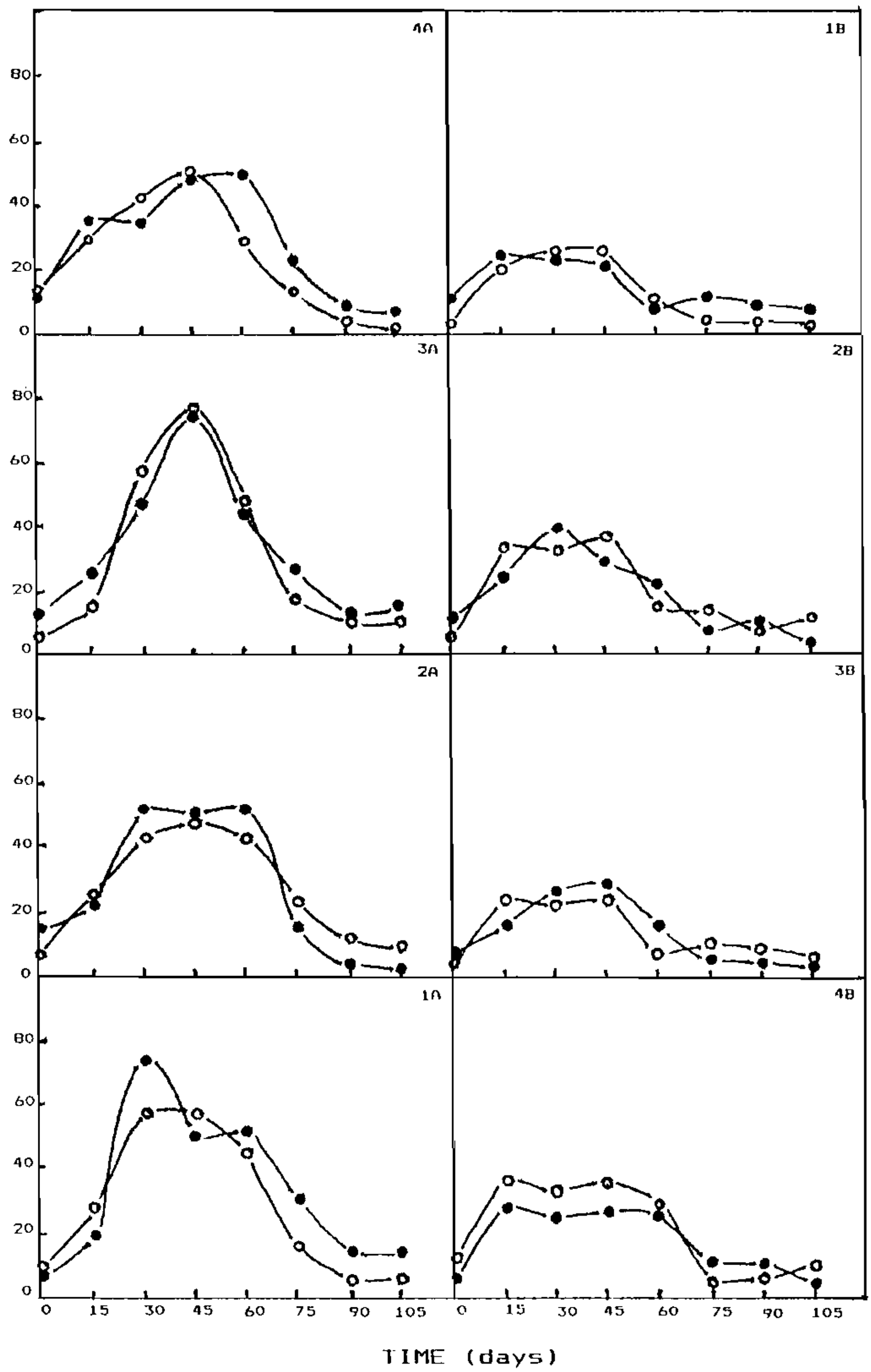


Figure 5. Population dynamics of Thanatephorus cucumeris on bean cultivars BAT 1155 (-●-) and BAT 1297 (-o-), grown on the following treatments: 1) ridge; 2) ridge plus mulch; 3) flat soil; 4) flat soil plus mulch. A=top soil (0-2 cm) and B=bottom soil layers (2-10 cm). Darien, Colombia, 1987B.

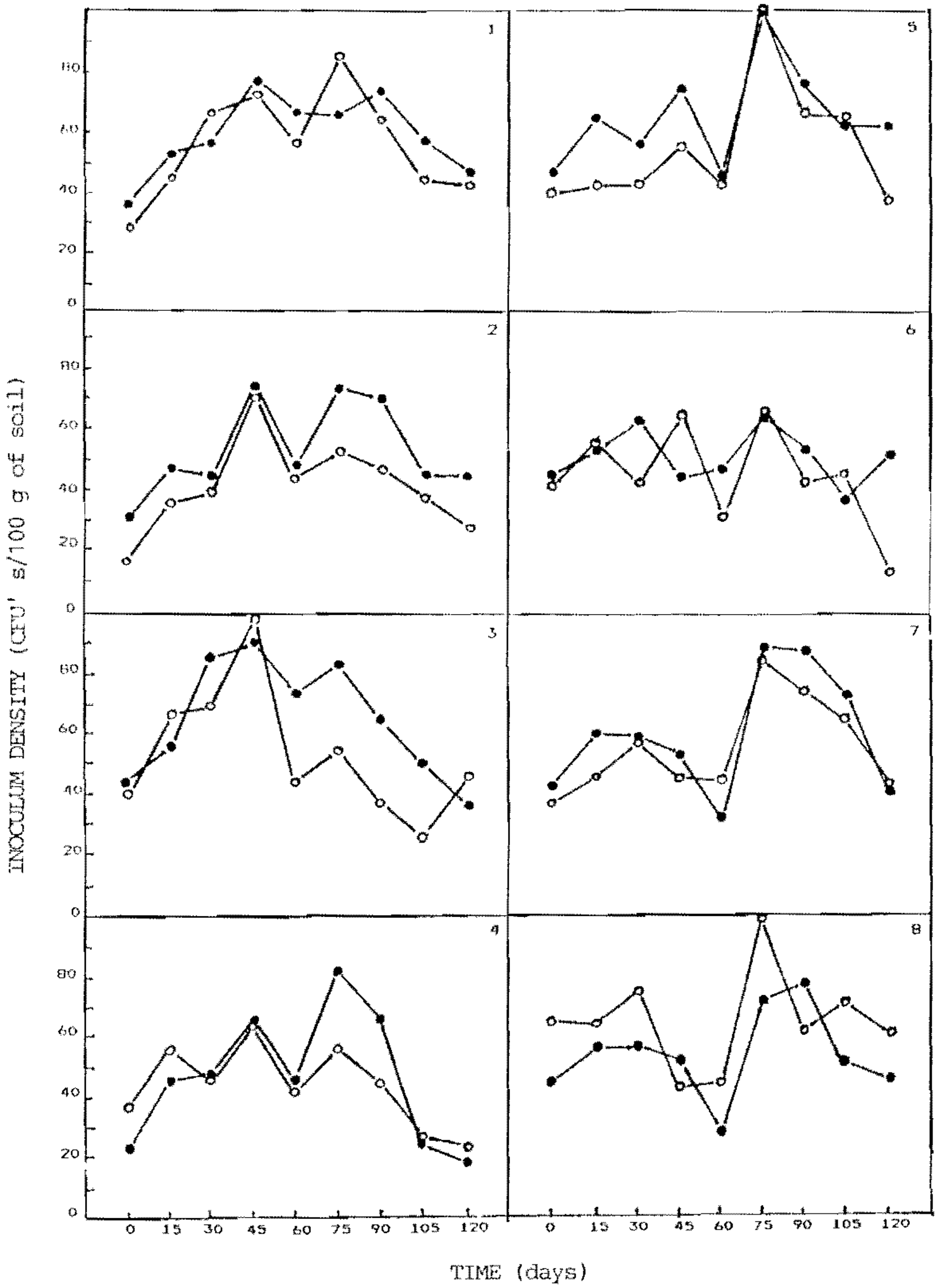


Figure 6. Population dynamics of Thanatephorus cucumeris on bean cultivars BAT 1155 (-●-) and BAT 1297 (-o-), grown on the following treatments: 1) ridge plus mulch; 2) ridge; 3) flat soil plus mulch ; 4) flat soil; 5) no mulch; 6) sugarcane residue; 7) plantain leaves; 8) weeds. Darien, Colombia, 1988A.

VIRAL PATHOGENS

Bean Common Mosaic Virus (BCMV)

A permanent responsibility since 1978, the screening of bean germplasm for bean common mosaic resistance will remain an important task of the VRU as long as resistance to BCMV is required for all improved bean germplasm developed by breeders both at CIAT and in national programs. CIAT's relative advantage in this area stems from the availability of all the necessary BCMV strains to characterize and select bean genotypes possessing dominant, recessive or multiple BCMV resistance. Also, CIAT has an artificial germplasm screening capacity in excess of 2,000 plants per work day.

Germplasm bank accessions. Table 1 shows the various germplasm materials screened this year. As can be observed, the characterization of the CIAT *Phaseolus vulgaris* germplasm bank continues for all accessions released by local quarantine authorities. The 1,688 bean accessions evaluated this year brings the total number of bean germplasm accessions evaluated for BCMV to 21,112. The results of these tests are already part of the Bean Program's computer data base. As in past years, the screening of early segregating materials, represented over half of the germplasm screened for common mosaic resistance.

Wild Phaseolus vulgaris accessions. A partial screening of wild *P. vulgaris* accessions for their reaction to a highly pathogenic strain of the virus (BCMV NL3) yielded some interesting results, in that 3 of the 327 accessions evaluated reacted with systemic necrosis, indicating the presence of the dominant necrosis (I) gene in wild *P. vulgaris*. A detailed study is currently being conducted with wild bean accessions of Meso-American and Andean origin in order to elaborate on the possible evolution of the I gene.

Black root resistance project. The black root resistance work continued this year with several F_2 families derived from crosses between the original sources of resistance and selected African materials. These evaluations revealed that while only 21% of the F_2 families yielded homozygous resistant selections, most of the F_2 families produced black root-resistant plants which can be selected and purified on an individual basis. A total of 123 materials selected in previous years from the various black root resistance projects, particularly the CIAT-INIA (Chile) and CIAT-IVT (Holland) collaborative projects, as well as from experimental crosses made at CIAT, were also advanced and reselected for their homozygous resistance to the predominant necrosis-inducing strains of BCMV. Of the black root resistant plants selected, 89% were immune, and 11% resistant (necrotic pin-point local lesions), when challenged with BCMV NL3, the most widely distributed and pathogenic BCMV strain detected so far in black root-affected regions.

Whitefly-Transmitted Bean Viruses

This has been an active year in which the bean geminivirus problem has been 'attacked' from all possible research angles: 1) selection of resistant germplasm; 2) initiation of genetic studies on the general combining ability of new germplasm sources of resistance; 3) characterization of the causal viruses at the molecular level; and 4) implementation of sensitive virus detection/diagnostic methods.

1. Selection of geminivirus-resistant bean germplasm
The development of an artificial inoculation methodology to evaluate bean genotypes for their reaction to the two main geminiviruses that attack beans in Latin America, bean golden mosaic and bean dwarf mosaic (formerly bean chlorotic mottle) viruses, made possible the detection of several non-black-seeded bean genotypes possessing different mechanisms of resistance to these viruses (CIAT: Bean Program 1986 Ann. Rept.). Based on this previous investigation, a total of 1,660 germplasm bank accessions belonging to the pinto, cranberry, great northern, and red kidney seed types; and some exotic genotypes from Africa, Asia, Australia, New Zealand, etc., were evaluated originally in Guatemala (Monjas) and Mexico (Los Mochis, Sin.). After three different evaluations at these locations, a total of 188 accessions was selected for further field evaluation in N.W. Argentina, Brazil (Goiania and Parana), Dominican Republic (San Juan de la Maguana), El Salvador (La Paz), and, again, in Guatemala (Monjas) and Mexico (Los Mochis); in all cases, with the cooperation of national program and regional scientists (EEAOC, INTA, and Ing. R. Ricci, in Argentina; CNPAF and IAPAR in Brazil; CESDA in the Dominican Republic; the University of El Salvador; ICTA and the Regional CIAT Program, in Guatemala; and INIFAP in Mexico. CIAT bean breeders were also present in most evaluations and some nurseries were evaluated by them, particularly for yield potential.

Table 2 shows a list of the 188 germplasm accessions selected and the countries where they exhibited superior adaptation or specific resistance traits under bean geminivirus pressure. Analyzing these results, it was found that approximately 16% of the 188 entries were selected in at least three different countries, indicating the existence of genotypes capable of expressing specific resistance traits under different environmental conditions. The least adapted of these various potential new sources of BGMV resistance were the Great Northern (GN) lines, which could not be properly evaluated in any of the selected evaluation sites. The contribution of the GN lines, however, can be readily appreciated by the superior performance of breeding materials derived from GN genotypes, both, under natural and artificial geminivirus pressure. Also, some GN lines, particularly GN 31 and GN 164557, possess a broad spectrum of virus resistance and also proved quite resistant to the inoculation of whitefly-transmitted bean geminiviruses, in artificial transmission tests previously performed at CIAT (CIAT Bean Program Ann. Rept., 1986).

Tuc 122, to cite one example, is an advanced small white-seeded line developed from GN 31 by EEAOC in Tucuman, Argentina, which has consistently exhibited good adaptation and yield potential in bean geminivirus-affected areas. In Brazil, GN 31 has also demonstrated a good combining ability in genetic crosses with Carioca and other Brazilian materials, such as A 478 and LM 306304. Finally, in Guatemala, a reciprocal cross between GN 164557 and the black-seeded genotype, Porrillo Sintetico, produced excellent F_2/F_3 populations with adequate variability and appreciable levels of BGMV resistance.

Several Pinto (seed color 2/4) and Cranberry (2/6) genotypes were also selected in different countries despite expected adaptation problems. In the various field evaluations, the pinto seed types exhibited better adaptation than the Great Northern lines. Pinto 114, the original source of BGMV resistance detected at CIAT, was selected in four out of the six countries where it was evaluated under field conditions. Two other Pinto lines, Pinto 72 and Gentry 21955 Garrapato, also performed well in at least 3 locations.

Pinto 114 has been selected as the most likely parental material to increase the level of BGMV tolerance of the Brazilian 'Carioca' cultivar. Some Brazilian lines crossed with Pinto 114 include: A 174, A 176, LM 306304, CNF 0178, and Emgoupa Ouro, most of which produced adequate populations to make bulk and/or individual plant selections. Two of the pinto accessions originally evaluated in Mexico (Sinaloa), Pinto Americano and Pinto Nacional, were selected as 'tolerant' and 'intermediate', respectively, for their reaction to BGMV. These materials have been selected by INIFAP breeders to improve Mexican BGMV-susceptible bean cultivars, particularly those genotypes of growth habit 2.

One of the most rustic pinto genotypes is 'Garrapato'. This genotype is one of the parents of A 429, one of the most tolerant lines previously found in a BGMV-affected bean nursery. Also, an improved 'Garrapato' line, Gentry 21955 Garrapato, was selected as one of the 12 most tolerant genotypes of the 1,660 germplasm accessions screened (see Table 4).

A related 'mottled' seed type, the Cranberry, was also included among the various seed types selected, particularly in Sinaloa, Mexico, where Cacahuate 72, Cacahuate Largo, and Cacahuate Bola behave as BGMV-tolerant materials. Two other cranberry-like accessions, one of Asian origin (Jatu Rong), and one of Brazilian origin (Gordo), were also selected in at least three different countries as part of the final selection of the 12 most tolerant bean accessions screened (Table 4).

But perhaps the most interesting group of the different seed types selected, was the Red Kidney, both the light and dark varieties. Two red kidney accessions: Gentry 21343 and Guaria, were selected in five out of the six countries chosen in this investigation. Two other red kidney accessions, 'Montcalm 023' and 'Red Kidney No. 2' were also selected at four locations. In the end, five red kidney accessions were selected among the 12 most resistant accessions of the 1,660 evaluated (Table 4).

PVAD 1111 is an example of a red-seeded genotype considered in Argentina as highly tolerant to both bean golden mosaic and bean dwarf mosaic viruses. This line possesses not only one but two red kidney genotypes, Carmine and Red Kote, in its pedigree. Two other lines recently selected in Argentina for their resistance to bean geminiviruses, AFR 180 and ZAA 2, were both derived from the red kidney genotype Royal Red.

In Brazil, some red kidney accessions were also selected not only for their tolerance to bean golden mosaic but, also, for their erect architecture, a desirable trait usually selected for in the progenies of crosses involving red kidney types. Five red kidney accessions: Red Kidney Wells, Red Kidney Dark, Kidney Royal Red, Dark Red Kidney 5305 and Red Kidney No. 2, were finally selected as potential sources of BGMV resistance, in Paraná (IAPAR), Brazil.

Also, the red kidney genotypes should be valuable to improve the red-mottled Pompadour seed types of the Dominican Republic. The red kidney accessions selected this year in the Dominican Republic by CESDA collaborators were: Gentry 21343; Riñon Rojo and Manitou. Unfortunately, this evaluation was done only for symptom expression and no yield data was taken.

In conclusion, preliminary screening tests had led to the identification of seven 'basic' sources of BGMV resistance (Table 3). Besides these seven genotypes, 12 germplasm accessions (Table 4) were later selected as the most promising new sources of bean geminivirus resistance among the 1,660 g. accessions evaluated in six Latin American countries.

We are confident that these bean genotypes will introduce enough genetic variability to the rather narrow genetic base from which most of the existing BGMV-tolerant/resistant genotypes have been derived (over 95% of all BGMV-tolerant lines have been obtained from a single black-seeded genotype, Porrillo Sintetico). The choice of materials should be primarily guided by the agronomic characteristics of the BGMV-susceptible cultivars to be improved. However, it is expected that the combination of the different genotypes selected here as BGMV-resistant/tolerant will result in even higher and more stable levels of resistance. Consequently, a genetic study of the general combining ability of the various seed-types selected (red kidney; pinto, great northern, red mexican, etc.) is currently being conducted.

Characterization of the Main Bean Golden Mosaic Virus Isolates Existing in Latin America

Considering the wide and yet dispersed geographical distribution of bean golden mosaic virus (BGMV) in Latin America, a thorough investigation of the degree of relatedness among the main Latin American isolates of BGMV is critical for the development of improved bean cultivars possessing stable resistance. This information will allow us to discriminate between pathogenic and environmental interactions with the bean germplasm under evaluation.

Up till very recently, there was circumstantial evidence suggesting that the BGMV isolates from Brazil were different from the Central American and Caribbean isolates, in that the Brazilian BGMV isolates have not yet been mechanically transmitted (neither the Brazilian nor the Argentinian BGMV-isolates have been mechanically transmitted while all other BGMV isolates, from Colombia to northern Mexico, are mechanically transmissible). Also, there is a conceptual problem regarding the definition of virus 'strains' within the whitefly-transmitted gemenivirus group. A 'strain' is usually defined as a variant of a pathogen that induces different effects in a plant. The concept of 'strain' is more easily understood when strains infect different genotypes. Unfortunately, all BGMV isolates evaluated are capable of systemically infecting all bean genotypes tested so far. Therefore, in the case of BGMV, we have to deal with the concept of 'strains' mainly in terms of differential symptom expression. Symptom expression, unfortunately, varies according to the host genotype and environmental conditions. The problem associated with the characterization of whitefly-transmitted bean viruses is further complicated by the close serological relationship that exists not only between related bean geminiviruses, such as bean golden mosaic and bean dwarf mosaic viruses, but among the whitefly-transmitted geminiviruses in general. For instance, an antiserum prepared to a whitefly-borne geminivirus of cucurbits (squash leaf curl virus), detects BGMV in bean plants as efficiently as the homologous (BGMV) antiserum.

Consequently, the characterization of BGMV strains has necessitated the implementation of two novel techniques currently used by molecular virologists: 1) the production of monoclonal antibodies and 2) the characterization of their ss-DNA genomes.

Production of Monoclonal Antibodies to BGMV

Last year (Bean Program, CIAT Ann. Rep. 1987), some preliminary serological comparisons with four different gemeniviruses, were kindly made at the Scottish Crop Research Institute by Dr. B.D. Harrison, using monoclonal antibodies produced to African cassava mosaic, another whitefly-transmitted geminivirus serologically related to BGMV. As already reported, one monoclonal antibody (SCR 18) was able to distinguish between the Guatemalan and Mexican isolates of BGMV; and between the Guatemalan isolate of BGMV (a typical BGMV isolate) and Bean Dwarf Mosaic Virus. Encouraged by these results, and with the cooperation of Dr. E. Hiebert, of the Plant Pathology Department, University of Florida, several monoclonal antibodies were produced against a related geminivirus isolated from *Macroptilium* sp. (the original BGMV isolate was also obtained from *Macroptilium* sp.). The results obtained in these tests (Table 5) are similar to those obtained using the African Cassava Mosaic Virus monoclonals, as well as with previous observations based on symptom expression, suggesting that the Mexican, Pto. Rican, and Salvadorian isolates of BGMV are different from all other BGMV isolates tested. Similarly, bean dwarf mosaic virus was shown to be related but distinct from BGMV (Table 5).

The ability to discriminate between BGMV and either BDMV or other closely-related geminiviruses, such as the *Macroptilium* isolate, is very important in bean production areas or breeding nurseries where these viruses usually co-exist. This level of serological specificity had not been possible with polyclonal antisera although the implementation of a qualitative and quantitative test, such as the immunosorbent electron microscopy (ISEM) test detected significant antigenic differences between some of the various bean geminivirus isolates tested (Table 6). The quantitative accuracy of the ISEM test, however, is affected by several variables.

The results obtained so far clearly indicate serologically that it is possible to differentiate some of the geminiviruses that attack beans. However, further screening is needed to select monoclonal antibodies specific enough to differentiate between the main BGMV isolates or strains. This work is pending approval of a special project proposal submitted jointly by the University of Florida and CIAT.

Molecular Approaches to Characterization of Bean Golden Mosaic Virus Isolates

The close antigenic relationship that exists among the various members of the geminivirus group transmitted by the whitefly species Bemisia tabaci, clearly constitutes a limitation to the implementation of standard diagnostic techniques. As mentioned earlier, viruses as apparently dissimilar as African cassava mosaic and bean golden mosaic viruses proved serologically related even in monoclonal antibody assays. Moreover, the extreme pathogenicity of all the BGMV isolates inoculated so far in thousands of P. vulgaris cultivars, all of which became systemically infected, left no alternative but to characterize the single-stranded DNA genomes of selected geminivirus isolates.

Nucleic Acid Hybridization Tests

Three complementary DNA probes produced by Dr. S. Haber at the University of Illinois: Hd 102 and 207 containing DNA-A sequences, and Sa 2, containing a 1,550 base pair fragment of DNA-B, were used in this investigation. These clones are M 13 (phage) recombinants, a vector increased in E. coli JM 101 cells. The screening procedure involved the selection at CIAT of plaques that contained the M13 replicating form (RF) possessing the appropriate fragment of the BGMV genome as determined by restriction enzyme digestion and electrophoresis of the resulting fragments (Figure 1). Only those RFs which contained the correct fragments were selected for nucleic acid hybridization (NAH) tests using radioactive (^{32}P) probes.

Figures 2 and 3 show the results of the NAH tests conducted with 10 BGMV isolates; a geminivirus isolated from Macroptilium sp. in Florida, USA; a geminivirus isolated from Phaseolus lunatus; and Bean Dwarf Mosaic Virus. All virus isolates were simultaneously inoculated in 'Topcrop' bean plants, and tested at the same time.

Autoradiograph I (Figure 2) shows little or no hybridization for the Mexican (MX) isolate of BGMV, an isolate which has consistently failed to induce typical golden mosaic symptoms in BGMV-susceptible bean cultivars under our experimental conditions (BGMV-MEX induces foliar chlorosis). Sample 6, a geminivirus isolated from Macroptilium sp. in Florida, USA, did not hybridize either, as expected for a different legume geminivirus. Samples 4 (P. lunatus isolate), 5 (BGMV Guatemala), and 7 (bean dwarf mosaic virus) gave intermediate reactions, suggesting either an intermediate degree of genome homology between BGMV-PR and these three viruses, or a differential virus multiplication rate in Topcrop bean plants. BGMV Costa Rica, on the other hand, gave a fairly strong signal (sample 3), indicating a high degree of homology between their DNA A genomes. The strongest radioactive signal, of course, corresponds to the homologous virus isolate, BGMV PR (No. 8).

Autoradiograph II (Figure 3) shows NAH reactions obtained with the rest of the geminivirus isolates tested. In this case, all geminiviruses reacted strongly with the exception of the El Salvador BGMV isolate, which induces a striking systemic yellowing (typical golden mosaic symptoms) contrasting with the chlorotic symptoms induced by the BGMV PR isolate cloned to produce the probe used in these tests. Coincidentally, the BGMV isolate from El Salvador was also differentiated in the monoclonal antibody tests described earlier in this report.

The VRU is further characterizing these BGMV isolates by 'fingerprint' analysis: geminivirus-RFs from infected tissue are extracted, restricted, Southern blotted, and hybridized with the probes containing labelled sequences from the BGMV genome. The resulting hybridizing band pattern should allows us to group geminivirus isolates.

Cloning and Sequencing of BGMV Isolates

The appreciable degree of homology observed between most of the BGMV isolates tested, clearly indicates the need to thoroughly characterize the genomes of the individual BGMV isolates selected.

The following data are the result of a cooperative CRSP/Title XII project first established between the University of Wisconsin and Brazil (CNPAF), and later joined by CIAT with a view to achieving the comparison of the main BGMV isolates occurring in Central and South America, and the Caribbean area.

Characterization of Brazilian, Guatemalan, and Dominican Rep. BGMV Isolates

DNA extracts prepared in Brazil from BGMV-infected bean leaves were used for cloning in suitable plasmid vectors. A full length DNA A clone of the Brazilian (BZ) BGMV isolate has now been produced and sequenced on both strands. The results of the comparative tests conducted at the University of Wisconsin between the original, Pto. Rican (PR) and BGMV-BZ DNA A components showed an overall divergence in their DNA sequences of over 25%.

Partial cloning and sequencing of the Guatemalan (GA) isolate of BGMV DNA A, show some regions common to both BGMV-PR and BGMV-BZ. Consequently, BGMV-GA has the character of a 'hybrid' between BGMV-PR and BGMV-BZ. Although genetic recombination between co-infecting geminiviruses has been demonstrated, further sequencing of the BGMV-GA components A and B is necessary to elucidate a probable evolutionary or epidemiological pattern for this BGMV isolate.

Recently, full length clones of the DNA A component of the Dominican Republic (DR) isolate of BGMV have been obtained by Dr. D. Maxwell at the University of Wisconsin. Partial sequencing suggests this isolate is more closely related to BGMV-PR and BGMV-GA than to BGMV-BZ. Efforts are now concentrated on the production of DNA B full-length clones of the GA and DR isolates of BGMV.

In conclusion, the results obtained so far demonstrate that considerable differences exist among the BGMV isolates tested. These genomic differences are considered by molecular virologists as sufficient evidence for the existence of distinct viruses. However, it is recommended here that as long as the various geminivirus isolates being characterized, exhibit a similar pathogenicity range in *Phaseolus vulgaris*, and induce characteristic golden mosaic (yellowing) symptoms in susceptible bean genotypes, they should be considered as bean golden mosaic virus strains.

On the contrary, those geminiviruses, such as the *Macroptilium* isolates or bean dwarf mosaic virus, which induce chlorosis rather than yellowing and exhibit a differential disease reaction with some BGMV-susceptible *P. vulgaris* cultivars, should be considered distinct from BGMV.

The VRU is currently complementing the information generated by molecular virologists at the University of Wisconsin, by means of pathogenicity tests using a fixed set of differential bean cultivars for all the geminivirus isolates being characterized. It is, thus, expected that the general data gathered from the various tests performed on these virus isolates, will allow breeders to make a better selection of parental materials and segregating populations. For instance, the characterization of the Mexican isolate of BGMV has indicated the existence of BGMV strains in N.W. Mexico, possessing moderate pathogenicity to the local cultivars. Therefore, there is no need to select highly BGMV-resistant but rustic parental genotypes to improve the erect cultivars of N.W. Mexico. Rather, some intermediate BGMV-resistant bean cultivars, such as those in the red kidney group, which already possess desirable architectural and agronomic characteristics, can be selected as sources of BGMV resistance in N.W. Mexico.

Table 1. Germplasm accessions and breeding materials screened for their response to selected bean common mosaic virus strains

Germplasm/Projects		No. Materials
Bank Accessions		
-domesticated *P. vulgaris*		1,688
-wild *P. vulgaris*		327
Parental materials		414
Progeny tests		6,905
CIAT Nurseries		
PRE-VEF 88	568	
VEF 88	804	
EP 88	368	1,740
Special Projects		
Pathology	768	
Earliness	100	
Local Red-seeded	104	
Medium-seeded	1,117	
Brazil	279	
IVT	20	2,338
Black Root Resistance		259
National Program Germplasm		
Brazil	35	
Peru	36	71
		15,333*

* An average of 15 plants per material.

Table 2. Preliminary bean germplasm selections of potential sources of resistance to bean golden and bean dwarf mosaic viruses

	Germplasm		Evaluation Site*						Seed Color**	
Entry	Ident. No.	Name	A	B	DR	G	M	S	PSC	SSC
1	G03844	Cascade	*	*					1	
2	G05050	Great Northern No. 59		*					1	
3	G05051	Great Northern No. 1140		*					1	
4	G05477	Great Northern No. 1 Sel. 27							1	
5	G05487	Great Northern U.I.123							1	
6	G05506	Great Northern 123							1	
7	G05710	Great Northern U.I.31	*						1	
8	G06156	Great Northern U.I.61		*					1	
9	G06361	Great Northern							1	
10	G06378								1	
11	G06659	Great Northern U.I.61	*						1	
12	G08774	Great Northern Valley							1	
13	G08790	Great Northern No. 15							1	
14	G08791	Great Northern U.I.1							1	
15	G09205	Great Northern U.I.31							1	
16	G09551	Great Northern							1	
17	G11279	Great Northern U.I.59							1	
18	G14784	Great Northern U.I.1130		*					1	
19	G14785	Great Northern D'Amerique							1	
20	G17686	Great Northern 164557							1	
21	G06622	Green Pod 473-A					*		1	
22	G06624	Green Pod 73047					*		1	
23	G06597	Jackpot					*		1	
24	G09358	Slender Green					*	*	1	
25	G13257	Spotted		*			*	*	1	6
26	G13315	Pink Beans	*	*			*		2	
27	G06599	Purple Runner					*		2	
28	G02193	Gentry 21088 Canario					*		2	3
29	G05722	Bush Romano 14				*			2	3
30	G10189	Little Parchement				*		*	2	3
31	G14704	Cachamundinho VIII		*			*	*	2	3
32	G02402	Gentry 21955 Garrapato		*	*	*			2	4
33	G03625	Pinto 72	*	*		*			2	4
34	G04338	Michoacan 6					*		2	4
35	G04449	Pinto 114	*	*	*	*			2	4
36	G05801	Pinto Dorado		*					2	4
37	G05879	Bayos 1941		*			*		2	4
38	G06437	Rayados	*			*			2	4
39	G08086	Pinto Columbia 114	*	*		*			2	4
40	G09892	Ojo de Venado					*		2	4
41	G10430	Portugal 375					*		2	4
42	G10947	Pinto Texano					*		2	4
43	G13608	Venado					*		2	4
44	G13639	Ojo de Liebre					*		2	4
45	G13669	Ojo de Liebre					*		2	4

Entry	Germplasm Ident. No.	Name	Evaluation Site*						Seed Color**	
			A	B	DR	G	M	S	PSC	SSC
46	G13764	Carioca			*	*	*	*	2	4
47	G13839						*		2	4
48	G16050	Pinto Nacional					*		2	4
49	G16060	Pinto	*				*	*	2	4
50	G16065	Garrapata	*				*	*	2	4
51	G16215	Gyongyostarjani TF 2247				*			2	4
52	G16703	Iran Sarab 978		*			*		2	4
53	G17254	31/1					*		2	4
54	G00014	Poucha Rosada			*	*			2	6
55	G00121	Jatu Rong	*		*	*		*	2	6
56	G00122	Jatu Rong	*		*	*			2	6
57	G00138	W. Koelz			*	*			2	6
58	G00404	Round Speckled Sugar	*			*			2	6
59	G00645	W. Koelz Rong			*	*		*	2	6
60	G00648	W. Koelz Rong			*	*		*	2	6
61	G00650	W. Koelz Rong			*	*		*	2	6
62	G00655	Granda x Erecta				*		*	2	6
63	G00719	Baldwin Jr. No. 5			*	*			2	6
64	G00834	Norvell No. 3152			*	*			2	6
65	G00890	Godfrey No. 425			*	*			2	6
66	G00906	Godfrey No. 887				*			2	6
67	G01058	Geneva 11369				*			2	6
68	G01389	Gentry 13874 Cote			*	*			2	6
69	G01451	E.W.Davis No. 199 A			*	*			2	6
70	G04508	Cuarentano		*			*	*	2	6
71	G04517	F5 JH 13/8/9				*		*	2	6
72	G05123	Tipo Tupi Sarg Do Sul	*			*			2	6
73	G05481	Cacahuate 72				*			2	6
74	G06500	Gordo	*			*	*		2	6
75	G09219	Kievit Koekoek				*			2	6
76	G09801	N.N.					*		2	6
77	G10082	Grootzadige (Zwaan)				*		*	2	6
78	G10083	Grootzadige (Tubergen)				*		*	2	6
79	G10084	Grootzadige (V. Namen)			*	*		*	2	6
80	G10085	Grootzadige (Wouda)			*	*		*	2	6
81	G10087	Grootzadige (Wageningen)			*	*		*	2	6
82	G10088	Grootzadige (Eng)			*	*		*	2	6
83	G10089	Grootzadige (Wageningen)				*		*	2	6
84	G10090	Renka				*			2	6
85	G10094	Grootzadige (Nieuwe Wete)			*	*		*	2	6
86	G10105	Grootzadige A (Dieren)				*		*	2	6
87	G10106	Grootzadige B (Dieren)				*		*	2	6
88	G10229	Dwarf Nervio Type				*		*	2	6
89	G10345	Catarina Type				*		*	2	6
90	G11867	Grootzadige (Wag. III)				*			2	6
91	G11871	Kievitsboon (Batenburg)				*			2	6
92	G13591	WYR 13210				*			2	6
93	G13592	Borlotto (Climbing)				*			2	6
94	G13593	Borlotto (Dwarf)				*			2	6
95	G13667	Cacahuate	*			*			2	6

Entry	Germplasm Ident. No.	Name	Evaluation Site* A	B	DR	G	M	S
96	G13675	Cacahuate	*			*		
97	G13848					*		
98	G13904					*		
99	G14057	Kievit Bulten				*		
100	G14171					*		
101	G14200	PLB 52			*	*		*
102	G14385					*		
103	G14402					*		
104	G14409					*		
105	G14678	IICA Z.A. 586 = radical				*		
106	G14777	Cranberry		*			*	
107	G15322					*		
108	G15584	TR 33065				*		
109	G15599	TR 33208				*		
110	G15638	M 7548 Cacahuate	*			*		
111	G15643	M 7633 Cacahuate				*		
112	G15669	M 7712-30 Cacahuate				*		
113	G15678	M 7721-6 Cacahuate				*		
114	G16227	Edelenyi TF 2368				*		
115	G16228	Edelenyi TF 2369				*		
116	G16242	Szalonna				*		
117	G16246	Szogligeti TF 2400				*		
118	G17007	Turkey Eshashir 1741			*	*		
119	G05672	T-N-U			*		*	
120	G13256	Carob	*		*		*	*
121	G10102	Kleinzadige Kootwijk					*	
122	G00023						*	
123	G00426	Harlan No. 8213 Cali			*	*		*
124	G10093	Grootzadige Met Afw.				*		
125	G13565	484048				*		
126	G14425					*		*
127	G15398					*		
128	G15407					*		
129	G15410					*		
130	G03609	Habilla Pinto Crema				*		*
131	G05125	Sacavem 1131	*			*		
132	G05129	Sacavem 597	*			*		
133	G05130	Sacavem 1000				*		
134	G13774						*	
135	G14045	Coco Nicois			*	*		*
136	G14298	409			*		*	
137	G05746	Redlands Greenleaf C	*	*	*		*	
138	G14523	Cornell Mas. 200				*		
139	G01743	Echan.& Salas 4				*		
140	G01935	Gentry 21343 Cacahuate		*	*	*	*	*
141	G03602	Red Kidney Wells		*		*	*	
142	G03626	Guaria	*	*	*	*	*	
143	G04458	27-R		*	*	*		
144	G04538	Riñon Rojo			*	*	*	
145	G04677	Revoltura				*		

Entry	Germplasm Ident. No.	Name	Evaluation Site* A	B	DR	G	M	S	Seed Color** PSC	SSC
146	G04798	Red Kote 7688		*					5	
147	G04813	Red Kote 7701				*			5	
148	G04961	27-R		*		*			5	
149	G05033	Red Kidney				*			5	
150	G06414	Manitou			*	*			5	
151	G06729	Linea 19					*		5	
152	G09154	Costa Rica 2		*		*			5	
153	G13222	Kidney Beans		*	*	*			5	
154	G00100	Clarendon W.X Wellington W				*		*	6	
155	G00254	Harlan No. 2255 Cali Oturak	*	*		*		*	6	
156	G03599	Red Kidney Dark	*	*	*	*		*	6	
157	G03721	K-133	*				*		6	
158	G04450	Royal Red	*			*			6	
159	G04956	Guat 174-C-2					*		6	
160	G05359	Dark Red Kidney	*			*		*	6	
161	G06054	Red Kidney				*			6	
162	G06416	Montcalm 023		*	*		*	*	6	
163	G06724	Kidney Royal Red Idaho	*	*	*	*		*	6	
164	G06960	Sacavem 81		*		*		*	6	
165	G08663	Bachicha				*			6	
166	G11699	Dark Red Kidney				*	*		6	
167	G13594	C-75-(Carruaro)	*			*		*	6	
168	G14474	Carmine	*		*	*			6	
169	G14949	Dark Red Kidney 5305		*					6	
170	G15017A				*	*			6	
171	G16102					*			6	
172	G17271	661313		*			*		6	
173	G17280	97					*		6	
174	G17292	115/2					*		6	
175	G17296	130/1					*		6	
176	G13384	Umaket 1					*		6	
177	G13388	Red Kidney No. 2		*	*		*	*	6	
178	G00687	Windsor Longpod		*			*	*	6	
179	G06384	Red Mexican U.I.35	*						6	
180	G06385	Red Mexican U.I.36	*				*		6	
181	G09162	Dark Red Kidney				*			6	
182	G15947	Charlevoix 1	*			*			6	
183	G13255	Fig Bean	*		*		*		6	2
184	G13228	Toiku 818		*			*		7	
185	G01660	College Early		*			*		7	
186	G16217	Turonyi TF 2250				*			7	
187	G11284	Tendergreen 32304					*		7	2
188	G01663	Fin de Monclair V.					*		8	

* A = Argentina; B = Brazil; DR = Dominican Republic; G = Guatemala; M = Mexico; S = Salvador.

** Psc = Primary Seed Color; SSC = Secondary Seed Color (mottle types).

Table 3. Basic seed types used as sources of bean golden mosaic resistance.

G. No.	Name
05481	Cacahuate 72
16059	Garrapato
05710	Great Northern 31
17686	Great Northern 164557
04449	Pinto 114
06384	Red Mexican 35
05746	Redlands Greenleaf C

Table 4. Final selection of non-black-seeded bean genotypes selected as new sources of resistance to bean geminiviruses.

Germplasm No.	Name	Origin	Size	Seed Color	Growth Habit
00121	Jatu Rong	India	Med.	Cream/Red	1
00254	Harlan No. 2555 Cali Oturak	Turkey	Large	Med.	1
02402	Gentry 21955 Garrapato	Mexico	Med.	Pinto	3
03599	Red Kidney Dark	USA	Large	Red	1
03602	Red Kidney Wells	USA	Large	Red	1
03625	Pinto 72	USA	Large	Pinto	3
04450	Royal Red	USA	Large	Red	1
05129	Sacavem 597	Brazil	Large	Cream/Black	1
06385	Red Mexican 36	USA	Med.	Red	3
06500	Gordo	Brazil	Med.	Cream/Red	2
06724	Kidney Royal Red	USA	Large	Red	1
08086	Pinto Colombia 114	USA	Med.	Pinto	3

Table 5. Serological relationship between selected bean geminivirus as determined by immuno-enzymatic assays with monoclonal antibodies

	Monoclonal antibody*			
Virus** Isolate	ED7-B2-A2 ASC 1/88	ED7-B2-A2 ASC 1/87	ED7-B2-A2 TCS 1	BB10-64-B10 TCS 2
BGMV DR	+	+	+	+
BGMV ES	+	+	-	+
BGMV GU	+	+	+	+
BGMV MX	+	+	-	+
BGMV PR	+	+	-	-
BDMV	+	+	-	-
GV MAC	+	+	+	+
Sano	-	-	-	-
PBS	-	-	-	-

* Monoclonal antibodies produced to the <u>Macroptilium</u> isolate of BGMV; ASC = Ascites; TCS = Tissue culture supernatant.

** BGMV DR = Dominican Republic; ES = El Salvador; GU = Guatemala; MX = Mexico; PR = Puerto Rico; BDMV = Bean Dwarf Mosaic Virus; GV MAC = geminivirus isolated from <u>Macroptilium</u> sp.

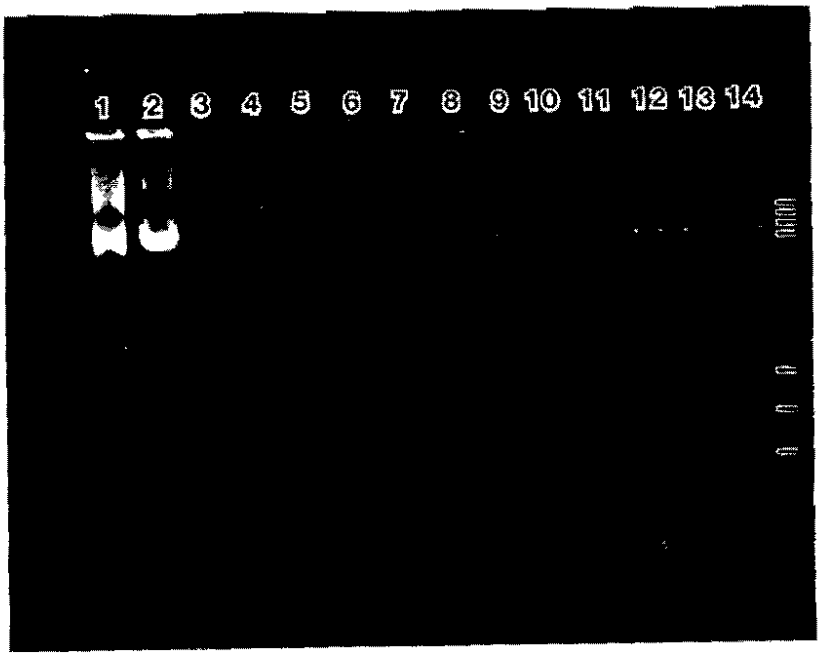
Table 6. Serological Relationship between two Bean Golden Mosaic Virus Isolates, Bean Dwarf Mosaic Virus and a geminivirus isolated from Macroptilium sp. as determined by the Immunosorbent Electron Microscopy (ISEM) test

ANTISERUM	ANTIGEN BGMV-GU		BGMV-PR		GV-MAC		BDMV	
BGMV GU	*15.887 **	100%	19.805	124%	6.881	43%	11.077 GU	69%
BGMV PR	12.084	6.3%	189.996	100%	11.748	6.1%	12.641	6.6%
GV-MAC FL	10.842	50%	17.791	82%	21.594	100%	9.399	43%
BDMV	11.278	55%	33.903	166%	7.720	37%	20.342	100%

Note: * No. of particles/mm^2

** Homologous reactions are considered of a 100% of homology and the rest of percentage are calculated based on that data.

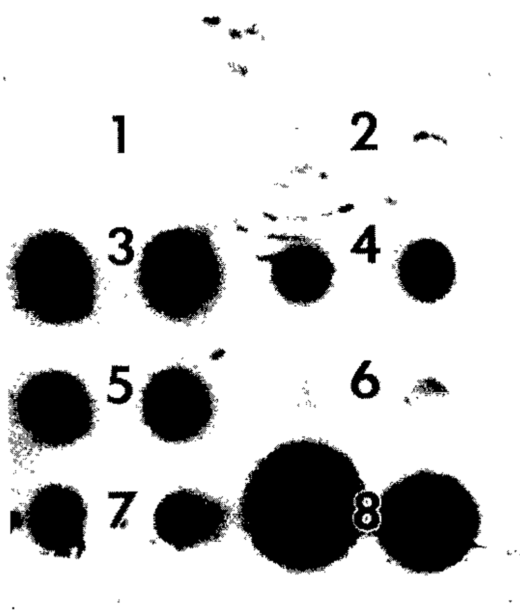
Figure 1. Agarose gel electrophoresis of replicative forms (RFs) of M13 recombinant phages isolated from transfected bacterium cultures. Each lane shows DNA from an individual plaque and the inserted Bean Golden Mosaic Virus (BGMV-Pto. Rico) genome fragment.



Lane

1 Undigested M13 RF
2 Hind III digested M13 RF
3 Undigested Hd 207 RF
4 Hind III digested Hd 207 RF
5 Hind III digested Hd 207 RF giving a fragment of 1,000 bp
6 Hind III digested Hd 207 RF giving a fragment of 1,000 bp
7 Undigested Hd 102 RF
8 Hind III digested Hd 102 RF giving a fragment of 1,650 bp
9 Hind III digested Hd 102 RF giving a fragment of 1,650 bp
10 Hind III digested Hd 102 RF giving a fragment of 1,650 bp
11 Undigested Sa2 RF
12 Sal I digested Sa2 RF giving a fragment of 1,550 bp
13 Sal I digested Sa2 RF giving a fragment of 1,550 bp
14 Sal I digested sa2 RF giving a fragment of 1,550 bp
15 Lambda DNA Hind III fragment and Φ X-174 RF Hae III fragment size standards from top to bottom (bp): 23,130; 9,416; 6,557; 4,361; 2,322; 2,027; 1,353; 1,078; 872.

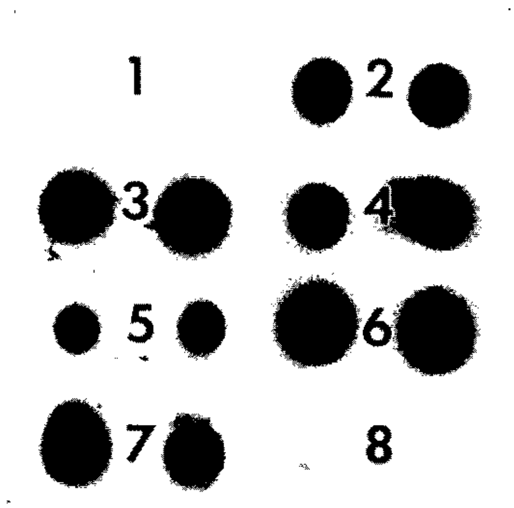
Figure 2. Autoradiograph of a nucleic acid squash hybridization test of seven different geminiviruses



Sample	Inoculated with	Geminivirus symptoms
1	Buffer	-
2	BGMV-Mexico	+
3	BGMV-Costa Rica	+
4	Phaseolus lunatus isolate	+
5	BGMV-Guatemala O	+
6	Macroptilium sp. isolate	+
7	BDMV Bean Dwarf Mosaic Virus	+
8	BGMV-Puerto Rico	+

Probe: DNA 1 labelled with ^{32}p (CP gene) from BGMV-Puerto Rico
Sample: All viruses were simultaneously inoculated and maintained in P. vulgaris cv Topcrop.

Figure 3. Autoradiograph of a nucleic acid squash hybrization test of ix golden mosaic virus isolates



Sample	Inoculated with	Geminivirus symptoms
1	Buffer	-
2	BGMV-Guatemala 1	+
3	BGMV-Guatemala 2	+
4	BGMV-Colombia	+
5	BGMV-Salvador	+
6	BGMV-Rep. Dominicana	+
7	BGMV-Cuba	+
8	Bean (N. def.) from field	+

Probe: DNA 1 labelled with ^{32}p (contains CP gene) from BGMV-PR
Sample: All viruses (but 8) were simultaneously inoculated and maintained in P. vulgaris cv. Topcrop.

INSECT PESTS

Breeding for resistance to bruchids, pod weevil and leafhoppers continued in 1988. Further studies on mechanisms and factors responsible for resistance to bruchids were conducted. Significant progress was made in the identification of appropriate techniques to select resistant materials in segregating populations. Lines with resistance to both species were identified and some of those are being advanced for further testing with the insects. Studies on mechanisms of resistance to pod weevil confirmed previous results and more resistant lines were identified in Honduras and Guatemala. Techniques for selection of bean materials (for resistance to leafhoppers were refined more recently, studies on integrated pest management of leafminers and whitefly were initiated. Results will be reported in 1989.

BRUCHIDS

Screening for Resistance

Characterization of wild *Phaseolus vulgaris* collections continued in 1988. Two accessions (G 02771 and G 12956) were added to the list of materials with reconfirmed levels of resistance to *Zabrotes subfasciatus*. Intermediate levels of resistance to *Acanthoscelides obtectus* were found in accessions G 12873A and G 12956. Given the fact that escapes to *A. obtectus* occur, 44 accessions previously reported as resistant to this species were rescreened in five replications. This study indicated that accessions G 12862B, G 12867, G 1280, G 12947, G 12949, G 12950, G 12951, G 12952, G 12953, G 12954, G 12955, G 13016, and G 13017 are truly resistant and can be incorporated with confidence in future crossing blocks.

In order to better understand insect-host plant relationships, studies on resistance to bruchids in species within the genus *Phaseolus* continued. A total of 104 accessions belonging to 18 different species were screened. A highlight of this study was the identification of very high levels of antibiotic resistance to *A. obtectus* in all of 22 *P. lunatus* accessions studied. Electrophoretic studies on these materials could provide valuable information on the mechanisms of resistance to this species.

Mechanisms and Factors Responsible for Resistance

As in 1987, extensive work was conducted on mechanisms and factors responsible for resistance to bruchids.In

Seed Color**	
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particular, emphasis was placed on the effect of arcelin and tannins on the biology of both Z. subfasciatus and A. obtectus.

As reported previously (see CIAT Annual Report, 1987) the presence of arcelin confers resistance to Z. subfasciatus but not to A. obtectus. This was reconfirmed when lines selected for the presence of four arcelin types were tested in replicated feeding tests. None of the lines was resistant to A. obtectus and those with arcelin 1 and 4 showed the highest levels of resistance to Z. subfasciatus. Arcelin 3 was the least active.

To further reconfirm these results, different tests were conducted on Z. subfasciatus reared in artificial and intact seeds of Sanilac-backcrossed lines selected for the presence of either arcelin-1, arcelin-2 or arcelin-4. As in previous studies, arc-1 conferred the highest levels of resistance to Z. subfasciatus (Table 1).

In addition, purified arcelin 1 and 2, received from the University of Wisconsin, were tested at increasing concentrations in artificial seeds. At the lowest level tested, arcelin-1 had no significant effect on larvae. As the concentration increased, larval mortality also increased and a linear dosage response was obtained (Figure 1). Probit analysis revealed that the LC_{50} was 6.8%, a figure almost identical to that obtained in 1987 (6.5%). A dosage response was also obtained when purified arcelin 2 was tested at increasing concentrations (Figure 2). In this case, the LC_{50} was k0.4%, indicating that, as stated above, arcelin-1 is more effective than arcelin-2 in supressing larvae of Z. subfasciatus.

In contrast, no dosage responses to the addition of purified arcelins were obtained with A. obtectus (Table 2). For instance, even at 10% concentration, a level which kills 95% of Z. subfasciatus larvae, arcelin-1 failed to impart acceptable levels of resistance to A. obtectus.

Further studies on the effect of tannins on the biology of bruchids reconfirmed that these do not have a significant effect on the biologies of both bruchids (Table 3).

Breeding for Resistance

Following the characterization of resistance factors, breeding for resistance to bruchids has been facilitated. Selection for resistance to Z.

subfasciatus is based upon serological tests (Ouchterlony plates) for the presence of arcelin at the rate of more than 7,000 seeds per year. Progress was made in the refinement of the technique as well as in developing the capability to produce at CIAT (in the Virology Unit) antibodies for arcelin-1 and arcelin-4. These were previously obtained from the University of Wisconsin. Progress was also made in accelerating selection in F_2 populations for resistance to *A. obtectus*. In the absence of a quick screening technique for this species, a modified, simplified feeding test with individual seeds was developed in 1988. Following are highlights of the breeding work.

At present, a number of progenies with commercial seed size and colors, and with reconfirmed levels of resistance to *Z. subfasciatus* are available in the program. These are being multiplied and reselected for agronomic characteristics under field conditions. Table 4 illustrates the levels of resistance that have been attained with some of the best F_4 and F_5 progenies. Table 5 also shows some of the best F_4 progenies selected not only for agronomic characters but also for the presence of arcelin and reconfirmed levels of resistance to *Z. subfasciatus*. In addition, we now have in the process of multiplication and/or selection for resistance, a large number of F1, F2, and F3 first and second backcross selections made for the presence of arcelin. These will soon be tested in replicated feeding trials with *Z. subfasciatus*. Virtually all of the progenies selected from backcrosses do not have the undesirable agronomic characters of the wild resistant parent and share the agronomic and seed size and color characteristics of the cultivated recurrent parent.

A study on inheritance of resistance to *A. obtectus* suggested that resistance to this species could be due to two or three genes recessively inherited. A backcross breeding scheme which involves individual seed testing with the insect in F_2 populations was then adopted. At present, 31 BC_1F_2 populations are being evaluated for resistance. Resistant seeds will be multiplied in the greenhouse and backcrossed again to the recurrent parent to be retested with the insect.

Detailed studies on possible toxic effects of arcelin on mammals were initiated in 1988. Mice are being used to study the effect of arcelin-containing-diets on nutrition and reproduction. Results will be reported in 1989.

EMPOASCA KRAEMERI

As reported in 1987, emphasis has shifted towards selection of red and white seeded materials, some of which outyielded the checks EMP 175 and BAT 41 in the F_3. These were evaluated as F_4 populations in the second semester of 1987. Following individual plant selections, the materials were progeny-tested in the first semester of 1988. The best are being yield-tested in the F_6 generation and will be harvested following the presentation of this report. Consequently, results will be presented in 1989.

Meanwhile, breeding for resistance in black- and cream-seeded materials has continued. As in previous occasions, several materials in the F_3 generation significantly outyielded the tolerant check, ICA-Pijao (Table 6). New, higher yielding EMP lines were tested in 1988. Several of these lines (Table 7) were better than Pijao.

BEAN POD WEEVIL

Bush and climbing lines selected for resistance to _Apion godmani_ in Honduras in 1987, were evaluated again in 1988. Due to low levels of infestation during the first semester, no infestation data could be obtained. However, several materials were selected for good adaptation and seed color and are being tested again. These will be evaluated in December, 1988, following the presentation of this report. The thirteen APN bush bean lines selected from the 1986 International Apion Nursery are being tested for yield in several locations in Honduras and data should be available on their performance by the end of 1988.

Studies on mechanisms of resistance to _A. godmani_ continued in two locations in Honduras. Across locations, larval mortality in resistant line APN 83 was significantly higher than in the susceptible check, Desarrural, throughout the growing period (Figure 3). Mean mortality in APN 83 was significantly higher than in Desarrural. Consequently, damage levels in the resistant line were significantly lower (Table 8). Larval mortality in the mesocarp of the pod was substantially higher than in the developing seed. These results confirm those previously reported and provide further indication that antibiosis is the mechanism responsible for resistance to the pod weevil.

Table 1. Development of *Zabrotes subfasciatus* on arcelin-containing lines. Means of six replications.

Line	Arcelin Type	Percentage emergence	Days to adult emergence	Adult weight ($gx10^{-3}$)
SARC 1	1	6.7c[1]	56.9a	0.5c
SARC 2	2	30.2b	45.2b	0.7b
SARC 4	4	79.3a	42.2b	0.7b
Sanilac	-	96.7a	33.0c	1.0a

[1] Means followed by the same latter are not significantly different at 5% level (Duncan).

Table 2. Development of *Acanthoscelides obtectus* in artificial seeds with the addition of purified arcelin-1.

Treatment	Percentage emergence	Days to adult emergence	Adult weight ($g \times 10^{-3}$)	Resistance Index[1]
Sanilac	97.4a[2]	34.3d	1.7a	100.0
Sanilac + 2.5% Arc 1	90.9a	34.9d	1.5ab	81.0
Sanilac + 5.0% Arc 1	93.4a	35.8c	1.7ab	89.7
Sanilac + 7.5% Arc 1	92.3a	36.8b	1.4ab	72.8
Sanilac + 10.0% Arc 1	89.5a	39.5a	1.3b	61.0

[1] With respect to Sanilac, the susceptible check

[2] Means followed by the same letter are not significantly different at the 5% level (Duncan).

Table 3. Development of Zabrotes subfasciatus and Acanthoscelides obtectus reared on artificial seeds with the addition of purified tannins. Means of three replications.

Species	Tannin concentration	Percentage emergence	Days to adult emergence	Adult weight ($gx10^{-3}$)
Z. subfasciatus	0%	88.4a[1]	34.0b	1.0a
	1%	78.5a	35.5a	1.0a
	2%	84.3a	36.2a	1.0a
A. obtectus	0%	97.9a	34.3c	2.3ab
	1%	95.4ab	35.4b	2.4a
	2%	91.8b	36.6a	2.1b

[1] Means followed by the same letter are not significantly different at the 5% level (Duncan). Each species analyzed separately.

Table 4. Levels of resistance to *Zabrotes* subfasciatus in some of the best F_4 and F_5 progenies evaluated in 1988. Means of three replications.

Progeny	Parents	Percentage emergence	Days to adult emergence	Susceptibility Index[1]
GG97-1-2	WI-85-5XBRU7	27.5	39.5	3.7
GG97-1-2-CM		20.2	40.8	5.1
GG98-10-2	PVA1025XWI-85-5	7.0	43.5	2.4
GG98-10-2-CM		10.8	45.5	3.4
GG98-13-1		1.7	44.5	1.9
GG98-13-1-CM		5.3	48.0	2.2
GG 98-28-2		6.4	43.1	2.3
GG 98-28-2-CM		5.3	44.2	2.4
GG 98-33-1		4.5	45.0	1.6
GG 98-33-1-CM		4.3	48.3	1.8
G 12952 (resistant check)		10.5	56.8	2.1
Calima (susceptible check)		95.4	30.2	11.1

[1] $\frac{\log (\text{progeny/female} + 1)}{\text{days to adult emergence}}$

Table 5. Levels of resistance to *Zabrotes subfasciatus* in some of the best F_4 progenies derived from simple crosses evaluated in 1988. Means of three replications.

Progeny	Parents	Percentage emergence	Days to adult emergence	Susceptibility Index[1]
GG 125-1-CM	859446-71xG 76	15.7	41.5	4.2
GG 125-4-CM		5.1	43.0	2.3
GG 125-9-CM		12.1	37.8	4.4
GG 125-19-CM	11.5	41.9	3.8	
GG 126-1-CM	859446-71xBAT 1297	11.2	43.5	3.2
GG 126-10-CM	16.3	42.3	4.5	
GG 127-3-CM	85446-67xXAN 105	12.1	42.1	3.4
GG 127-6-CM		8.5	42.7	3.3
GG 127-9-CM		7.8	43.0	2.8
GG 129-3-CM (brown)	859446-67xBAT 1297	5.6	47.0	2.5
GG 129-3-CM (red)		10.1	44.5	3.4
G 12952 (resistant check)		5.7	61.8	1.7
Calima (susceptible check)		93.9	32.1	11.8

[1] $\frac{\log(\text{progeny/female} + 1)}{\text{days to adult emergence}}$

Table 6. Best F_3 populations from the XI cycle of recurrent selection for leafhopper resistance. Means of three replications.

Population	Color	Yield (kg/ha)		Percentage yield
		Nonprotected	Protected	reduction
ER 13285(B)-CM(V)	2	938	1592	41.1
ER 14223-CM(V)	8	909	1692	46.3
ER 14234-CM(V)	8	944	2104	55.3
ER 14236-CM(V)	7	966	1733	44.2
ER 14241-CM(V)	2	1059	2021	47.6
ER 14245-CM(V)	2	1010	2025	50.1
ER 14247-CM(V)	2	929	1923	51.7
ER 14249-CM(V)	2	932	1966	52.6
ER 14259-CM(V)	1	882	1850	52.3
ER 14292-CM(V)	2	1016	1954	48.0
Checks:				
ICA-Pijao	8	746	2452	69.6
BAT 41	6	298	1372	78.3
EMP 88	7	297	1037	71.3
LSD (5%)		195.1	374.8	
C.V. (%)		16.1	13.2	

Table 7. Best indeterminate bush lines from the IX cycle of recurrent selection cycle for leafhopper resistance. Means of three replications.

Line	Color	Yield (kg/ha)		Percentage yield reduction
		Nonprotected	Protected	
EMP 201	8	1328	1405	5.5
EMP 202	8	1271	1473	13.7
EMP 203	8	1182	1325	10.8
EMP 204	8	1139	1122	0.0
EMP 205	8	1289	1585	18.6
EMP 206	8	1138	1223	6.9
EMP 207	2	1489	1675	11.1
EMP 208	2	1729	1728	0.0
EMP 209	2	1321	1388	4.8
EMP 210	2	1432	1584	9.6
EMP 211	1	1073	1186	9.5
EMP 212	1	1199	1396	14.1
EMP 213	2R	1515	1942	21.9
EMP 214	2R	1606	1831	12.3
Checks:				
EMP 187	8	1180	1502	21.4
EMP 198	2	1280	1324	3.3
ICA-Pijao	8	1142	1317	13.3
BAT 41	6	790	1364	42.1
LSD (5%)		285.5	364.9	
C.V. (%)		13.6	14.3	

Table 8. Percentage larval mortality and levels of damage by *Apion godmani* in two bean varieties. Means of four replications. Two locations.

Variety	% Larval mortality		% Pods damaged		%Seeds damaged	
	El Barro	Villa Ahumada	El Barro	Villa Ahumada	El Barro	Villa Ahumada
APN 83	78.8a[1]	87.3a	1.7b	12.5b	0.3b	2.3b
Desarrural	1.0b	8.3b	74.1a	29.2a	37.1a	9.3a

[1] Means followed by the same letter are not significantly different at the 5% level (Duncan)

Figure 1. Concentration-mortality responses of Z. subfasciatus to Arcelin 1.

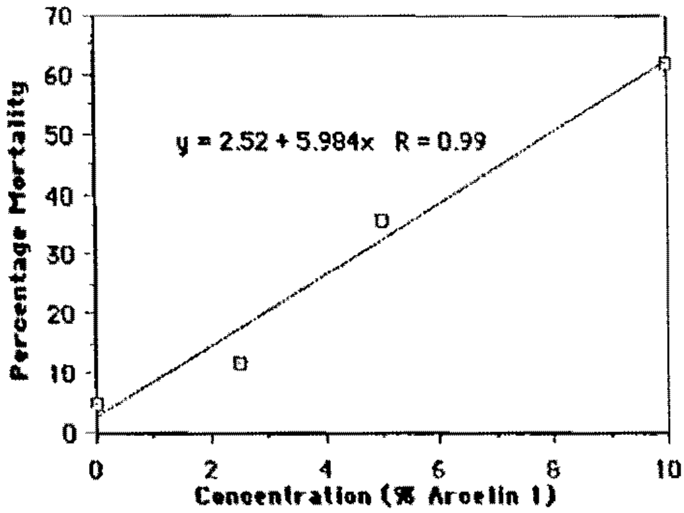


Figure 2. Concentration-mortality responses of Z. subfasciatus to Arcelin 2.

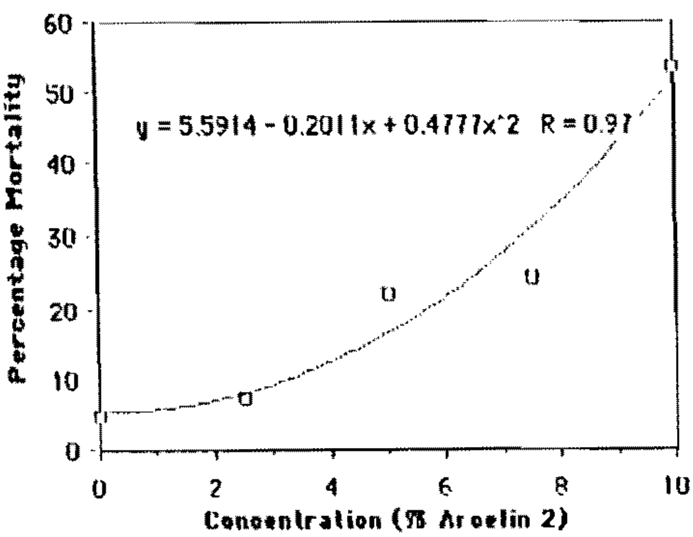
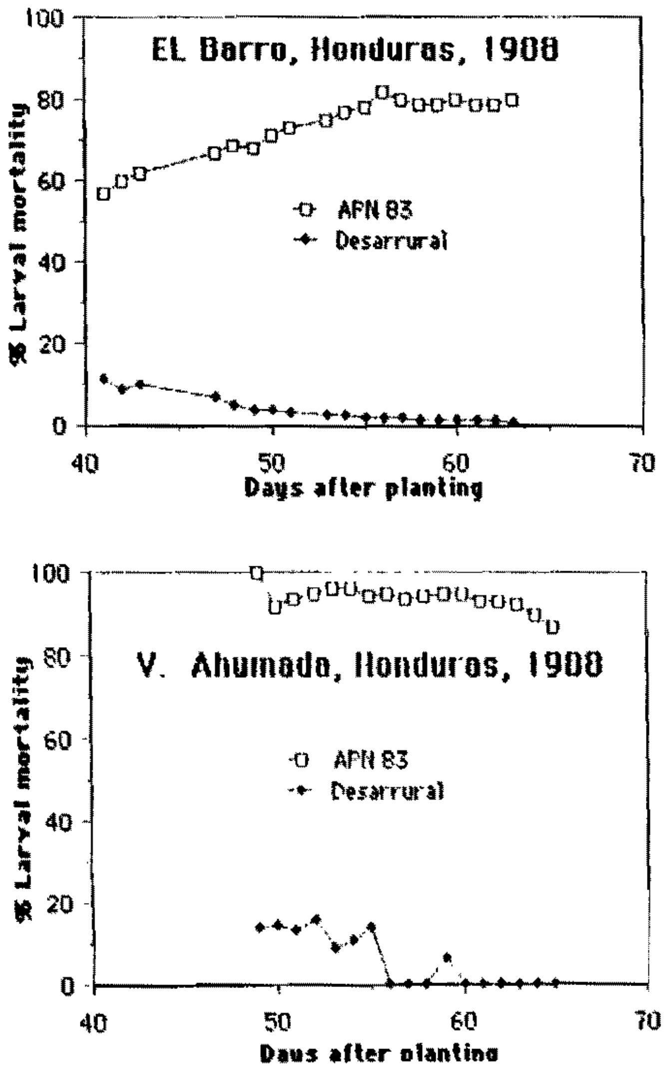


Figure 3. Fate of <u>Apion godmani</u> larvae in two bean varieties.



ON FARM AGRONOMY

LATIN AMERICA

On-farm research continued this year emphasizing development and adaptation of impoved technology; training for on-farm researchers; establishment and strengthening of research networks and, in improving methodological approaches to the above. In Colombia, technology development and adoption was highlighted through the planting of 72 on-farm trials developed in a collaborative effort between ICA and the Microbiology, Pathology and Entomology sections of the Bean Program at CIAT.

Thirty-seven of these trials (in six regions) comprised varietal evaluations; 17 trials investigated low cost inputs for root rots, fertilization, Rhizobium inoculation and chemical pest controls; 10 were variety verification trials; and eight were trials on semicommercial farms managed entirely by the farmer (Table 1).

Training was also emphasized this year. A course on on-farm research methods given in March and April had 23 participants from 9 Latin American countries, and two from Africa. Networks were strengthened through training courses given in Peru, Colombia and Mexico. These training courses emphasized participatory research in the recognition and identification of production problems, their causes and practical solutions--i.e. in farmers and researchers working together to design and implement trials on-farm.

Development and Adoption of Specific Technologies

Varietal Evaluations

Germplasm evaluation consisted principally of adaptation nursery observations. Two nurseries were planted in two different locations south of Nariño and two bush bean nurseries planted in three different locations each north of Nariño.

A uniform nursery planted in each of the following locations: Malaga and San Gil (Santander), Darien (Valle) and in Pescador (Cauca), consisted of 256 lines of red or red mottled medium climate bush beans. Results permitted the selection of 42 best lines from the four locales--of the five check varieties planted, Calima and Nima also performed well. A nursery was planted in the second semester 1988 in

Palmira and El Tambo. When results from all nursery trials are in, an analysis across all six locations will be performed, and final line selections will be placed in the Bean Program's VEF as well as in on-farm trials.

Low Cost Inputs

Fertilization

Fertilizer trials with bean/maize intercrops have been on-going since 1982, near Ipiales. In 1983, results indicated that fertilizer applications applied at the first mounding of the beans was most effective. Trials from 1985 concluded that maize and beans benefit from applications of formula 13-26-6 in a dose of 200-300 Kg/Ha.

Keeping the previous results in mind, and with the additional information from 1986 that a yellowing problem due probably to magnesium deficiency was affecting beans, four fertilizer in association trials were implemented in 1987B with maize (Morocho Blanca) and bean (Frijolica 0-3.2) to evaluate the effectiveness of three different doses of the 13-26-6 formula (150,225 and 300 Kg/Ha) in combination with three levels of magnesium sulphate (0,100, and 200 Kg/Ha). At harvest, it was seen that maize responded best to doses of 225 and 300 Kg/Ha of 13-26-6, whereas beans responded better to the higher dose. Maize showed no response to magnesium applications, but beans gave greater yield with applications of 100 Kg/Ha of magnesium sulphate (Table 2). Table 3 gives a cost benefit analysis of various levels of magnesium sulphate application.

Seed and Soil Treatments

Diagnostic studies done in Ipiales 1982-85 indicated that root rots due to the fungus Fusarium oxysporum were a significant constraint to bean production. Control studies begun in 1982 evidenced that Frijolica 0-3.2 and TIB 30-42 suffered fewer plant losses than did the local farmers' variety, Mortiño. Chemical treatments involving a combination of Benomyl and Carboxin increased bean yield and retarded anthracnose infection. Soil treatments of Captafol applied at planting, did not affect bean yield but did increase the yield of maize planted in association, by 300 Kg/Ha.

Varietal studies of seed, soil and foliage treatments completed in 1987 showed the effect of plant variety on number of plants at harvest, and yield. TIB 30-42 was again superior to Mortiño. Fungicide applications of Difolatan on seeds, and Benomyl and Manzate sprayed on leaves, increased the number of plants at harvest, but did not increase yield.

Verification Trials

Varieties in Intercropping and Succession

An evaluation of varieties of beans and maize good for intercropping systems was carried out, with emphasis placed on resistance to disease, high yield, and more efficient use of soils. Frijolica 0-3.2 and TIB 30-421 showed good characteristics, and a precoce bush bean called Antioquia 8 showed excellent adaptation to the area and was capable of performing well in intercropping or succession with maize. Maize from Pool 7, Morocho Blanco, was very good in combination with TIB 30-42; a short precoce variety, Pool 5, also was well-adapted and could be followed with another cultivar in the same growing cycle.

With these results in mind, a verification trial was established in 1987B to test yields of some of the promising bean/maize combinations.Results presented in Table 5 show the yields of each of the seven groups of cultivars. Highest bean yields came from Antioquia 8 (monocropped); Antioquia 8 intercropped with Pool 5, and TIB 30-42 and Frijolica 0-3.2 in association. Yields from Pool 7 and MB 521 were highest for maize. Potatoes, among the crops planted in succession as second cultivars, showed highest yields on average over 5 locations, with 17.2 tons/ha. Analysis showed that the most economically profitable planting combination was that of the bush bean Antioquia 8 intercropped with Pool 5 maize, and followed by a second cultivar that could be potatoes, peas or barley. Another efficient combination was TIB 30-42 in association with Pool 7, which allowed the farmer to harvest a month early.

In conclusion, technology adaptation and development studies completed in 1987B, support previously collected data which indicate that technology is most efficiently transferred to semicommercial enterprises that are managed completely by farmers.

Table 1. Number and type of on-farm trials planted in various regions of Colombia in 1987B and 1988A.

	Nariño 1987B		Santander Sur 1988A		Valle 1988A	Cauca 1988A
Trial Type	Ipiales	El Tambo	Malaga	San Gil	Darien	Pescador
Varieties and Lines						
On-farm nurseries of selected lines	4	6	3[a]	3[a]	3	2
Advanced varietal and line trials	3	8			3	2
Economic Studies						
Seed and soil treatments	3					
Fertilization	4					
Rhizobium	4[b]	4[b]				
Chemical control--"toston"	2					
Varietal verification	10					
Semicommercial varieties	8					
Total	39	18	3	3	6	4

a With participation of ICA

b With participation of the Microbiology Unit - CIAT

Table 2. Yields of beans and maize in fertilizer trials in the south of Nariño 1987B.

Treatment (Kg/Ha)	Yield (Kg/Ha) Cordoba F	Cordoba M	Suraz F	Suraz M	Chaquaipe F	Chaquaipe M	Average F	Average M
13-26-06								
150	188	1887	510	1224	891	1149	530[b]	1420[b]
225	193	2220	536	1463	912	1407	547[b]	1697[a]
300	218	2250	637	1360	1008	1363	621[a]	1698[a]
DMS (10%)	77.7	136	83	123	204	401	72	135
SO_4 Mg								
0	200	2072	384	1436	907	1315	497[b]	1608
100	211	2101	670	1256	939	1309	607[a]	1555
200	188	2184	629	1356	965	1295	594[a]	1612
DMS (10%)	64	428	118	158	154	302	63	168

Maize variety: farmer-preferred (Morocho Blanco)
Bean variety: Frijolica 0-3.2
Values having the same letter do not differ significantly

Table 3. Results of fertilizer trials from maize/bean intercrops in various locations in the south of Nariño 1987B.

Treatment 13-26-06	(Kg/Ha) SO_4 Mg	Yield Kg/Ha Cordova F	Cordova M	Suraz F	Suraz M	Chaquaipe F	Chaquaipe M	Average F	Average M	Thousand/pesos per Ha Cost	Net Benefit
150	0	226	1848	339	1281	833	1446	466	1525	12.5	148.4*
150	100	169	1709	596	1028	897	877	554	1205	18.4	146.4
150	200	168	2104	595	1361	943	1123	569	1529	24.3	172.6
225	0	158	2453	358	1469	942	1128	486	1683	17.7	163.2*
225	100	266	2145	741	1297	804	1818	604	1753	23.6	204.0*
225	200	154	2062	509	1625	991	1275	551	1654	29.5	171.5
300	0	217	1915	456	1557	947	1371	540	1614	23.2	170.7
300	100	198	2447	673	1441	1115	1231	662	1706	29.1	214.6*
300	200	241	2386	781	1082	691	1488	661	1652	35.0	203.9
Average		200	2118	561	1349	937	1306	566	1591		
DMS (10%)		116	602	181	248	290	570	114	273		
Plants/m^2		0.82	3.87	1.35	2.98	1.99	3.84	1.39	3.56		
Content- Mg (me/100 g)		2.32		2.50		1.71		2.17			
Acidity (pH)		5.30		5.70		5.80		5.60			

* Economically beneficial treatments
Fixed costs: $126,846.oo calculated in pesos in 1987
Price of beans: $300.oo kg. Price of maize: $80.oo kg.
Maize variety: Morocho Blanco. Bean variety: Frijolica 0-3.2
** Critical Mg value = 2.0 me/100 g.

Table 4. Root rot control of beans planted in association with maize, by variety and chemical, Ipiales 1987B.

Treatment	Plants Established M^2	Plants Harvested M^2	Yield Kg/Ha
<u>Variety</u>			
TIB 30-42	3.07	2.18 a	758 a
Mortiño	3.04	1.53 b	421 b
<u>Fungicides</u>			
Seed - soil - foliage			
D - N - BM	3.1 a	2.1 a	615
BV - N - BM	3.1 a	1.9 ab	612
D - D - BM	3.2 a	1.7 ab	591
N - N - N	2.8 b	1.6 b	540

D = Difolatán B = Benomyl M = Manzate

V = Vitavax N = no treatment

Results of one trial

Values with the same letter do not differ significantly

Table 5. Verification trials for association and succession plantings of maize, beans and another cultivar, in 7 locations south of Nariño, 1987B.

Treatment: Association Var. Bean + Var. Maize	Treatment: Succession Other cult.	Yield Kg/Ha: Beans	Yield Kg/Ha: Maize	Yield Kg/Ha: Other cult.	Costs Variables $000pesos/ha	Benefits Net $000p/ha
Antioquia 8 ——	P, A or B	1258	——	**	45.2	291.1
Antioquia 8 + Pool 5	P, A or B	1023	1121	**	47.3	326.0*
TIB 30-42 + Pool 7		831	2747		27.6	314.8*
Frijolica 0-3.2 + MB 521		692	2527		30.4	304.2
V 8001-433 + MB 521		499	2613		28.4	273.8
Productor + Productor		411	2113		31.8	211.1

* Economically efficient treatment.

** Yields: potato (P) = 17,200 (X 5 loc); peas (A) = 1223; barley (B) = 2162

Bean prices: Mortiño = $330.oo kg; others: $300.oo kg. Maize prices = $80.oo kg.

Fixed costs for maize-bean in 1987 = $83,025/ha.

Fixed costs for potatoes in 1987 = $287,821/ha

ON FARM AGRONOMY

THE GREAT LAKES-AFRICA

Climbing Bean Promotion

An on-farm study of climbing beans was begun in 1986 with 100 farmers in the Nyabisindu area of Rwanda, where an extension network had already been established by a German development group. Collaborating farmers had received 500 gr. of climbing bean seed in 1986A ...one year later, in 1987A these farmers were planting six times more of their land to this bean than in 1986. Most of them expressed the wish to plant even more, but stated the availability of staking materials as the major constraint to their increasing climbing bean production.

Within this network of 100 farmers a series of on-farm variety trials was started in order to compare the performance of the initially distributed local varieties Gisenyi 2 and C 10 with new cultivars tested in the national breeding program. Results showed that the local varieties yield well, and G 2333 (named Mubanomwiza) was also appreciated because of its grain type and cooking characteristics. Droughts occurring both early and late in one season however, showed the need for climbing bean selection to be based on earliness and quick establishment.Both local varieties compared favorably to the new introductions for these characteristics. Close collaboration this year with the extension services led to the distribution of 1.2 tons of Gisenyi 2 by the German project. Seeds were distributed at a higher than market price, to farmers on demand in small 1 Kg. quantities. The farmers received instructions how to grow them at the time of seed distribution.

Studies undertaken so far indicate that yields of climbing beans may better bush bean harvests by 40-50% Monitoring the adoption of climbing beans that are recently introduced will be accomplished through a major extension effort in 1989 to follow up on these farmers. Further promotional work on climbing beans will include the production of training materials, as well as offering training courses for extension personnel.

Several other projects in Rwanda have started studies to explore the potential for climbing beans in their zones following the methodologies used in Nyabisindu. In Burundi as well, the national bean program is seeking support from extension projects to do similar work.

Sustainability Issues

As various options for increasing yields per unit of land are made accessible to farmers, the sustainability of these technologies becomes as important as the improvements. One approach which is being tested within national programs in Africa aimed at sustaining high yields over time, is to promote the adoption of technologies likely to increase production, through the demonstration of techniques that help to sustain this high productivity.

In the case of climbing beans, finding enough stakes to support the crop was an immediately recognized constraint to sustainable production. Therefore, research was begun (concurrently with climbing bean introduction), on multipurpose trees to be used as sources for stakes. These trees would act as erosion stoppers when planted along antierosion ridges or integrated in the field; they would help to sustain production by nitrogen fixation, recycling of phosphorus and the production of organic matter which can be used as green manure or animal feed. Results to date show the extraordinary performance of Calliandra calothyrsus for stake and organic matter production; however, many other species could and should be used as well, as planting mixtures of trees will stabilize productivity over time just as planting crop mixtures does.

Observation trials with farmers doing participatory research alongside program scientists and extension workers, has shown that the obvious short term benefit to farmers of planting trees is the increased availability of stakes. Long term effects of soil fertility, erosion control, and additional fuel source, however, are only of secondary importance to farmers, but will become more obvious valuable over time. Another constraint to be to the survival of these trees exists in farmers' reluctance to tether free wandering hungry goats. This is especially relevant given the small farm sizes of Rwanda, where goats of one farmer have easy access to neighbors' fields. Presumably, farmers seeing the value of protecting these tree crops over time, will find alternatives to letting their goats eat the trees.

Staking materials have become so important to the planting of climbing beans in Rwanda, that the German project in Nyabisindu is launching a new extension program with stake production as the main argument for recommending the trees, and the national agroforestry program is now systematically evaluating new species for their capability to produce stakes.

Other Agronomic Trials

Fertilizer trials have shown that manure applications at the third trifoliate stage of climbing bean plant growth, can increase production by as much as 60% This technique will be further tested on-farm with the participation of involved farmers.

Other trials include planting the tree <u>Sesbania</u> <u>magrantha</u> in association with semi-climbing beans. This trial was designed to test the hypothesis that the negative competition to be expected could be partly balanced by the positive effect of <u>S.</u> <u>magrantha</u> fertilizing the soil, and by being able to use stems from this plant as staking material. Over three seasons no significant yield losses of beans were observed in trials on-station at Rubona, when associated with <u>S.</u> <u>magrantha</u>. In turn sorghum yielded more when grown on a plot where the <u>Sesbania</u> which had been grown in association with beans were incorporated in the soil one month before planting (Table 2 and 3).Parallel to the trials on-station at Rubona, on-farm trials have been installed in collaboration with the Service Agricole de Kibuye, Rwanda. Preliminary results show the need to target this technology to soils having medium fertility with no deficiencies in micronutrients.

Table 1: Stake and organic matter production of selected agroforestry species destinated to be associated with climbing beans (1 Kg fresh weight/Ha); Nyamishaba; Rwanda.

Species	Stakes/ha	Fresh matter (tons/Ha)
Leucaena leucocepha	5566	10.0
Calliandra calothyrsus	7400	14.4
Sesbania sesban	*1160	2.2

* 18 months after planting
** 18 months after cutting at soil level

Table 2. Performance of the bean cultivar "Kilyumukwe" (Type II) grown in association with Sesbania magrantha with different planting intervals (Kg/Ha) (Rubona, 1988A).

Sesbania magrantha and beans planted at same time	1225 A*
Sesbania magrantha planted 1 week after beans	1269 A
Sesbania magrantha planted 1 week before beans	898 B
Beans as sole crop	1245 A

Density of Sesbania magrantha: approx. 50,000 pl/ha broadcasted

Coefficient of variation:17.7%

* Means marked with the same letter do not differ at p=0.05 (LSD)

Table 3. Effect of incorporation of Sesbania magrantha on sorghum for S. magrantha grown in association with semi-climbing beans at different planting intervals (sorghum yield in Kg/Ha) (Rubona, 1988B).

Sesbania magrantha planted 1 week before beans	4282 A*
Sesbania magrantha planted at same time as beans	3445 AB
Sesbania magrantha planted 1 week after beans	2954 B
Semi-climbing beans sole crop	2841 B

Coefficient of variation: 22.45%

* values marked with same letter do not differ at p=0.05 (LSD)

ECONOMICS

LATIN AMERICA

The Bean Economics section contributes in four ways to technology development and diffusion.

1. Bean production and consumption trends in the developing world are monitored and interpreted.

2. Bean production and consumption circumstances are diagnosed and research strategies defined.

3. The probabilities for success of any given new technology, and the impact of released technology is assessed, by means of acceptability, adoption and impact studies.

4. The release and diffusion of new technology is studied in order to understand how to maximize its impact.

As an additional responsibility, the Bean Economics section is presently studying the economic importance of snap beans and the feasibility of snap bean research (see Improving Other Varieties--Snapbeans).

Strategic studies by the Bean Economics team are usually carried out in Colombia where CIAT headquarters offers support, with more applied studies being done in various regions of the world.

Dry Bean Economic Research

The following studies or projects are currently being investigated by the Economics section:

Bean production management in Colombia: This study will document present cultural practices in the five major (bush) bean producing areas in Colombia. The objective is to gain further understanding of how farmers adapt their management strategies to the variety they plant, given the climatic and soil conditions of their farms, and how this affects their use of inputs. In conjunction with data gathered in 1974 in a similar study, results will be used to describe the historic development of input use in Colombia.

Bean marketing in Colombia: This is a study of market channel influences on farmers' production decisions. Price series have been collected and regional wholesalers have been interviewed.

Small scale seed production in Santander, Colombia: The value of seed quality improvement for small bean farmers is under investigation, as is the feasibility of commercial bean seed production.

Varietal preferences by farmers: This study tries to quantify and compare the importance that farmers attach to varietal characteristics, such as yield, resistance, grain size, color and shape. This study is executed in collaboration with the Cropping Systems section and the CIAT/Kellogg project on participatory on-farm research.

The studies described above are presently in execution or analysis. The remainder of the report on dry bean economic studies will be dedicated to projects that were concluded in 1988.

Varietal release strategies: The value of successful technology dissemination strategies is often underestimated. For example, if a new variety with a target area of 10,000 hectares is disseminated throughout that area in three years, rather than five years, the additional benefits are approximately $US 1.4 million. Inappropriate or ineffective release strategies are a major bottleneck in transferring improved technology to those who need it most--the farmers.

A comparative study on the varietal release strategies of Costa Rica, Honduras, El Salvador and Guatemala was completed this year. Their most salient characteristics are described in Table 1.The decision to release a new variety was taken by a committee in three of the four countries, but in the other country it is not clear how it was decided that the variety was appropriate for release. In most countries the release took place with very little publicity. Field days were held in only one country to announce the variety to the local farmers. In one country, seed availability at the moment of release was not sufficient to cover the existing demand. In two countries, regional recommendations were made for the newly released varieties. In the other two, the new varieties were recommended for the entire country.

The availability of seed is the principal constraint for the rapid diffusion of a new variety. Seed production was organized in different manners in the countries studied. In two countries, government organizations were responsible for seed production, in the others private seed producers or artesanal seed producers held a major role. The quantities of seed available varied considerably. In two countries, less than 30 tons was available. At a seed requirement of some 50 kg per hectare this would allow less than 600 hectares to be planted with the new variety. In none of the four countries, was seed of the improved variety obtainable in the villages close to the production zones. Farmers always had to travel to the regional centers to be able to purchase new varieties.

For the successful spread of a new variety, appropriate information on its characteristics is very useful. In one country varietal transfer was the responsibility of the extension service. In two countries extension and research collaborated and in one country the research organization was responsible for diffusion! Demonstration plots were planted in three of the four countries. Written information on the new varieties was available in only two of the four countries. Mass communication (by radio or press) was non-existent in any of the studied countries.

While the quality of varietal release strategies differs strongly from country to country, certain strategical faults were found in all.

Increased seed production combined with appropriate and effective distribution was lacking in all countries. Where artesanal methods may increase seed availability in some areas, distribution paths are still unclear. Where government organizations are responsible, seed distribution might be easy, but seed production will put a heavy burden on the capacity of these same responsible organizations.

Information on the availability and specific characteristics of new varieties is another area which needs improvement. By better informing farmers, false expectations and subsequent disillusionment will be avoided. As well, better prepared farmers will increase the demand for seed and make seed production more profitable.

In conclusion, it seems evident that the development of more appropriate release strategies would aid countries in harvesting the benefits of successful research in the fields of their farmers.

Data Base of Socio-Economic Statistics on Beans

The proper analysis of bean production and consumption is often constrained by lack of data, or by the lack of information on where data are available. To overcome these problems a systematic search has been started on bean statistics. A data base has been designed which stores information on institutions that collect data, type of data, geographic and historic coverage and place where these data are most readily available. At present 174 sources of statistical information on beans have been classified.

Table 2 provides a summary of the institutions holding the classified data. Presently most classified data sources contain production information or price data.Data on bean consumption and on imports and exports are less easy to obtain.

At the moment the data base is oriented to Latin America, at the expense of Africa and the Near East. Unfortunately, the current lack of bean economists in Africa and the Middle East limit the possibility that data sources from that region will be well classified soon.

The data base can be made available to interested people or institutes having access to the DBASE 3 Plus program.

Comparative Adoption Studies, Costa Rica

A study on adoption of improved bean varieties for the peninsula of Chorotega in Costa Rica was completed. Adoption can now be compared across major production regions in Costa Rica. Table 3 shows some main indicators for selected regions.

Adoption of improved varieties was highest in the Huetar-Norte region close to the Nicaraguan border. This is a non-traditional bean production region recently planted to beans when the profitability of traditional enterprises (cattle) fell. Adoption was also high in the Brunca-region, towards the southeast of the country. In the third production area, the peninsula of Chorotega, diffusion was very reduced.

Which factors explain the adoption differences? A primary reason appears to be that extension services covered a higher percentage of bean producers in the Huetar-Norte region, than in the other two regions. Secondly, Huetar Norte and Brunca produce black beans while the peninsula of Chorotega produces more red beans. Most impact has been obtained with black beans, which tends to favor the Huetar Norte and Brunca region. Thirdly, in the Huetar Norte and Brunca regions, beans are produced as a market rather than home consumption crop.

The correct interpretation of adoption data is dependent on the validity of the cause-effect relation. For example, instead of farmers adopting new varieties because they are market oriented, it might be that they have become more market oriented because of adopting new varieties. The same problem shows up with the interpretation of input use data. More than 70% of farmers in Perez Zeledon and San Carlos use chemical control and fertilizers, but less than 20% in Nicoya use them. Two factors might be involved: more productive improved varieties provide increased marginal returns to fertilizer and chemical control; secondly, when farmers grow improved varieties, their incomes increase and they might have more resources available to purchase inputs.

In Costa Rica, improved varieties have been grown for a number of years and their impact in terms of production is becoming very clear. In the future, it will be useful to study the impact of these new varieties on farm income and organization.

Follow-up Study on Frijolica 0-3.2, Colombia

The adoption of Frijolica 0-3.2, a variety released in 1985 was studied. Frijolica was dispersed in the extreme south of Colombia, to replace Mortiño, a vigorous climber with a dark brown, mottled grain type. Frijolica matures slightly more rapidly, has a smaller seed size and a more purple tone than Mortiño and is resistant to anthracnose, rust, root rot and ascochyta. In the southern part of Colombia, beans are grown as a cash crop, with only the seed for the next crop cycle kept stored at the farm. Most beans grown in the area are consumed around Cali.

Table 4 shows how poorly awareness of the qualities of Frijolica were diffused in the market channel--while almost all farmers knew the variety, less than a quarter of the retailers could recognize it. Apparently, very little of the production has found its way to the urban consumer.

70% of the farmers had once planted Frijolica 0-3.2, but only 40% still planted it. Two-thirds of the farmers that did not plant Frijolica expressed that the variety had marketing problems because of color and seed size. Agronomically, Frijolica was more appreciated than Mortiño on a large number of characteristics, such as yield, anthracnose and root rot resistance and earliness. However, these disadvantages did not compensate for its reduced marketability. Most farmers who had discarded Mortiño, started planting bean varieties brought in from other regions, because although these varieties had other grain types, they were well known in the Colombian market and could easily be sold.

Market constraints dominated adoption decisions of these small but commercial farmers. Although part of these constraints are caused by the conservatism of the market agents, it should be recognized that, within the Colombian situation, Frijolica was an improved variety from an agronomic point of view but an impoverished variety from a commercial point of view. As a result of the growing awareness on marketability, new lines that are tested in the south of Colombia, are now being submitted to more stringent commercial screening.

The Effect of Imports on Domestic Bean Production and Consumption, Colombia, 1974-1987.

While beans are a typical small farm crop in Colombia as well as in most other countries of Latin America, bean markets are influenced by international trade. A study was undertaken to understand how international trade affected domestic bean production and consumption in Colombia.

A first conclusion of this study is that bean imports in Colombia, especially around 1982 and 1983, were not demanded because of domestic scarcity, but by international abundance. After some years of harvest failure, Mexico obtained a bumper crop in 1982 and did not need any bean imports. Consequently the world market was flooded with small red beans from the U.S.A., that were originally meant for Mexico. Prices decreased strongly and provided the opportunity to domestic traders to import beans and sell them at a considerable profit. After two years of importation, the Colombian government began to restrict imports, to protect domestic production.

The effect of the imports on bean consumption and consumer prices has been significant. In 1982 consumer prices for Calima (the most common bean in the Colombian market) were some 20% lower than they would have been without imports. In 1983 prices were almost 50% lower. In 1982 and 1983 bean imports accounted for 23% of total supply (Table 5).

The bean that was most commonly imported in Colombia was a small red. This was a non-preferred grain type. Its imports affected more strongly the prices of the intermediate sized-less preferred grain types such as Calima, than the prices of large, highly preferred grain types such as Bolon Rojo and Cargamanto. A 10% increase in bean supply through imports would reduce prices of preferred grain types by 10% and prices of less preferred grain types by 17% (Table 6). Since the lower income strata mainly consume less preferred grain types, they benefitted most from the imports.

Import-caused price reductions also influence domestic supply. A short term supply elasticity of 0.27 and a long term supply elasticity of 0.83 were estimated. On the basis of these elasticities, it was estimated that every ton of imported beans reduced domestic supply in the three years afterwards by 0.69 tons (Figure 1). Its major impact has been to advance supply through time. It should be observed that this advance was obtained to a large extent at the cost of the bean farmers.

An outstanding conclusion of the study was the degree of sensitivity of the bean sector. Traditionally small farm production is considered to be unresponsive to price changes and market conditions. The present study, however, found a rapidly reacting bean production sector and effective market segmentation. Bean production appears to be more sensitive to policy and market intervention than was realized before. Adequate governmental support to bean production could positively influence small farm income as well as food availability.

Table 1: Characteristics of variable release strategies in selected Central American countries

	Guatemala	El Salvador	Honduras	Costa Rica
Varieties studied	ICTA-Ostua	Centa-Izalco	Catrachita	Huetar/Huasteco
Release committee	yes	---	yes	yes
Field days	---	---	---	yes
Seed available at the moment of release	yes	---	yes	yes
Regional recommendations	yes	---	yes	---
Seed production	private	state/artesanal	state	state
Tons of seed produced	51	19	27	90
Local seed sales	---	---	---	---
Responsible for varietal transfer	extension service	research institute	extension + research	extension + research
Demonstration plots	yes	---	yes	yes
Leaflets	---	---	yes	yes
Information by radio or press	---	---	---	---

Table 2: A summary of the data base on socio-economic statistics of beans

	Source			
	International Institute	National Institute	CIAT	Total
<u>Type of data</u>				
Production	54	54	25	133
Consumption	2	4	--	6
Prices	6	42	5	53
Trade	5	8	--	13
Credit	--	2	--	2
Total	67	120	30	174

Table 3: Adoption of improved bean varieties, Costa Rica

	Perez Zeledon, Brunca	San Carlos, Huetar Norte	Nicoya, Chorotega
% of farmers that adopted new varieties	66	100	11
Average/yield (kg/ha)	813	553	373
Area planted (ha)	8100	2500	2500
% of farmers that receive technical assistance	37	60	29
Dominant grain color	black	black	red
Principal bean utilization	sales	sales	sales and home-consumption
% of farmers that use fertilizer	77	70	17
% of farmers that use fungicides	80	74	16

Source: Bean Economics, internal data

CNP, Agrotecnico, vol No. 2, 1988

Table 4: Familiarity with Frijolica 0-3.2, Nariño and Cali, Colombia 1988.

	% that knows Frijolica 0-3.2	Sample size
Farmers	94	50
Rural assembly agents	80	10
Wholesalers	39	23
Retailers	24	21

Table 5: The impact of bean imports on the domestic market of Colombia, 1976-1986

Year	(1) Imports	(2) Observed production	(3) Simulated production without imports	(4) Difference between (2) and (3)	(5) Observed price (pesos of 1980)	Simulated price without imports
1976	88	67600	67600	0	22.88	22.88
1977	3595	74900	74900	0	22.23	22.23
1978	107	74823	74823	0	18.62	20.72
1979	1604	74707	76811	1988	23.95	23.81
1980	4134	83556	84862	1306	22.92	24.10
1981	2258	74100	75883	1783	18.33	18.24
1982	25944	72900	73972	1072	22.44	27.41
1983	21413	81800	87800	6000	16.67	32.57
1984	8935	80155	100692	20537	25.71	25.29
1985	4262	98964	114214	15250	28.05	19.53
1986	0	103943	105598	1655	12.29	11.73

Source: 5) DANE, Boletin Mensual de Estadistica, various years.
2) Oficina de Planeacion del Sector Agricola, Ministerio de Agricultura.
1) IDEMA, Bogota.
3), 4), 6) Bean Economics, CIAT, internal data.

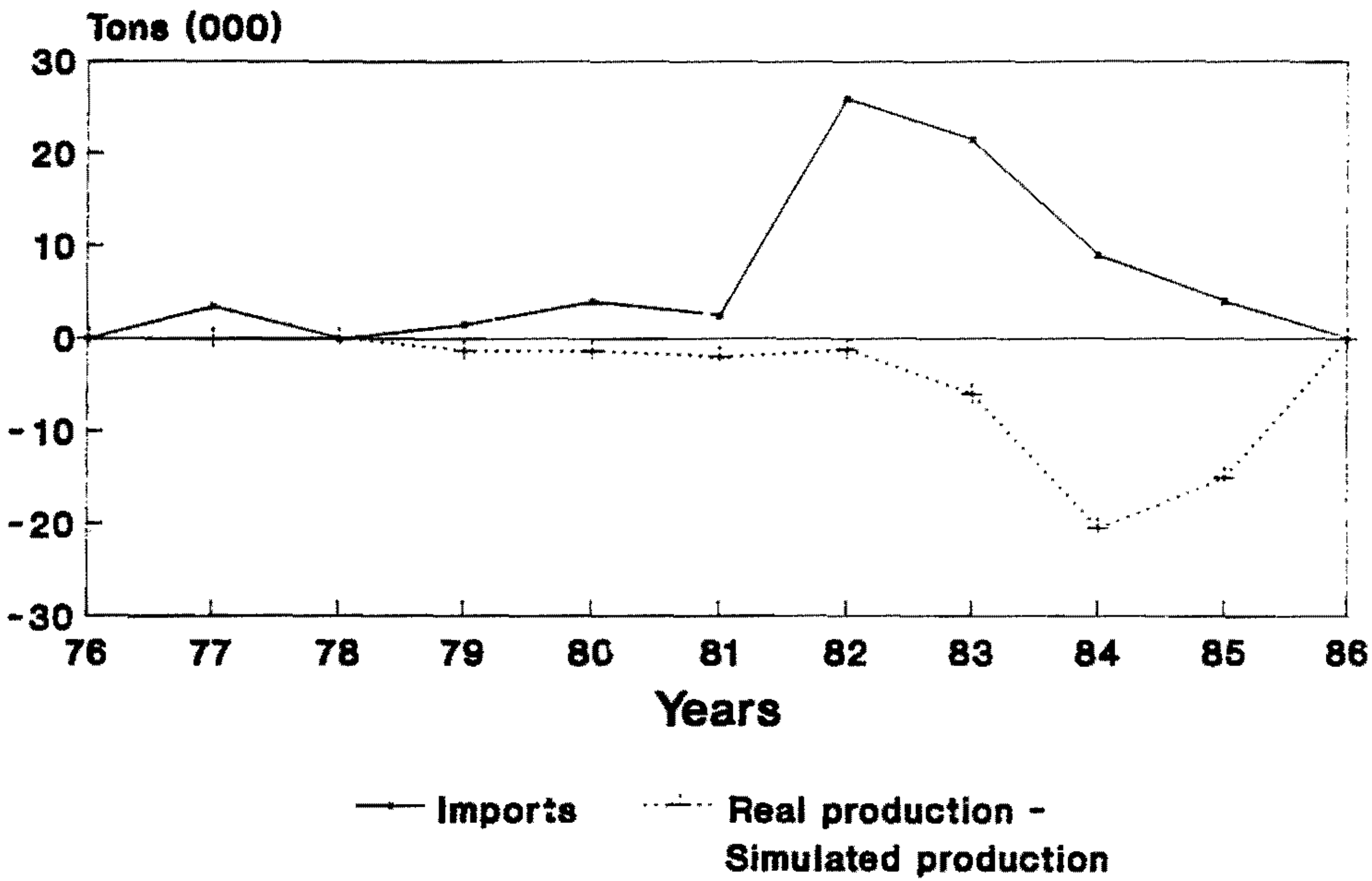
Table 6: The effect of imports on bean prices in Colombia, 1973-1987

	Average price (pesos of 1975)	Effect of 1% increase in supply by means of imports on the price*
Less preferred grain types	21.82	- 1.7% (5.33)
Highly preferred grain types	28.32	- 1.0% (4.55)

* t- Values in parenthesis.

Source: Bean Economics, internal data

Figure 1 : The impact of bean imports on domestic production



Source : Bean Economics, internal data

UNIFORM NURSERIES

CIAT's Bean Program uses a three-stage evaluation system consisting of an equal number of uniform nurseries in order to guarantee that advanced lines from breeding programs distributed internationally fulfill the following requirements:

- All advanced lines have commercial grain characteristics.
- Yield trials for international distribution do not include any susceptible material to any of these diseases: BCMV, angular leaf spot, rust, anthracnose or common bacterial blight.
- No susceptible material for the five above mentioned diseases is included in the Observational Trials or distributed internationally if any of these diseases are prevalent in the trial region.

First Stage: The Bean Team Nursery (VEF)

The objectives of this nursery are:

a. To demonstrate the relative potential and deficiencies of advanced selections from all sources having commercial grain characteristics.

b. To enable selection of candidates for national or international nurseries.

c. To enable selection of parents for subsequent germplasm improvement.

Nursery management:

Entries are submitted at the beginning of the year and evaluated for a year in Colombia for reaction to diseases and insects. Yield, growth habit, grain characteristics and growth duration is also recorded. At the end of the year a detailed record of the evaluations is published and seed of all entries is ready for international distribution upon request. The whole nursery is kept in reserve for two years but only non susceptible materials for any of the five diseases under evaluation are kept for the second stage (EP).

Results of the 1988 VEF (Semester A):

Table 1 shows the number of entries that exhibited a resistant or intermediate (R/I) reaction to the following diseases: bean common mosaic virus (BCMV), common bacterial blight (CBB), angular leaf spot (ALS), anthracnose (ANT) and rust. Furthermore, since CBB and BCMV are the two most common seed-transmitted diseases present in the main bean producing areas, results are shown on a number of materials with R/I reaction to CBB and resistant to BCMV.

Table 2 shows the progress reached in disease resistance in snap bean types. Around 50 entries showed resistance or intermediate reaction to the four most prevalent bean diseases in the tropics.

Second Stage: Preliminary Yield Trials (EP)

After the VEF is completed all non-susceptible materials were selected for a following phase (EP) which should corroborate the disease reaction of the selected entries and provide an estimate of their yield potential.

The objectives of this nursery are similar to those of the VEF with the obvious advantage that data accumulated from the previous VEF plus yield data should facilitate better selection.

Nursery Management:

For 1988 EP no entries were selected from the 1987 VEF if they showed susceptible reaction for CBB and BCMV. As a routine procedure all EP entries are subjected to the same kind of evaluation as in the VEF, except that in EP, yield potential is estimated through replicated trials where materials are grouped according to plant and grain characteristics.

Results of the 1988 EP (Semester A):

From 801 entries tested in the 1987 VEF, 368 were selected for further evaluation in EP nurseries; with the exception of climbing beans, only materials resistant to BCMV and either R or I to CBB were selected. Table 3 shows the effectiveness of selection based on two very important diseases and the manner in which an important number of resistant materials is being built up.

Yield evaluations for bush lines were conducted at CIAT-Palmira and Popayan. Materials were arranged in 12 trials according to their grain and plant characteristics. Climbing beans were tested at Popayan in 4 trials. Complete data on the year round evaluation of the EP is published every year. Tables 4 and 5 show a summary of results from the bush bean trials at Palmira and Popayan respectively.

Beans for moderately cool climates were tested at La Selva Experiment Station, Rionegro, Antioquia (2100 masl). Table 6 shows the average yield of the best lines for medium climate.

Third stage: International Bean Yield and Adaptation Nursery (IBYAN)

Starting in 1988 all advanced lines to be included in the IBYAN should show R or I reaction to CBB and anthracnose in VEF and EP evaluations and be resistant to BCMV.

Table 7 shows a summary of the best lines tested in the 1987 IBYAN trials in Palmira and Popayan, during the second semester.

Table 1. Reaction to diseases of 1988 VEF entries. (Semester A)

Grain color	Total	R/I to all diseases[1]		R/I to CBB R to BCMV		Market Class
White	180	11	(6.1%)	79	(43.8%)	Alubia, Great Northern, Navy, Panamito, White Kidney
Cream	180	12	(6.6%)	36	(20.0%)	Bayo Chimu, Cranberry, Carioca, Bayo Titan
Yellow	152	4	(2.6%)	68	(44.7%)	Azufrado, Canario, Liborino, Andino, Flor de Mayo
Pink	52	26	(50.0%)	32	(61.0%)	Red Kidney, Rosinha
Red	475	56	(11.8%)	141	(29.6%)	Calima, Gualí, Honduras 46, Linea 24, Pompadour, Red Mexican, Zamorano, Sangretoro
Black	169	6	(3.6%)	101	(59.7%)	
*Mat. Igx	4					
Other	46					Argentino, Funes, Mortiño, Duva, Otros
Snap Beans	65	49	(75.4%)	58	(89.0%)	
	1323	164	(12.4%)	515	(38.9%)	

[1] BCMV-CBB-ALS-ANT-Rust.

* Interspecific Gembloux Materials

Table 2. Number of snap bean entries with R/I reaction to the most prevalent diseases in the tropics. 1988 VEF Semester A.

	Disease			
No. of entries	CBB	ANT	ALS	BCMV
21	I	R	R	R
23	I	R	I	R
5	I	I	R	R
4	I	I	I	R

Table 3. Reaction to diseases of 1988 EP entries.

Grain color	Total	R/I to all diseases[1]	R/I to R to BCMV
White	49	7 (14.2%)	24 (48.9%)
Cream	45	2 (4.4%)	5 (11.1%)
Yellow	31		5 (16.1%)
Pink	10	8 (80.0%)	10 (100 %)
Red	112	37 (33.3%)	51 (45.5%)
Black	31		4 (12.9%)
Snap Beans	90	2 (2.2%)	68 (75.5%)
	368	56 (15.2%)	167 (45.3%)

[1] BCMV-CBB-ALS-ANT-Rust

Table 4. Average yield (kg/ha) of the most outstanding bush lines evaluated in Palmira, Colombia. 1988 EP-Semester A.

Line	kg/ha	% relationship with best check: In trial	% relationship with best check: In site[1]	Best check	kg/ha	Mean	LSD	CV
Small white-seeded n = 24								
RJR 12	3330	117.7	0.66	Ex Rico 23	2829	2141	312	8.9
Medium white-seeded n = 20								
WAF 109	2318	100	0.60	Alubia Cerrillos	2317	1903	432	13.7
Large white-seeded n = 12								
ABA 33	2626			Alubia Cerrillos	1872	1969	294	8.8
Cranberry types n = 12								
SUG 13	2360	98.4	0.61	Calima	2399	2222	389	10.3
Pinto types n = 16								
EMP 188	3607	97.3	93.7	Carioca	3707	2021	350	10.4
Medium yellow-seeded n = 24								
CAN 50	3073	113.4	79.8	Mayocoba	2711	2410	462	11.7
Light Red Kidney n = 12								
KID 23	2682	110.6	69.7	Calima	2426	2494	438	10.4
Dark Red Kidney n = 12								
DRK 11	3410	134	78.4	Calima	2544	2547	424	9.8
Large red mottled-seeded. Warm climate n = 22								
EMP 178	3016	120.4		Calima	2505	2349	315	8.1
Large red mottled-seeded. Warm climate. L-24 type n = 36								
CAL 44	2614	85.6	67.9	BAT 1297	3055	2151	415	11.8
Medium red mottled-seeded. Warm climate n = 12								
PAD 96	3097	114.2	80.5	Calima	2711	2695	434	9.5
Small black & red-seeded								
EMP 189	3421	88.9	88.9	ICA Pijao	3849	2952	438	9.0

[1] ICA PIJAO = 3849 kg/ha

Table 5. Average yield (kg/ha) of the most outstanding bush lines evaluated in Popayan, Colombia. 1988 EP-Semester A.

Line	kg/ha	% relationship with best check: In trial	% relationship with best check: In site[1]	Best check	kg/ha	Mean	LSD	CV
Small white-seeded n = 24								
ZIRCON	2538	95.1	91.5	Ex Rico 23	2668	1910	595	19
Medium white-seeded n = 20								
WAF 58	1434	108.4	51.7	Alubia Cerrillos	1323	1069	372	20.8
Large white-seeded n = 12								
ABA 16	1927	148.5	69.5	Alubia Cerrillos	1552	1298	342	15.5
Cranberry types n = 12								
SUG 18	2306	106.9	83.1	Calima	2157	1614	501	16.9
Pinto types n = 16								
EMP 183	2408	102.3	86.8	Carioca	2354	1684	333	11.9
Medium yellow-seeded n = 24								
CAN 50	1808		65.2	Mayocoba	130	729	383	32
Light Red Kidney n = 12								
LRK 4	2127	117.5	76.7	PVA 1111	1810	1716	284	9.8
Dark Red Kidney n = 12								
DRK 2	2565	113.3	92.5	Calima	2264	1642	450	16.2
Large red mottled-seeded. Warm climate n = 22								
DOR 374	2212	136.5	79.7	Calima	1620	1345	445	19.6
Large red mottled-seeded. Warm climate. L-24 type n = 36								
CAL 74	2233	106.6	80.2	BAT 1297	2085	1723	368	13.1
Medium red mottled-seeded. Warm climate n = 12								
PAD 99	2243	114.3	80.9	Pompadour Mocana	1962	1775	438	14.6
Small black & red-seeded								
MUS 51	2934	105.8	105.8	ICA Pijao	2773	2383	350	8.8

1 ICA PIJAO = 2773 kg/ha

Table 6. Average yield (kg/ha) of the most outstanding lines for medium climate evaluated in La Selva, Colombia. 1988 EP-Semester A.

Line	kg/ha	Best check	kg/ha	Mean	LSD	CV
Climbing:						
Large red-mottled seeded. Medium climate n = 30						
RAD 7	3541	ICA Viboral	2988	2685	714	16.3
Large cream-mottled seeded. Medium climate n = 24						
AND 700	4361	ICA Viboral	2918	2846	916	19.4
Large yellow and yellow-mottled seeded. Medium climate n = 12						
LIB 1	3658	ICA Viboral	2176	2815	1078	22.6
Small white and black-seeded. Medium climate n = 16						
ASC 35	4670			3868	925	14.4
Bush:						
Medium red-mottled seeded. Medium climate n = 16						
SAN 11	3103	Catio	2593	2045	486	14.2

Table 7. Yield (kg/ha) of most outstanding bush lines in 1987 IBYAN trials tested in Popayan. Semester B.

Trial	Line	kg/ha	check = 100%	Mean	LSD	CV	Best lines in Semester A Popayan	Best lines in Semester A Palmira
Black (n = 20)	NAG 121	3492	117	2818	579	12.4	NAG 146	BAT 271
Small Red (n = 16)	XAN 192	3229	104	2539	1387	32	XAN 194	XAN 194
Red Mottled (n = 24)	AND 312	3309	99	2839	481	10.3	ICA 15384	AND 312
Red Mottled: Habit II (n = 14)	PAT 6	2873	121	1998	338	10.1	ICA 154505	PAT 6
Guali & Calima types (n = 14)	PVA 846	3317	118	2763	717	15.5	PVA 844	PVA 844
Red Kidney types (n = 16)	ZAA 64	2344	95	1976	445	38.5	ZAA 105	ZAA 105
Small White (n = 14)	PAN 129	2802	142	1763	516	47.5 '		EMP 175
Small White: Navy (n = 12)	PAN 126	3388	110	2677	819	80.6	PAN 126	PAN 123
Large White (n = 16)	WAF 78	2314	120	1670	823	24.9		
Carioca type (n = 12)	AFR 81	3602	105	3144	742	13.9	AFR 81	Carioca
Mulatinho type (n = 14)	RIZ 62	3646	112	2654	568	12.8	RIZ 62	BAT 561

GERMPLASM FOR OUTREACH PROJECTS

Collaboration with National Programs

Bean Breeding III has the direct responsibility for the development of improved germplasm of large seeded grain types for the Andean Region in both bush and climbing beans. The breeding program collaborates closely with the national programs of Colombia (ICA), Ecuador (INIAP) and Peru (INIAA) in the evaluation of germplasm accessions, breeding lines, and segregating populations. In addition to its Andean mandate, Breeding III also supports the three regional programs in Africa (Great Lakes, Southern and Eastern) in germplasm development and training.

Germplasm Development

In 1988 over 1100 crosses were made (Table 1). More than half of these crosses were for cultivar improvement of large-seeded bush and climbing bean types. Crosses for red and mottled bush bean grain types are principally bred for Colombia, Uganda, Tanzania, Rwanda, Burundi, Zaire and Zambia. Crosses for red and mottled climbing bean types are for Colombia, Ecuador, Uganda and Rwanda, and whites and yellow seeded types are bred for Peru and Ecuador.

Segregating materials and advanced lines are evaluated in five locations within Colombia (Table 2) in different cropping systems and for varying objectives. Multiple disease resistance, yield and commercial grain types are the principle selection criteria in the cultivar improvement programs. The F_2 populations resulting from these crosses also are evaluated and selected by the national programs for specific adaptation, resistance and yield. In 1988 over 600 F_2 populations were sent to national program breeders (Table 3).

Character improvement projects fall into two broad groups ---breeding for high levels of resistance to specific insects and diseases, and increasing yield potential of large-seeded grain types (Table 1). Backcross breeding programs are used to transfer genes that are easily selected into preferred commercial genotypes (Table 4).

For resistance traits that are quantitatively inherited, such as <u>Empoasca</u>, Web Blight, and Ascochyta Blight, recurrent selection breeding programs are used to increase overall resistance levels.

Regional Trials - Colombia

The best advanced lines from ICA and CIAT with appropriate grain types for Colombia, enter into the ICA- CIAT Regional and Confirmation Trials. Six different trials have been formed for varying agroecological adaptation requirements in bush and climbing bean types.

These trials are made available for testing to collaborating institutions such as the CVC (Corporación Autónoma Regional del Cauca), FNC (Federación Nacional de Cafeteros), ICA-CIAT on-farm research projects, farmer cooperatives, and private individuals. These trials are as follows:

	Regional Trials	No. of entries	Results
1.	Bush beans - med. altitude, warm (1000-2400 masl)	42	Table 5
2.	Climbing beans - med/high altitude, cool (1900-2400 masl)	17	Table 6
	Confirmation Trials		
1.	Bush beans - med. altitude, warm (1000-1700 masl)	9	Table 7
2.	Bush beans - high altitude, cold (2000-2800 masl)	7	
3.	Climbing beans - med/high altitude, cool (1900-2400 masl)	6	Table 8
4.	Climbing beans - high altitude, cold (2400-2900 masl)	4	

Regional trials are composed of new breeding lines and superior local cultivars that have commercial grain types and resistance to one or more of the major diseases in Colombia. The trial is planted for three cropping seasons in diverse regions of the country. The best lines from the Regional Trials enter into the Confirmation Trial and are again evaluated for three seasons. From the Confirmation Trial, the two or three outstanding lines in different regions are selected to enter Demonstration Plots and are then considered as potential varieties. The demonstration plots serve as the final verification of the materials' agronomic performance and as a means of seed increase for subsequent distribution. In most cases, the trials are planted on-farm with the farmer assisting in the evaluation and selection of the materials.

Three bush bean lines of determinate growth habit and large red mottled grain type are presently in demonstration plots for the mid-altitude regions of Colombia. The three lines, PVA 476, PVA 916, and PVA 1261 are improved materials from CIAT. The three lines have been widely tested throughout Colombia and were chosen by ICA, CVC, FNC and other individuals as being superior to the local checks. PVA 476, which has been selected for the Antioquia region, is scheduled to be released this year, and the two other lines may be released in 1989.

Table 1. Crosses made during 1988 for cultivar and character improvement for the Andean Region and Africa.

I. Cultivar improvement for large seeded grain types.

	Cutivar types		Adaptation range (masl)	# crosses
1.	Bush	Reds and mottles	1000-1700	215
		Creams and bayos		15
2.	Bush	Reds and mottles	2000-2800	92
3.	Climbers	Reds and mottles	1000-1700	40
		Whites and yellows		53
4.	Climbers	Reds and mottles	2000-2400	112
		Whites and yellows		63
5.	Climbers	Reds and mottles	2500-2800	30
		Whites and yellows		67
			Total	687

II. Character improvement projects	# crosses
1. Insect resistance	
a. Empoasca leafhoppers - bush	69
b. Bruchid storage beetles - bush + climbers	62
c. Beanfly - African grain types	69
2. Disease resistance	
a. Web blight - bush, reds and mottles	39
b. Halo blight - bush and climbers	36
c. Ascochyta - climbers	15
d. Anthracnose - bush, reds and mottles	12
e. BCMV - climbers (I gene)	67
bush (recessive genes)	12
3. Yield potential for large seeded bush beans	91
Total	472

Table 2. Summary of locations in Colombia where major breeding effort are being conducted.

Location	Altitude (masl)	Major cropping system	Principal bean types	Primary objectives
CIAT-Palmira	1000	Monoculture	Bush - large red, mottles, Sugar bean types Snap beans (bush+climbers)	Resistance (BCMV, rust, CBB, Empoasca, Bruchids) Yield potential
CIAT-Popayan	1700	Trellis	Climbers - all major grain types, wild P. vulgaris	Resistance (ANT, ASC)
Darien - farmer's field	1450	Monoculture	Bush - large red, mottles, sugar, yellows	Resistance (ALS, Web blight, Powdery Mildew)
ICA-La Selva Medellin	2100	Relay with maize	Climbers and bush - large red, mottles, whites, yellows	Resistance (ANT, ASC)
ICA-Obonuco Pasto	2600	Direct association with maize	Climbers and bush - large red, mottles, whites, yellows	Resistance (ANT, ASC, Halo Blight)

BCMV = Bean Common mosaic virus, CBB = Common bacterial blight, ANT = Anthracnose, ASC = Ascochyta

Table 3. Germplasm accessions, advanced lines and F2 populations from Bean Breeding III sent to collaborating national programs during 1988.

	Number of materials		
Countries	F2 populations	Advanced lines	Germplasm
	LATIN AMERICA		
Argentina	33		
Ecuador	18	961	283
Peru	25	996	
	AFRICA		
Burundi	8		
Ethiopia	45		
Rwanda	324	283	
Tanzania	8		
Uganda	66		
Zaire	29		
Zambia	63		
Total	619	2240	283

Table 4. Backcross breeding program. Number of F2 populations evaluated and crosses made in 1988.

Project	No. of Populations screened	No. of crosses made		
		Simple	BC1	BC2
BCMV	1116*	119	167	63
Anthracnose	301	86	74	62
Halo Blight	84	47	39	30
Nitrogen Fixation	-	10	10	-
Non-Nodulating Mutants	34	16	-	-
Others	-	116	-	9
Total	1535	394	293	173

BC1, BC2 = backcross 1 and backcross 2, respectively.

Table 5. Yields of 10 best bush bean lines from ICA-CIAT Regional Trial for mid-altitude adaptation. 1988[1]

Material	Rioblanco Tolima	Altamira Huila	Popayan Cauca	Pescador Cauca	Pescador Cauca	Dagua Valle	Quimbaya Quindio	La Cumbre Valle	Darien Valle	La Catalina Pereira	Mean	Seed color
	LOCATIONS											
Sangretoro B.	1208	252	2872	671	431	-	1583	1050	-	1794	1233	6
AFR 251	1000	667	1169	623	334	1249	2377	1208	971	1566	1116	7
AND 629	1223	575	1998	748	950	906	1183	1168	462	1733	1095	7M2
AND 628	987	889	1904	689	500	1330	1100	1346	324	1697	1076	6M2
PVA 1327	791	405	2010	735	584	1200	1087	1402	402	1982	1060	7
PVA 773	593	572	2293	885	814	1116	1800	865	114	1514	1056	6M2
ICA L 63	1032	444	1999	585	500	-	1325	915	699	1696	1022	6M2
PVA 7	1039	711	2030	637	385	633	1738	907	187	1914	1018	7
AND 331	1219	528	1521	903	906	-	1103	894	397	1685	1017	6M2
AND 364	955	244	2721	788	503	643	867	1052	450	1569	979	6M2
Mean	1004	528	2051	726	590	1011	1416	1080	445	1715		

[1] A total of 42 materials were tested.

Table 6. Yield of mid-high altitude climbing bean lines from ICA-CIAT Regional Trial. 1988.

	LOCATIONS									
Material	La Union Valle	Cajamarca Tolima	Pescador Cauca	Michinal Cauca	Michinal Cauca	Pescador Cauca	Mean	Seed color	Seed size	Growth habit
LAS 67	1406	1453	405	472	350	103	698	2M6	52	4B
LAS 74	1328	1274	491	467	380	285	704	2M6	63	4B
LAS 79	1816	1888	423	655	-	249	1006	2M6	44	4B
LAS 94	1510	1815	385	492	449	141	798	2M6	58	4B
LAS 106	911	2188	395	365	275	283	736	2M6	54	4B
LAS 109	729	2286	523	232	154	290	702	2M6	53	4B
LAS 110	899	2020	379	150	194	-	728	2M6	57	4B
LAS 111	1323	2462	261	727	521	264	926	2M6	66	4B
LAS 181	3164	1764	777	680	428	237	1175	6	33	4A
LAS 210	553	1629	370	424	-	177	630	6	54	4B
LAS 213	834	1764	307	418	243	-	713	6	52	4A
LAS 219	813	1822	393	324	193	297	640	6	59	4A
LAS 220	794	1914	315	266	560	165	669	6	44	4A
LAS 231	1458	1684	492	305	279	148	727	6	56	4A
Frijolica LS3.3	1644	1832	291	159	127	393	741	2M6	65	4B
ICA Viboral	1471	1624	129	491	-	-	928	2M6	67	4B
Local Variety	1731	1357	-	532	245	10	775	-	-	-
Mean	1317	1811	396	421	314	217				

Table 7. Yield of five best lines per location from the ICA-CIAT bush bean Confirmation Trial. 1988[1]

Location	Yield (kg/ha) of 5 best lines					
	1	2	3	4	5	Mean
MELENDEZ	CALIMA	ANT 8	ZAA 69	PVA 1195	PVA 864	
(VALLE)	1770	1460	1458	1458	1302	1490
B/LA GRANDE	PVA 1195	PVA 782	PVA 1261	ICA 10509	PVA 476	
(VALLE)	1295	1156	1038	875	861	1045
RUTA-TORO	PVA 1195	ICA 10509	PVA 782	PVA 698	RADICAL	
(VALLE)	1317	1273	1235	1205	1177	1241
RUTA-LA UNION	PVA 782	PVA 1261	ZAA 69	ZAA 71	ANT 8	
(VALLE)	683	629	543	520	376	550
RUTA-LA UNION	PVA 782	CALIMA	ZAA 69	PVA 1261	ZAA 71	
(VALLE)	1301	1236	1001	998	935	1094
RIO BLANCO	PVA 476	ZAA 69	PVA 782	TEST. LOCAL	PVA 1261	
(TOLIMA)	1208	1094	962	906	903	1015
DAGUA	PVA 476	PVA 1261	ZAA 69	PVA 698	PVA 864	
(VALLE)	1553	1525	1401	1115	1071	1333
ENSAYO No. 5	PVA 698	PVA 1261	ICA 10509	PVA 476	PVA 864	
(VALLE)	1298	1071	1047	1031	915	1072
ENSAYO No. 6	PVA 1261	ZAA 69	PVA 864	ZAA 71	RADICAL	
(VALLE)	1820	1803	1716	1648	1618	1721
PESCADOR	PVA 1261	PVA 864	PVA 476	PVA 782	ZAA 92	
(CAUCA)	2125	2053	2008	1850	1820	1971
MORALES	PVA 1261	PVA 782	ANT 8	PVA 476	ZAA 92	
(CAUCA)	978	840	728	720	653	784

[1] Total of 12 materials in Confirmation Trial.

Number of times each line in the Confirmation Trial figured among the 5 best, and total points received[2].

Materials	No. of times among 5 best	No. of points accumulated[2]
PVA 476	6	18
PVA 698	3	9
PVA 782	7	26
PVA 864	5	11
PVA 1261	9	33
ZAA 69	6	20
ZAA 71	3	5
ZAA 92	2	2
ICA 10509	3	9
ANT 8	3	8
TESTIGO LOCAL	5	13
PVA 1195	3	11

[2] If a line had the highest yield of the 5 best lines, then it received 5 points, No. 2 received 4 points... No. 5 received 1 point, then the number of points received is summed over locations

Table 8. Yield of mid-high altitude Climbing Bean Confirmation Trial, Colombia.

Material	LOCATIONS 1985A Marmatos Caldas	1985B Aranzasu Caldas	1986 Tambo Valle	1985 Sevilla Valle	1986 Ensayo # 4	Mean	Seed color	Seed size	Growth habit
Frijolica LS 3.3	1167	1528	1040	2150	706	1318	2M6	65	4B
ICA La Selva 4	1333	2613	1291	1845	422	1561	2M6	60	4B
ICA La Selva 7	1167	1750	1825	2483	407	1526	2M6	62	4B
ICA Viboral	1167	1394	885	1983	293	1144	2M6	67	4B
ICA Llanogrande	1333	1264	1750	1984	116	1289	2M7	57	4A
Local Variety	1500	1655	1456	1183	656	1290	-	-	-
Mean	1278	1701	1375	1938	433				

LATIN AMERICA

THE ANDEAN REGION

The Andean Bean Project funded by the the Swiss Development Cooperation (SDC) began its activities in 1988.The project will place emphasis during its beginning year on Peru, Ecuador and Bolivia. Colombia and Venezuela are not included in this project as they are within the mandate of PROCIANDINO and CIAT headquarters.

The primary objective of the project is to increase bean productivity in the Sierra and Coastal areas through the development and successful adoption of small-farmer oriented technologies.

Beginning activities used to introduce the project to scientists of the Peruvian and the Ecuadorian Bean Programs, included two seminars using the "Project Planning by Objectives" (PPO) Methodology.

The PPO in Peru was held in Lima, May 9-13, and 18 scientists from INIAA participated representing different disciplines: planning, socioeconomics, technology transfer. These researchers came from all three bean producing areas of Peru--the Sierra, Coast, and Jungle regions.In addition, there were representatives from three universities, SDC, and CIAT.

The PPO Seminar for Ecuador was held in Ibarra, August 15-18, but was poorly attended due to political turmoil. The main focus of the bean project in Ecuador will be to increase the production, and even more importantly, the consumption of this important grain in the country.

Regional Subprojects

Subprojects were decided upon during a meeting of the leaders of the Bean Programs of INIAA, Peru, and INIAP, Ecuador, with the CIAT Andean Bean Project. Peru will be the leader for the development of materials resistant to antracnose and ascochyta blight, whereas Ecuador will lead the development of a pilot project on "artesanal" seed production. Training was reviewed, and three courses were decided upon for 1989. The first 1989 steering committee will meet in March in Peru.

PERU

The project in Peru will emphasize the development of consumer-acceptable bean varieties for the Sierra and the Coast regions. In the Sierra, these varieties need to be resistant to anthracnose and ascochyta blight. Non-aggressive climbing bean varieties will be selected for their nitrogen fixing ability, and suitability for intercropping with Peru's valuable exported maize. Materials for the Coast must have resistance to BCMV, rust and nematodes. The first nursery with canarios and bayos from Los Mochis, Mexico, was planted in 1988 to test their adaptation to Peruvian Coastal conditions.

CIAT's breeding program at headquarters sends materials for these two regions of Peru to the Peruvian Bean Program which then multiplies improved materials at the experiment station level. Emphasis from the CIAT Andean Program will be directed toward building strong on-farm-research and seed production programs to make these materials available to the farmers.

On-Farm Research

The Peruvian National Program has a good number of trained specialists on OFR. A large number of trials will be set up in different bean regions in the Sierra with the active participation of involved farmers. This participatory methodology will be emphasized to better familiarize the farmers with the newly introduced varieties and improved cultural practices.

Microbiology

Peruvian Universities have been involved in *Rhizobium* research for some time, and two of them are currently producing "commercial" inoculants. The National Research Institution, INIAA, has just one microbiologist working in this field. Previous studies indicate that the native *Rhizobium* is efficient in some areas of the Sierra. The Andean Project has therefore initiated a joint venture with the national bean program and some of the universities to further explore this. The INIAA microbiologist has been able to isolate some native strains from Cusco, and four strains have been selected from greenhouse trials to be tested on-farm in Cusco and Cajamarca. The selected strains were CIAT-CUS 1 (Cusco cv. ZAV 83099), CIAT 10 (Ipiales), and CIAT 632.

Genetic Resources

The Andean Project was involved in coordinating collection trips for the GRU Scientists and the CIAT breeder with INIAA personnel in Peru to collect wild species in the Sierra (Cusco). They were able to collect 25 landraces of *P. vulgaris*.

ECUADOR

An economic study of Ecuadorian consumers and markets is really needed to better understand the current low consumption of beans. Meanwhile, CIAT is providing early and advanced generation trials to Ecuador for planting this year. The Ecuadorian Bean Program has recently released four varieties which are selections of germplasm entries. The Andean Project will emphasize on-farm research and seed production in Ecuador, and will take advantage of the collective on-farm research methodologies used by CIAT and ICA in the Colombian regions close to the northern province of Ecuador.

Training and Workshops for the Andean Region

Training at CIAT

Three Peruvian scientists received training at CIAT this year, in Pathology, Agronomy and Genetic Resources Management.

In-Country Courses

The Andean Project organized three courses in the region, to strengthen on-farm research and seed production. Two of the courses will be given in Peru: one on artesanal seed production (in Cusco), and the second on on-farm research (in Cajamarca). The course in Ecuador will deal with artesanal seed production. The courses in seed production are organized in collaboration with the CIAT Seed Unit.

All these courses will be given in three phases to follow bean growth: at planting, at the pod formation stage, and at harvest. The artesanal seed production courses will be attended by farmers and technology transfer specialists from the Cusco (Peru) and the Imbabura (Ecuador) regions.

MSTAT Course -Four INIAA bean scientists participated in a MSTAT statistical software use training course given by CIMMYT in collaboration with CIAT and CIP.

Workshops

Rhizobium Workshop

A regional workshop on *Rhizobium* is being organized in Peru to create a network among scientists from Ecuador, Bolivia, and Peru. Most of the attendants (16) are from Peruvian Universities, supplemented by two agronomist/microbiologist teams from Bolivia and Ecuador. The formation of agronomist-microbiologist teams is important both for successful inoculant testing in the field, and for making the inoculum available to the small farmers. It is hoped that the workshop will standarize methodology and strategies in the region.

On-Farm Research Workshop

CIAT gave a three phase course of OFR in 1985, and a follow-up course was needed. Therefore, a workshop is being organized to specifically include participants who took this course and are still active in OFR. In addition, the socioeconomic section INIAA will be invited to participate to incorporate them in the OFR process. The workshop will be held in Cajamarca with field work in the San Marcos and Cajabamba regions where the improved variety Gloriabamba has been planted by the farmers in the past years.

International Workshop on Bean Anthracnose

Two Peruvian bean pathologists attended this International Workshop at CIAT headquarters, to familiarize themselves with the disease control technology available for this production limiting disease in the Sierra.

Planning Seminar For The Sierra Region

The scientists responsible for bean research in the Sierra Region, the coordinators of the Coast and the Jungle regions, and the leader of the INIAA Grain Legume Program, plus CIAT representatives for breeding, agronomy, microbiology, plant pathology, on-farm research and training, met in Chiclayo (Peru), August 22-23, to program all the activities for the Sierra planting season 1988-1989.

Collaboration with PROCIANDINO

The presence of CIAT bean representatives in the region has improved the relations with the Programa Cooperativo de Investigacion Agricola para la Subregion Andina, PROCIANDINO, (BID/IICA), particularly with the Subprograma 1, Grain Legumes.

The Coordinador of the CIAT Andean Bean Project acts as the Associate Coordinator of the Grain Legume Subprogram of PROCIANDINO. Responsibilities are shared, with the CIAT scientist taking over beans and the PROCIANDINO Coordinator taking care of activities involving broadbeans, lentils and peas.

CIAT has been able to provide technical advice through its association with PROCIANDINO in Virology to Venezuela, Entomology to Bolivia, and Germplasm Management to Peru. Scientists from the National Programs of Colombia and Peru have received training at CIAT in Physiology, of Colombia and Ecuador in Entomology, and of Colombia and Peru in Plant Pathology. Some of the scientists of the CIAT Bean Program have participated as instructors in PROCIANDINO courses in Colombia (Production Course on Broadbeans, Lentils, Peas and Chickpeas) and in the Seminar on Technology Transfer in Peru. CIAT has also provided improved black beans to Venezuela through the Central America Bean Project through the VIDAC-87, VIDAC-88, and the VICAR-88 nurseries. These nurseries will be planted by FONAIAP, and the Central University of Venezuela, by the end of this year.

CENTRAL AMERICA AND THE CARIBBEAN

The Central American and Caribbean bean project, headquartered in Costa Rica, continued this year to emphasize research, training, and seed production in collaboration with national programs in the region. Existing interinstitutional and interregional collaborations were furthered strengthened through increased backup for regional research projects as well as various other information and germplasm exchanges.

Regional Collaboration

March 26, 1988 marked the second annual meeting of the Steering Committee of the Bean Program's regional project in Central America, Mexico, and the Caribbean (Table 1). Costa Rica, Cuba, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, and the Dominican Republic sent representatives to this meeting wherein they presented the research results from regional projects. Priorities for the coming year were determined, and it was agreed to continue the four basic projects initiated in 1987 on the following constraints to bean production: Web Blight, Apion, Earliness, and Common Bacterial Blight.

The Web Blight project is the responsibility of Costa Rica, the Dominican Republic, El Salvador, Panama, and Honduras.

The Apion project is the responsibility of Honduras, El Salvador, Mexico, and Guatemala.

Earliness will be investigated by the national programs of Guatemala, Nicaragua, Mexico, and Cuba.

The Common Bacterial Blight project will be managed by Cuba, the Dominican Republic, and Nicaragua.

In addition to the presentations and discussions of regional projects, the assembly set up meetings and interchanges for 1988-1989 among the four regional projects to discuss methodology and to coordinate work between the countries involved in each regional project.

Training

Nine courses were given in the region on bean production, on-farm research, and artesanal bean seed production. The majority of the 220 participants in these courses were extension agents or regional scientists from different countries. These courses were primarily taught by Caribbean and Central American national program scientists, backed up by training personnel from CIAT.

In addition to training activities within the region, 31 people participated in an intensive specialized course on bean production given at CIAT by scientists from the Bean Program, or by scientists in the Seed Unit. Also, 24 scientists from the region participated in specific workshops at CIAT during the course of the year.

Table 2 lists bean courses organized by the Central American and Caribbean Bean Project in 1988.

Table 3 lists presentations made by regional scientists at the 34th annual meeting of the PCCMCA held in San Jose, Costa Rica in March 1988.

Regional Nurseries

The Black VIDAC and Red VIDAC nurseries for 1988 include the best selections from 1987 and new entries from various countries that did not have enough multiplied seed available in 1987.

The Black VIDAC 88 nursery includes: 92 lines selected from the 87 VIDAC; 48 lines to test for BGMV resistance from Monjas and Cuyuta (Guatemala) and 26 lines from Los Mochis, Sinaloa, Mexico, with a local check for each six entries.

The Red VIDAC 88 includes: 111 lines from the Red VIDAC 87; 17 from the web blight project in Costa Rica; 19 selections from the SRN program in Honduras; 18 from the breeding program of the Escuela Agricola Pan Americana, Zamorano, Honduras, as well as three elite checks. Local checks are provided for each six materials under investigation. Eighteen VIDACs of large-seeded black beans and 16 VIDACs of large-seeded red beans were sent on request to the countries shown in Table 4.

Adaptation Nursery for Central America (VIDAC) 1987

Of the Black VIDAC planted in the first and second semesters of 1987, 20 lines showed good seed size (between 23.25 and 27.25 mgs); eight showed stable earliness; seven showed resistance to common bacterial blight (Xanthomonas phaseoli); 33 showed equal or less susceptibility to BGMV damage than did ICTA Ostua in the nursery at Monjas, Guatemala; nine were superior to the check Tolerante (Talamanca) in Esparza, Costa Rica and 13 yielded more than

2100 Kg/Ha in seven locales as opposed to 760 Kg/Ha for the checks.

Six black lines showed outstanding desirable characteristics for combatting the most frequent and important constraints to bean production in the region, and these lines will be used in future crossing programs. Those lines showing more than one desirable characteristic are listed below:

No. Entry	Identification	Source	Characteristics
2	Jut84-3-CM(6-B)	Guat.	Earliness, BGMV resistance, 1800 Kg/Ha
3	Jut84-7-CM-(8-B)	Guat.	Earliness, BGMV resistance, 1400 Kg/Ha
4	XAN 236	CIAT	XAN resistance, Tolerance to Mustia, 1300 Kg/Ha
13	NAG 224	CIAT	XAN and BGMV resistance, 2298 Kg/Ha
16	NAG 209	CIAT	BGMV resistance, good seed size, 1950 Kg/Ha
129	NZHC13646-M	C.R.	BGMV resistance, good seed size, 1950 Kg/Ha

In the Red VIDAC 1987 the majority of entries showed good seed size with 45 of the lines having an average of more than 24 mgs, which improved their acceptability. Twenty lines showed earliness (62-65 days to maturity); 14 showed resistance to rust over three locations (Esteli, Jalapa, and Palmira); 28 lines showed better tolerance to CBB than the test check in Jutiapa, Zamorano, and Carazo; 14 selections showed greater tolerance to Golden Mosaic Virus than did RAB 50 (test check); five lines showed tolerance to mustia hilachosa; and 30 yielded better than 2100 Kg/Ha while the test check yielded 880 Kg/Ha. The most promising lines overall are:

No. Entry	Identification	Source	Characteristics
218	RAB 457	CIAT	Tolerance to Mustia, 2193 Kg/Ha
224	RAB 462	CIAT	Good seed size, BGMV Tolerance, 2207 Kg/Ha

225	RAB 463	CIAT	XAN and Mustia Tolerance, 2207 Kg/Ha
244	RAB 478	CIAT	XAN and Mustia Tolerance, 2285 Kg/Ha
252	RWZI11155-CM(8-C)	GUAT	XAN and BGMV Tolerance, 2113 Kg/Ha

VIDAC 1988--Esparza, Costa Rica

Table 5 shows the ten black-seeded materials and one red-seeded material having resistance to mustia hilachosa that were selected in May 1988 in Esparza, Costa Rica.

Adaptation and Yield Nursery for Central America (VICAR) 1988

At the 34th PCCMCA meetings in San Jose, it was decided to change the composition of the VICARs by replacing the lowest yielding entries in each category; the black entries Nayarit and NAG 80 were eliminated and replaced with ICTA Quetzal and ICTA CU85-11, and among the red-seeded entries RAB 70 was replaced by DOR 364. Requests received during the meeting were filled by shipping 35 Black 1988 VICARs and 33 Red 1988 VICARs (Table 6).

The Black VICAR-88 showed that there were an ample number of varieties available for adverse conditions with more than one variety recommended for each locale (Table 7).

The Red VICAR-88 showed that the varieties DOR 364 and RAB 383 demonstrated overall superiority to the stresses of BGMV and Mustia, as well as showing the best adaptation to the tropics (Table 8).

VICAR 87

In an analysis of the yields over 27 repetitions and nine locales, the following five varieties in the Black VICAR yielded on average about 1700 Kg/Ha: ICTA Ostua, ICTA CU85-12, Talamanca, Chirripo, and ICTA CU85-15. Six yielded between 1500-1600 Kg/Ha: NAG 15, ICTA CU85-12, NAG 20, XAN 154, HT77001-1 and ICTA Tamazulapa (Tables 9 and 10). Statistically, the yield differences were highly significant for localities, varieties, and local interactions X varieties, at the level of 1%. In the Red VICAR, a combined analysis of the harvests of 33 repetitions over 11 localities showed the best variety to be RAB 311 with 1690 Kg/Ha followed by RAB 310 and RAB 204 (1662 Kg/Ha) and RAB 39 (1610 Kg/Ha). The best four varieties in the 1500-1550 Kg/Ha yield class, all surpassed the check Rojo de Seda (Tables 11 and 12).

Nurseries Introduced to the Region

A great deal of germplasm was introduced to the region during 1988 (Table 13). The germplasm sent included 15 IBYANs, 43 diverse international nurseries, 493 F_2 and F_4 populations, 231 diverse lines and 3 crossing blocks.

Production of Basic Seed

The production of basic seed is a major constraint to bean production everywhere. The Central American and Caribbean Bean Project is attempting to answer this need by multiplying seed for regional and national nurseries, as well as for test plots to facilitate the more rapid transfer of improved technology to the farmer.

COUNTRY STUDIES

GUATEMALA

The three bean producing areas in this country involved with the Regional Project are the southeast, Peten, and the central high plateau (Chimaltenango).

ICTA Ostua was introduced in 1985 as a short cycle, black variety having resistance to BGMV virus. Since then, on-farm research has produced much information on the acceptability and diffusion levels of ICTA Ostua as well as on the factors influencing these levels. Tables 14, 15, and 16 summarize data from trials executed in 1986A, 1986B, and 1987A. Table 14 shows average yields from transfer plots, sole cropped and intercropped. When ICTA Ostua was evaluated in monocrop systems, it performed better than farmers' varieties on average by 30 percent, and by 22 percent in intercrop systems. In Table 15 it can be seen that a high percentage of the harvest from each plot was saved for future plantings. Table 16 shows the good harvest, good architecture, drought tolerance and BGMV resistance characteristic of ICTA Ostua which make it so readily acceptable to farmers. Other characteristics making this bean superior include: resistance to BCMV, tolerance to web blight, resistance to rust, and good adaptation to poor soils and a variety of production systems.

In the southeast of Guatemala, PROGETTAPS-DIGESA is developing a seed production system for small farmers which in this year made available to farmers 1000 packages of seed of the varieties ICTA Ostua, ICTA Tamazulapa, and ICTA Quetzal.

In an attempt to understand more about post release acceptability of ICTA Ostua, a study was initiated this year to follow the variety with the cooperation of DIGESA and ICTA in Jutiapa. Data was collected from 28 extension workers, 155 agricultural leaders, and 70 agricultural representatives having access to the new material. The results are currently undergoing analysis but preliminary results indicate an extremely effective transfer of ICTA Ostua to the small farmers in 1987 as shown by the 2000 farmers planting ICTA Ostua in May 1988 in ten areas of Jutiapa.

Another study directed at increasing understanding of the problems facing bean producers in the area was initiated with the Project PROGETTAPS-DIGESA. Data has been collected from 150 farms studied through multiple visits throughout the growing season in the southeast of Guatemala.

INACOP (Instituto Nacional de Cooperativas) continued the diffusion of the varieties ICTA Tamazulapa and ICTA Ostua in the north of Guatemala in Peten, among seven agricultural cooperatives serving 350 farmers. Average yields of 1300 to 1625 Kg/Ha were obtained in 1987-88 from introduced varieties (Table 17).

A critical problem observed in Peten is seed quality. Commercial quality grain is carried by truckers to the region for each planting. Therefore, areas with the best production conditions had to be identified for the introduction of new varieties. Seed sent to these areas was well-protected with triple bagging, resulting in harvests of clean seed (95 to 98% pure) having germination of 91 to 96%.

Harvests in the Pacific coast of Guatemala gave the following yields: Mochis 84 (2700 Kg/Ha), ICTA Ostua (2300 Kg/Ha), ICTA CU85-12 (2400 Kg/Ha), ICTA 883-2-M (2300 Kg/Ha), DOR 364 (2573 Kg/Ha), RAB 383 (1800 Kg/Ha) and Selec. Dark Red Kidney (2000 Kg/Ha).

EL SALVADOR

CIAT, in collaboration with CENTA and MAG, conducted work in two regions: Region I (Santa Ana, Sonsonate, Ahuachapan);

Region III (San Vicente, Cabañas, La Paz). Yield trials were planted in the first semester to test CENTA Izalco and RAB 204 (CENTA Jiboa) in on-farm trials. CENTA received ten packets of seed of RAB 204 and 1.5 quintales of each of the varieties DOR 364, RAB 383, RAB 310, RAB 311, and RAB 282. In Region I data was collected from nine trials and 27 validation plots. In Region III positive results were obtained from six trials and 66 validation plots.
RAB 204 was released in San Vicente with the name CENTA Jiboa, in a formal ceremony attended by all technical staff and agricultural leaders of the region. In Central America, this variety has demonstrated its superiority to all locally or commercially grown red beans (See the Red VICAR for 1985, 1986, and 1987). RAB 204 showed the following characteristics in on-farm trials:

Resistance to the Common Mosaic Virus (BGMV)
Tolerance to Web Blight (*Thanatephorus cucumeris*)
Tolerance to Common Bacterial Blight (*Xanthomonas phaseoli*)
Resistance to Rust (*Uromyces phaseoli*)
Resistance to Anthracnose (*Colletotrichum lindemuthianum*)

New varieties were tested on-farm in Region III and data from the first semester indicate that all were superior to the farmers' local checks as shown by the following yields: DOR 364 (1773 Kg/Ha), RAB 383 (1416 Kg/Ha), RAB 310 and 311 (1350 Kg/Ha). The earliness of RAB 383 made it preferable in Region III although it is less tolerant to BGMV and CBB than is DOR 364.

Variety trials were conducted on-farm in nine locales in Region I during 1988A. All four lines under study surpassed the check in yield tests: DOR 364 (1571 Kg/Ha), RAB 311 (1487 Kg/Ha), RAB 204 (1413 Kg/Ha), RAB 310 (1410 Kg/Ha), Local Check (1162 Kg/Ha).

If these results are confirmed in the second planting, DOR 364 can be promoted as an alternative to RAB 204 in areas where BGMV is a problem.

In the upcoming year, work in El Salvador will focus on following the diffusion of CENTA Jiboa in Region III and in studying the origin, handling, and quality of seeds used by farmers in Region I.

NICARAGUA

In collaboration with MIDINRA, a diagnostic study of Zone IV (Masaya,Granada) was carried out, as was a varietal adoption study of Revolution 84 and Revolution 84A. These studies served as basic training for the 33 technicians and extension workers actually working in this area.

The work comprised a preadoption study carried out by the participants of a three phase onfarm course.

The first phase provided basic training in 10 zones where the following production constraints were observed by the participants: the presence of CBB; the unavailability of good quality seed; the lack of awareness among farmers of alternative varieties to Revolution 81 (planted by 78%), the inefficiency or nonexistence of extension methodologies; late plantings; fields affected by web blight, slugs, and soil management problems.

The second phase of the course comprises a diagnostic analysis which will be carried out in farmers' fields in Region IV. The results of these studies will be available in May 1989.

An adoption study in Zone IV is almost complete. Preliminary data from all these studies indicate that Revolution 81 is by far the most widely used seed, and that other varieties are hardly known. It is to be hoped that demonstration plots will facilitate the acceptance and diffusion of alternative varieties, particularly those less susceptible than Revolution 81 to CBB and web blight.

A second adoption study was initiated in November 1988 in Region I. MIDINRA had begun a basic seed multiplication project to answer the crying need for more available healthy seed.Revolution 81, 84 and 84A were multiplied, as were the new lines RAB 310, RAB 311, RAB 213 and XAN 107.

HONDURAS

A mid-year study on the factors favoring or limiting the diffusion of the new variety Catrachita was initiated. Information from this study led to the following conclusions:

1. Farmers and technicians agreed that Catrachita is a good variety that yields as well or better than the traditional ones. The color, size, shape,and flavor was acceptable to consumers and the plant architecture was approved by the growers. Other favorable characteristics mentioned by those interviewed were resistance to BCMV and earliness.

2. Negative aspects of Catrachita mentioned included loss to drought during 1987-88, that left many farmers and official seed distributors without seed. The price of this now rare seed skyrocketed to US$89.00 for 46 kilos.

3. All involved agreed that more seed had to be made available in the markets and through distribution channels

at a reasonable cost to effectively increase distribution. Also, artesanal seed production should be increased.

While Catrachita is superior to local varieties, its resistance to CBB and angular leaf spot needs to be improved. It is resistant to BCMV, anthracnose, demonstrates tolerance to rust and apion, and is somewhat resistant to BGMV.

On the national level, 18% of all cultivated land in Spring or Winter months is planted to Catrachita. As second plantings of beans are extremely important in Honduras, it was decided to continue this adoption study through the second stage. The support of the national bean program will enable this second half of the study to cover a larger number of farmers and a larger geographic area.

In Yoro, 11 demonstration plots were planted on-farm with Catrachita, yielding on average 1257 Kg/Ha, as opposed to 850 Kg/Ha for the local control. This high yield so enthused the farmers, that an additional 56 parcels were planted. Five pounds of Catrachita seed with accompanying description and planting information were given to each of the producers. These farms will be evaluated through multiple on-site visits. The principle objectives of this work are: to diffuse this variety; investigate its agronomic characteristics and compare them with local varieties; and to report farmers' observations on Catrachita, during its various stages of growth and development. This method of giving small amounts of seed to many farmers, has been very effective in diffusing new varieties in areas that normally receive little attention.

In 1988, the national bean program produced 1386 quintales of seed for the first season planting, and another 1266 quintales for the second season. Forty-two percent of the total yearly production was the new variety Catrachita. Figure G1 shows the seed sales distribution paths for 1988 in different regions.

COSTA RICA

Adoption and technology development studies were begun in Costa Rica, in Nicoya. A large number of small farmers, and lack of previous attention to this area made it the choice for this study. Information obtained indicate adoption levels of new varieties to be far lower than in the rest of the country (Tables 18,19).

A comparison of yield by cropping system and variety type shows that farmers' mixtures yielded much lower than national program selections in any cropping system.

Bean farming in Nicoya is subsistence level agriculture, involving very little technology and low use of selected seed. Institutional support like technical assistance and credit is very limited and plays no part in the diffusion or tranference of new bean technology.

Varietal Release Studies

At the beginning of the year, four countries were involved in an attempt to define strategies for production, release and diffusion of new varieties. The study concentrated on the following varieties: ICTA Ostua, CENTA Izalco, Catrachita, and Huetar (Table 21).

ICTA Ostua from its release to its diffusion, encountered all the right conditions to make a good impact. It had already experienced a great deal of diffusion through the planting of demonstration plots (700 between 1986-1988) and through artesanal seed production at the state and private levels.

Another variety from Guatemala, ICTA Quinackche did not have desired diffusion. In cooperation with the socioenonomics section of ICTA, a study was designed for the department of Chimaltenago to investigate the causes for this poor diffusion.

Catrachita needs a bit more diffusion to insure a relevant impact in Honduras, as does CENTA Izalco in El Salvador. In Costa Rica, adoption of selected materials is generally very high; however, there are areas where lack of technology transfer has kept production levels low.

Some of the factors influencing adoption are: the conservatism of small farmers and their unwillingness to try nontraditional methods or varieties; the risk and uncertainty that are tied to all new technologies and how farmers judge the magnitude of these risks; the type of market to which the crop is destined, in that farmers won't invest in improved seed if it is for consumption, unless they feel that the new variety has a highly preferable flavor; and, the support services available (seed selling sites etc).

Disease and Fertilizer Studies

The following investigations were carried out under project auspices during the year, with major efforts being devoted to mustia hilachosa studies.

1. A study on the effect of foliar urea applications on yield was carried out in El Peten, Guatamala. Three demonstration plots were planted with ICTA Ostua. These plots received an application of sprayed urea at 20, 35 or 45 days after planting, resulting in 20%, 30% and 130% yield increases, respectively.

2. Fungicide application experiments were performed in El Peten to look for optimal doses to apply against the ubiquitous mustia hilachosa. Improved seed combined with applications of Brestan 60 resulted in yields of 491 Kg/Ha whereas farmer varieties receiving no fungicide yielded 177 Kg/Ha.

3. PC 50, a variety recently released in the Dominican Republic, is very susceptible to mustiaand CBB. Based on integrated control studies, it is recommended that PC 50 receive three applications of Brestan 60 and one of Coccide 101.

4. Apion is a major constraint to bean production throughout Honduras. Studies show that Piretroides applications are effective in all regions.

5. Nitrogen fixation studies were established through the joint efforts of CIAT, the national university, and the Ministry of Agriculture in six on-farm trials in El Salvador. A native Rhizobium strain, selected the year before, was used in these trials planted with the varieties CENTA Jiboa and CENTA Izalco, to test nitrogen fixing efficiency. Preliminary observations indicate favorable differences due the inoculations.

MUSTIA HILACHOSA

A major effort was devoted to researching better methods of control for web blight (WB) this year.

In the second semester of 1987 and the first of 1988, research was directed toward investigations of different aspects of WB management, in the search for an optimum disease control strategy. The severity of web blight can be reduced through the use of resistant varieties, cultural practices and the application of fungicides. In an attempt to increase the effectiveness of each of those controls, and to integrate these methods into a strategy, the following experiments were conducted:

1. **Optimal stages for fungicide application**--This was evaluated with the variety Huasteco in Esparza, Costa Rica.

Each parcel was treated with three applications of Benomyl at intervals of 12 days. Treatments began at 10, 12, 14, 16, 18, 20, and 22 days after planting. Treated plants showed less disease than did the check, and the least disease when treated at 10, 12, or 14 days after planting (Table 22).

2. **Effect of timed applications on the efficiency of fungicide**--Benomyl was applied before and after the cierre de copa stage in test plots in Esparza, Costa Rica. Less disease was apparent on plants treated with Benomyl between the first trifoliate to the cierre de copa or pod filling stage. Highest yields were obtained from plots treated with the fungicide between the cierre de copa and first trifoliate stages, showing yields 46% higher than that of the check (Table 23).

3. **Integrated management of mustia hilachosa**--again in Costa Rica, an evaluation was conducted of disease severity and yield on two common bean varieties, BAT 1155 (susceptible) and Chirripo (resistent) under two planting systems and with and without fungicide. All control methods significantly affected yield and disease severity. The bean variety was the variable that had most effect on yield, followed by fungicide application and planting method (Table 24). Benomyl was most efficient in plots planted to the susceptible variety, which suggests that improving the resistence of varieties may render insecticide applications unnecessary (Table 25).

4. **Evaluation and confirmation of resistent lines to mustia hilachosa**--The objective of this nursery was to reevaluate 52 MUS coded lines, to confirm their resistence to mustia. Lines showing equal or less disease severity and greater yield than the check (Talamanca) were: MUS 1, MUS 2, MUS 3, MUS 33, and MUS 52. Other lines yielded more than the check, but showed greater disease (Table 26).

5. **Segregating populations selected from the breeding program for resistence to mustia**--A May, 1988 planting in Esparza, Costa Rica using 22 large seeded red families (F_5) resulted in the selection of 13 lines, eight of which came from RZHC 13672. From 28 F_6 and F_7 lines, seven were selected pertaining to these five populations--RZHC 10721, RCWI 10723, RCDS 11171, RCHC 12452 and RCHC 13740. From 12 F_6 and F_7 large seeded black lines, four were selected from the following populations--NZHC 13641, NXHC 13594, and NXHC 13596.

All populations selected for WB resistence are bush beans, indicating an association between this architecture and disease reaction.

6. **International Mustia Nursery**--The objective of this nursery is to evaluate levels of disease reaction and select parents to be used in a breeding improvement program. Varieties demonstrating greatest disease resistence in the May, 1988 planting in Costa Rica were: MUS 22, XAN 226, ICTA 883-5-2-M, RAB 47, RAB 72, RAB 408 and RAB 204.The firat three are black beans and the rest are red. Eighteen nurseries were sent to fulfill requests made at the PCCMCA meetings (Table 27).

7. **Development of inoculation methods**--pathology studies in 1988 were concentrated on strengthening the technical methodology to facilitate the selection process, and to transfer these techniques to personnel from the national programs involved in the mustia regional project.

a. Evaluating resistence from inoculations in the field and in the laboratory. To distinguish between plant architecture and physiological resistence, two inoculation techniques were developed. The first consisted of applying mycelia in suspension (60,000 frags/ml) or sclerotia (100/ml) on plant foliage in the field, or on cut leaves in a growth chamber. To reduce the chance of natural inoculation, the soil was covered with dead weeds or rice hulls. **Mycelia Inoculation:** Significant differences in resistence levels were discovered between varieties (seed from the national WB nursery of Costa Rica) inoculated in the field.This methodology made it possible to distinguish differences in severity of less than 15%.The inoculation of the same varieties in the greenhouse will eliminate differences in microclimates possible in the field, but results are not yet available from that experiment.
Sclerotia Inoculation: Leaves from 102 lines from the International Mustia Nursery-1988 were inoculated with a suspension of sclerotia. Marked differences between lines were observed 84 hours later, with RAB 79, RAB 29, NAG 217, MUS 76 and RAB 204 presenting severity levels of between 16 and 25%. In contrast, DOR 310, BAT 1514, MUS 56, BAT 450 and MUS 70 showed severity between 80 and 90% (Table 29).

b. Developing soil inoculation methods for Rhizoctonia solani: When inoculum in the field is in low quantity and irregular,the soil can be inoculated with the sexual stage of the pathogen to spread uniformly and raise inoculum to acceptable levels for evaluation purposes. Applying sclerotia and mycelia to the soil raised the disease severity and lowered variation by 36-42%, in comparison to the noninoculated soils (Table 30).

Table 1. Meetings and Workshops of the Caribbean and Central American Bean Project, 1988.

Event	Location	Date	No. Participants
1st Executive Committee Meeting	Guatemala, Guatem.	25 March	5
PCCMCA	San Josè, C.R.	21-25 March	45
Second Meeting	San Josè, C. R.	26 March	21
Coordination Meeting	San Josè, C. R.		
Work Meeting--Regional Project on Earliness	Guatemala, Guatem.	27-28 April	8
2nd Executive Committee Meeting	San Josè, Costa R.	19 April	3
Work Meeting--Regional Project on Mustia	San Josè, Costa R.	5-6 May	9
Work Meeting-- Project on CBB	Havana, Cuba	21-22 June	7
Executive Committee Meeting	Guatemala, Guatem.	4 Oct.	4
Workshop--Management and Evaluation of Mustia	San Jose, C. Rica	14-19 Nov.	13
Executive Committee Meeting	San Josè, Costa R.	25 Nov.	4
International Apion Workshop	Danlì, Honduras	29 Nov.-1 Oct.	26

Table 2. Training Courses Organized by the Regional Bean Project for the Caribbean and Central America, 1988.

Title and Location	Date	No. Participants
Artesanal Seed Production Phase 1 San Vicente, El Salvador	24-28 January	20
Production and Promotion of Varieties Santa Ana, El Salvador	24-28 January	29
Bean Production Havana, Cuba	7-18 March	19
Bean Agronomy and Production Region 4, Nicaragua	11-15 April	33
Bean Seed Production for Farmers Phases 1 and 2. Danli, Honduras	8-12 August	22
Production of Artesanal Seed 1st Phase Santa Ana, El Salvador	22-26 August	18
Production of Artesanal Bean Seed 2nd Phase Santa Ana, El Salvador	7-11 November	22
On-Farm Research, 1st Phase Region 4, Nicaragua	3-15 October	29
International Course: Research and Production of Beans for Extensionists and On-Farm Studies. Sololà, Guatemala	17-28 October	32
Bean Production Danlì, Honduras	31 Oct-11 Nov.	22

Table 3. Papers Presented at the XXXIV PCCMCA Meeting in San Jose, Costa Rica, by country and research discipline, 1988.

Country	Research Discipline						
	Agronomy + Physiology	Evaluation of Genetic Material	Plant Protection	Genetic Resourc.	Socio Econ.	Nutri. Values	TOTAL
CIAT/CALI	1	4		2	1		8
CIAT/PROJECT--CENTRAL AMERICA AND THE CARIB:	4	10	5	1	2	1	23
COSTA RICA	9				1		10
EL SALVADOR	1		1				2
GUATEMALA	3	3				4	10
HONDURAS	1		1				2
MEXICO	1	3					4
NICARAGUA			1				1
TOTAL	**20**	**20**	**8**	**3**	**4**	**5**	**60**

Table 4. VIDAC 88. Nurseries Distributed.

Country	Red		Black	
	A*	B	A	B
El Salvador	2	2	-	-
Guatemala	1	1	2	2
Costa Rica	1	2	1	2
Honduras	2	2	-	-
Nicaragua	1	1	1	1
Cuba	-	1	-	1
México	-	-	1	3
Venezuela	-	-	-	4
TOTAL:	7	9	5	13

* Semester

Table 5. Lines Selected from VIDAC 88, in Esparza, Costa Rica, May-August 1988.

Entry No.	Identification	Parents	Color*	Mustia	Yield (GR/M^2)
124	NZHC 13663-M	NAG 30 x TALAMANCA	8	6	77
58	NAG 256	BAT 58 x SEL 718	8	6	60
11	NAG 222	BAT 1647 x G8519	8	6	63
16	NAG 209	XAN 108 (DOR I5 X DOR 146)	8	5	97
56	NAG 255	BAT 58 x SEL 718	8	6	72
81	NAG 273	G 4495 x SEL 718	8	6	75
82	NAG 274	G 4495 x SEL 718	8	6	33
125	NZHC 13662-M	NAG 130 x MUS 14	8	5	93
126	NZHC 13661-M	NAG 130 x L 81-3	8	5	105
128	NZHC 13641-M	NAG 12 x L 883-2	8	6	82
129	NZHC 13646-M	MUS 11 x NAG 12	8	5	93
131	MEX E-1		8	6	76
268	RCDS 11171-8-1-CM (5-B)		7	6	59
	TALAMANCA	VENEZUELA 44 x JAMAPA	8	5	50
	BAT 1155	G 4792 x G7131	7	8	12
	HUETAR	MEXICO 80 R x BAT 202	6	6	35

* 8 = black, 7 = purple, 6 = red

Table 6. VICAR 88. Distributed Nurseries

Country	Red		Black	
	A	B	A	B
El Salvador	2	2	-	-
Guatemala	3	4	3	6
Costa Rica	3	3	3	3
Honduras	4	4	2	2
Nicaragua	3	3	-	2
Cuba		1	-	1
Dominican Rep.	-	-	-	2
México	-	-	-	5
Venezuela	-	-	-	4
Puerto Rico	-	-	-	1
Haití	-	1	-	1
TOTAL:	15	18	8	27

Table 7. Average Performance--Black VICAR 88 A.

Identification	EEFB-ALAJUELA-C.R.			MONJAS,GUATEMALA			CHIAPAS,MEXICO	
	No.	Kg/Ha.	Duncan 0.01	BGMV	Maturity	Kg/Ha.	Kg/Ha.	Duncan 0.01
ICTA CU85-14	8	1616	A	6	65	1258	2096	AB
ICTA CU85-12	15	1571	AB	5	66	1883	2038	AB
OCH N84	7	1529	ABC	6	65	1634	2093	AB
ICTA CU85-11	1	1447	ABCD	6	65	1470	1821	ABC
NAG 20 (SIBONEY)	12	1443	ABCD	6	65	1148	1881	ABC
NAG 15	6	1430	ABCD	6	68	1537	1842	ABC
ICTA CU85-15	13	1424	ABCD	6	65	1211	2464	A
ICTA QUETZAL	10	1368	ABCD	4	65	1657	1902	ABC
TALAMANCA	4	1359	ABCD	5	66	1394	1879	ABC
XAN 154	14	1355	ABCD	6	69	1214	1882	ABC
HT7719 (CHIRRIPO)	2	1295	ABCD	5	65	1214	1244	BC
MOCH N83	11	1261	BCD	5	68	1784	1680	ABC
TESTIGO LOCAL	16	1237	BCD	4	66	2011	1576	ABC
HT7700-1	9	1197	CD	6	67	1441	1461	BC
ICTA OSTUA	3	1170	D	4	65	1762	1753	ABC
ICTA TAMAZULAPA	5	1110	D	5	64	1540	1104	C

Table 8. Average Performance—Red VICAR 88 A.

Identification	No.	EEFB-ALAJUELA-COSTA RICA Kg/Ha	Duncan 0.1	BGMV	MONJAS GUATEMALA Maturity	Kg/Ha	Duncan 0.1
DOR 364	2	1614	A	2	66	2195	A
RAB 310	12	1336	AB	6	66	721	CD
RAB 204	10	1272	ABC	6	64	915	BCD
RAB 383	9	1230	ABC	5	62	1449	B
RAB 404	13	1207	ABC	7	67	681	D
RAB 282	4	1206	ABC	7	60	674	D
RAB 311	15	1193	ABC	7	66	726	CD
ORGULLOSO M5	5	1176	ABC	7	61	1050	BCD
CENTA IZALCO	11	1174	ABC	7	59	900	BCD
ROJO DE SEDA	3	1164	ABC	8	59	835	CD
MCD 2004	8	1104	BC	7	62	713	CD
LOCAL CHECK	16	1091	BC	4	62	1195	BCD
RAB 39	1	1040	BC	7	66	891	BCD
RAB 50	7	953	BC	5	62	934	BCD
COMP. HON.	14	817	C	5	62	1281	BC
RAB 60	6	814	C	5	62	1044	BCD

Table 9. Average yields (Kg/Ha) of varieties from Black VICAR 1987 A. planted in four different locales in Central America.

Varieties	Source	No. ENT.	GUATEMALA JUTIAPA	HONDURAS S. F. DEL VALLE	HONDURAS V. AHUMADA	COSTA RICA E.E.F.B.	Average Kg/Ha	Duncan's Test 0.01
ICTA CU85-12	GUAT	5	2370	1365	2495	2488	2179	A
TALAMANCA	C.R.	1	1812	1815	2149	2663	2110	A
ICTA CU85-14	GUAT.	3	1659	1777	2103	2844	2096	A
ICTA OSTUA	GUAT.	15	2146	1500	2150	2561	2089	A
XAN 154	CIAT	11	2636	1487	1765	2347	2059	A
ICTA CU85-15	GUAT	2	1673	1666	2032	2737	2027	A
HT 7700-1	C.R.	12	2023	1595	1629	2805	2013	A
HT 7719	C.R.	7	2175	1472	1862	2490	2000	A
NAG 20	CUBA	8	1414	1229	2552	2799	1998	A
NAG 15	CUBA	6	1305	1941	1735	2371	1838	AB
ICTA TAMAZULAPA	GUAT.	4	883	1550	1937	2340	1678	AB
MOCH N83	MEX.	13	1900	1320	1351	2131	1676	AB
MOCH N84	MEX.	14	2764	1147	1112	1642	1666	AB
NAG 80	CIAT	10	1273	1095	1307	2113	1447	B
NEGRO NAYARIT	MEX.	9	946	1050	1462	2154	1403	B
Average			1799	1467	1843	2433		
Repetitions		2	2364806.38**	699630.87**	2993486.54**	39584.21		
Varieties		14	975373.15**	216501.54**	535979.40**	327247.28*		
Error		28	335890.33	62796.67	113530.43	162110.15		
Total		44						
C.V.%			32.22	17.08	18.28	16.55		

** level of significance 1%

* level of significance 5%

Table 10. **Average yields (Kg/Ha) of 15 varieties from Black VICAR 1987 B. planted in five different locales in Central America.**

Varieties	Source	No.	GUATEMALA JUTIAPA	H O N D U R A S COMAYAGUA	LAS ACACIAS	ZAMORANO	COSTA RICA ESPARZA	Average Kg/Ha	Duncan's Test 0.01
ICTA OSTUA	GUAT.	15	2300	1809	868	1461	827	1453	A
NAG 15	CUBA	6	2913	1295	633	1548	735	1425	A
HT7719	C.R.	7	2049	1983	840	1478	638	1398	AB
ICTA TAMAZULAPA	GUAT.	4	2729	1120	636	1638	711	1367	ABC
ICTA CU85-12	GUAT.	2	2049	1464	861	1385	1074	1367	ABC
TALAMANCA	C.R.	1	2457	1073	727	1373	975	1321	ABC
ICTA CU85-15	GUAT.	5	2307	1521	624	1411	670	1307	ABC
NAG 20	CUBA	8	2372	1159	761	1397	519	1242	ABCD
HT 7700-1	C.R.	12	1860	1315	783	1361	732	1210	ABCDE
ICTA CU85-14	GUAT.	3	2152	946	765	1532	646	1208	ABCDE
XAN 154	CIAT	11	1769	1576	860	1190	558	1191	ABCDE
MOCH N83	MEX	13	1975	706	884	1292	663	1104	BCDE
MOCH N84	MEX	14	1878	639	827	1466	683	1098	CDE
NEGRO NAYARIT	MEX	9	1824	631	747	1511	220	987	DE
NAG 80	CIAT	10	1628	659	622	1518	293	944	E
Average			2151	1193	763	1437	663	1241	
Repetitions		2	502455.79*	1171588.01*	79911.65	485178.89**	170362.22*		
Varieties		14	394318.13**	553550.90**	27610.66	37157.04	144009.72**		
Error		28	109790.62	98905.43	57603.95	49578.03	40440.35		
Total		44							
C.V.%			15.41	26.36	31.47	15.49	30.34		

** level of significance 1%

* level of significance 5%

Table 11. **Average yields (Kg/Ha) of 15 varieties from Red VICAR 1987A. planted in six locales in Central America.**

Varieties	Source	No.	GUATEMALA JUTIAPA	H O N D U R A S COMAYAGUA	LAS ACACIAS	ZAMORANO	COSTA RICA ESPARZA	E.E.F.B.	Average Kg/Ha 0.01
RAB 204	E.S.	1	2627	1053	2009	2003	1181	2705	1930
RAB 310	HOND.	14	2154	1288	1570	2615	1213	2317	1859
RAB 39	HOND.	6	2567	1241	2470	1542	942	2045	1801
MCD 2004	HOND.	12	3008	931	1618	1394	878	2802	1772
RAB 311	E.S.	9	2625	599	1761	2150	1292	2141	1761
CENTA IZALCO	E.S.	5	2716	769	1704	1937	989	2366	1747
ORGULLOSO M5	NIC.	3	2613	1077	1844	1748	886	2291	1743
RAB 282	E.S.	10	2320	966	1691	1993	798	2611	1730
RAB 383	E.S.	15	2119	836	2324	1763	720	2528	1715
RAB 404	E.S.	11	2413	1131	1513	2223	1062	1886	1705
RAB 60	CIAT	2	2667	795	1847	1797	816	2268	1698
COMP.HONDUREÑO	HOND.	8	1908	1220	1960	1752	756	2123	1620
RAB 70	CIAT	7	2208	1168	1137	1772	971	2302	1593
RAB 50	HOND.	4	2251	1025	1897	1709	674	1940	1583
ROJO DE SEDA (T.U.)	E.S.	13	2259	926	1518	1632	686	2215	1539
Average			2430	1002	1791	1869	924	2303	1720

Repetitions	2	822055.36	68760.42	1077924.80**	484668.05**	119912.88**	1021917.98**
Varieties	14	250677.47	115488.65	324792.24**	271620.24**	113853.52**	214276.99
Error	28	272014.54	113960.05	131742.93	79683.91	13370.11	86191.27
Total	44						
C.V.%		21.46	33.70	20.27	15.11	12.51	12.75

** level of significance 1%

* level of significance 5%

Table 12. Average yields (Kg/Ha) of 15 varieties from Red VICAR 1987 B, planted in five locales in Central America.

			GUATEMALA	H O N D	U R A	S	COSTA RICA	Average	Duncan's
Varieties	Source	No.	JUTIAPA	COMAYAGUA	LAS ACACIAS	ZAMORANO	E.E.F.B.	Kg/Ha	Test 0.01
RAB 311	E.S.	9	2375	1943	1042	1350	1309	1604	A
RAB 310	HOND.	14	2297	1518	628	1561	1124	1426	AB
RAB 404	E.S.	11	2129	1098	943	1260	1578	1402	AB
RAB 39	HOND.	6	2005	1279	737	1165	1722	1382	AB
RAB 383	E.S.	15	1639	2356	556	960	1367	1375	AB
RAB 60	CIAT	2	1884	1204	749	1387	1633	1372	AB
RAB 50	HOND.	4	1898	1390	727	1238	1600	1371	AB
RAB 204	E.S.	1	1970	1326	756	1375	1276	1341	AB
COMP.HONDUREÑO	HOND.	8	1811	1291	640	1198	1713	1330	AB
ORGULLOSO M5	NIC.	3	2281	855	671	1319	1351	1295	AB
RAB 282	E.S.	10	1472	1758	795	854	1424	1261	B
CENTA IZALCO	E.S.	5	1983	1077	807	1218	1139	1245	B
RAB 70	CIAT	7	1994	990	677	1135	1407	1241	B
ROJO DE SEDA (T.U.)	E.S.	13	2202	771	487	1096	1118	1135	B
MCD 2004	HOND.	12	2316	659	566	915	1211	1133	B
Average			2017	1301	719	1202	1398	1327	

Repetitions	2	72986.71	491027.59*	144730.03*	53882.26	709173.94**
Varieties	14	199296.15	616964.84**	62754.92	109808.05*	131790.65*
Error	28	176761.26	145599.30	35001.22	48817.84	54347.06
Total	44					
C.V.%		20.84	29.33	26.03	18.38	16.67

** level of significance 1%

* level of significance 5%

Table 13. Nurseries from CIAT, Colombia sent to countries in the Caribbean and Central American Regional Bean Project, 1988.

First Planting	Second Planting
COSTA RICA	
1 Anthracnose Nursery	1 Anthracnose Nursery
2 Snapbean Nurseries	1 IBYAN Red small-seeded
2 Earliness Nurseries	1 VEF Red
2 IBYAN Red small-seeded	1 VEF Black
1 IBYAN Black small-seeded	18 Pop. F_2 various
GUATEMALA	
2 Earliness Nurseries	1 High-Temp. Nursery
2 Apion Nurseries	1 Crossing Block
32 Populations F_2	
1 Rust Nursery	
1 CBB Nursery	
1 Ascochyta Nursery	
1 High-Temp.Nursery	
1 VEF - all colors	
1 Architecture Nursery	
1 IBYAN - White small-seeded	
1 IBYAN - Red small-seeded	
1 IBYAN - Black small-seeded	
CUBA	
1 Earliness Nursery	24 popl. F_2 drought
1 CBB Nursery	35 popl. F_2 architecture
1 Rust Nursery	1 VEF Snapbeans
1 EP - all colors	1 Red, Black Climbing Nursery
1 Drought Nursery	
1 IBYAN Red large-seeded	
1 IBYAN Red Mottled large-seeded	
1 IBYAN White small-seeded	

H O N D U R A S

1 Apion Nursery
1 CBB Nursery
1 IBYAN 208803
1 EP 87 Red small-seeded
1 VEF 87 Climbers
18 Pop. F_2 Apion
42 Pop. F_4 Apion
1 Rust Nursery
1 Anthracnose Nursery
1 VEF 88 Red small-seeded
1 Crossing Block

N I C A R A G U A

1 Earliness Nursery
1 Apion Nursery
90 BCMV Resistant lines
1 Drought Nursery
1 Anthracnose Nursery
1 Drought Nursery

M E X I C O

120 F_3 populations
58 F_4 BGMV resistant lines
46 Various F_3 lines
1 Apion Nursery
3 Earliness Nurseries
1 Rust Nursery
1 VEF 88 Pink and cream
1 Crossing block
3 BGMV nurseries
59 pop. F_2 various
1 VEF yellow
37 Popl. F_2 BGMV

E L S A L V A D O R

1 Apion Nursery
7 Various F_2 popl.
37 BCMV lines
18 Pop. F_2 Apion
42 Pop. F_4 Apion
15 pop. F_2 Apion

D O M I N I C A N R E P U B L I C

2 CBB Nurseries
6 F_2 Mustia pops.
30 F_2 Architecture pops.

P A N A M A

1 High Temp. Nursery
2 IBYAN Red large-seeded
2 IBYAN Red mottled
1 VEF Red large-seeded, and mottled.
1 Nursery of Colombian types.

Table 14. Average yields of 281 transfer plots planted with ICTA Ostua over three planting seasons. Jutiapa, Guatemala.

	1986 A 1/ Sole	-Inter.	1986 B 2/ Sole	-Inter.	1987 A 1/ Sole	-Inter.
ICTA Ostua	1327	1075	1336	-	1293	1241
Farmers' Varieties	1028	886	877	-	864	918
Increments in %	23	18	34	-	33	26

Source: Acceptability Studies- DIGESA-ICTA

1/ 54 Plots
2/ 40 Plots
3/ 187 Plots

Table 15. End destination of ICTA Ostua seed harvested from 281 demonstration plots planted over three planting seasons in Jutiapa, Guatemala.

	1986 A % AGR.*	% PROD.**	1986 B % AGR.	%PROD.	1987 A % AGR	% PROD.
% To plant	91	77	97	46	93	48
% To eat	31	22	48	38	47	24
% To sell	2	1	13	16	63	28

Source: Acceptability Studies-DIGESA-CIAT
1. Per cent of farmers
2. Per cent of production

Table 16. Favorable characteristics of ICTA Ostua observed in 281 demonstration plots planted over three planting seasons in Jutiapa, Guatemala (farmers' opinions).

	1986 A 1/ % of farmers	1986 B 2/ % of farmers	1987 A 3/ % of farmers
Good yield	87	73	69
Good plant architecture	63	63	65
Drought tolerance	42	24	16
BGMV resistent	32	14	28
Easy to remove grain from pod	8	—	—
Uniform flowering	5	—	—

Table 17. Yields of ICTA Ostua planted in Tapado (minimal tillage) systems in El Peten 1987-1988.

Location	No. Plots	Seed	Yield
Cooperative TANHOC	7	40 Lbs.	585 Lbs.
Cooperative Unión ITZA	4	20 Lbs.	266 Lbs.
Cooperative Machaquila	7	56 Lbs.	325 Lbs.
Aldea Canchacan, Poptún	3	15 Lbs.	250 Lbs
Aldea Sacul, Dolores	1	8 Lbs.	130 Lbs.
TOTAL:	22	139 Lbs.	1596 Lbs.

Table 18. Varieties used by farmers in Nicoya, Costa Rica.

Variety	First Season Planting		Second Season Planting	
	NO.*	% **	NO.	%
TALAMANCA	6	8.95	8	5.50
BRUNCA	2	2.98	1	0.70
HUASTECO	1	1.49	-	—
HUETAR	1	1.49	-	—
MEXICO 80	7	10.45	6	4.10
JAMAPA	-	—	2	1.40
Farmers' mix--red	17	25.37	67	45.90
Farmers' mix--black	19	28.36	23	15.80
Farmers' mix--yellow	12	17.91	2	1.40
Farmers' mix--red and black	1	1.49	30	20.50
Farmers' mix--red and Mexico 80	1	1.49	1	0.70
Farmers' mix--red, black, yellow	-	—	3	2.10
Farmers' mix--red, black, Mexico 80	-	—	1	0.70
Farmers' mix--red and butter	-	—	1	0.70

* Number of farmers
** Percentage based on total number of answers

Table 19. Type of variety planted by season, Nicoya, Costa Rica.

	Selected Varieties		Farmers' Varieties	
	NO.	%	NO.	%
Summer Harvest (2nd.)	17	11.73	128	88.27
Winter Harvest (1st.)	17	25.37	50	74.63

Table 20. Total average yield by planting system, Nicoya, Costa Rica.

Variety	Yield/System Kg/Ha. ESPEQUE (conventional)	Yield/System Kg/Ha. TAPADO (minimal)	Average Yield Kg/Ha. TOTAL
TALAMANCA	624.22	441.60	509.22
BRUNCA	1314.22	-	1314.22
MEXICO 80	-	483.00	483.00
JAMAPA	1623.34	644.00	1133.90
Farmers' mix--red	359.72	333.96	336.72
Farmers' mix--black	950.36	255.76	346.38
Farmers' mix--yellow	92.00	186.76	151.80
Farmers mix--R,B	1104.00	258.06	286.12
Farmers' mix--R,B,Y	322.00	16.56	220.34
Farmers' mix--R,B, Mex.	-	110.40	110.40
Farmers' mix R, Y.	-	76.82	76.82

R = Red B = Black Y = Yellow Mex. = México 80

Table 21a. Varietal release studies, 1988.

R E L E A S E

STRATEGY	COUNTRY/VARIETY: GUATEMALA ICTA OSTUA	EL SALVADOR CENTA IZALCO	HONDURAS CATRACHITA	COSTA RICA HUETAR/ HUASTECO
1. Integration of research and extension	X[1]	-	X	X
2. Qualifying committee	X	-	X	X
3. Field days	-	-	-	X
4. Delivery of free seed	X	-	-	-
5. Seed to the private sector	X	-	-	-
6. Seed (for immediate demand)	X	-	X	X
7. Local distribution	-	-	-	-
8. Recommended for specific areas	X	-	X	-
9. Publicity	-	-	-	-

1. X = Strategy applied

Table 21b. PRODUCTION OF SEED

STRATEGY	GUATEMALA ICTA OSTUA	EL SALVADOR CENTA IZALCO	HONDURAS CATRACHITA	COSTA RICA HUETAR/ HUASTECO
	COUNTRY/VARIETY			
1. STATE PRODUCTION	+/-	+/-	+/-	+
2. PRIVATE PRODUCTION	+	-	-	-
3. ARTESANAL PRODUCTION	+/-	+/-	-	-
4. BASIC SEED	+	+/-	+/-	+
5. CERTIFICATION	+	-	-	+
6. AVAILABILITY	+/-	-	+/-	+
7. QUANTITY PROD. (TONS)	51	19	27	23 - 67

Table 21c. TECHNOLOGY TRANSFER

STRATEGY	GUATEMALA ICTA OSTUA	EL SALVADOR CENTA IZALCO	HONDURAS CATRACHITA	COSTA RICA HUETAR/ HUASTECO
	COUNTRY/VARIETY			
1. RESPONSIBILITY:				
RESEARCH	-	X	-	-
EXTENSION	X	-	-	-
BOTH	-	-	X	X
2. DEMONSTRATION PLOTS	X	-	X	X
3. MEETINGS BETWEEN SCIENTISTS AND FARMERS	X	-	X	X
4. MARKETING METHODS				
VARIABLES	X	-	-	-
UNIFORM	-	X	X	X
5. LOCAL SALES	-	-	-	-
6. PUBLICITY:				
DISPLAYS	-	-	X	X
RADIO, PRESS	-	-	-	-

TABLE 22. Effectiveness of applying benomyl at different stages of plant growth in controlling web blight (mustia).

Initial Application (days after planting)	Severity (%)	Yield (Kg/Ha)
12	12.00 A	954.17
14	12.00 A	736.46
10	13.00 AB	629.17
16	14.00 BC	620.83
18	14.00 BC	859.37
20	14.25 BC	644.79
22	15.25 C	719.79
CHECK	26.25 D	438.54

Table 23. Association of plant growth stage with effectiveness of benomyl application.

Stage of Fungicide Application	Severity (%)	Yield (Kg/Ha)
1st. Trifoliate to canopy closure	18.0 A	974 A
1st Trifoliate to pod filling	21.1 AB	880 A
Canopy closure to pod filling	26.3 BC	746 B
Check	28.5 C	524 C

Table 24. Effects of planting system, variety and fungicide application on yield and mustia severity, Esparza, 1987.

Variable	Yield	Severity
Minimal tillage	946.1 a	19.4 a
Conventional tillage	793.3 b	26.76 b
CHIRRIPO	1179.4 a	18.6
BAT 1155	610.0 b	27.5
BENOMYL	1111.4 a	18.7
Check	678.1 b	27.3

Table 25. Effect of interaction of variety X fungicide application on disease severity.

Interaction	Severity (%)	Difference (%)
CHIRRIPO + BENOMYL	15.8 A	5.5
CHIRRIPO - BENOMYL	21.3 B	
BAT 1155 + BENOMYL	21.6 B	11.7
BAT 1155 - BENOMYL	33.3 C	

Table 26. Promising lines selected from 52 MUS-coded lines tested in Esparza, Costa Rica, September 1987.

Identification	Cross	Yield G/M^2	Severity Percent.
	(G3664 x G2045) x (G4792 x G5694)		
MUS 1	(G3662045) x (G4795694)	208	9
MUS 3	BAT 245 X BAT 450	126	10
MUS 2	BAT 887 X BAT 76	122	9
MUS 5	BAT 861 X BAT 76	114	18
MUS 33	DOR 42 X (DOR 42 x XAN 112)	66	12
MUS 6	BAT 93 X BAT 1230	64	18
MUS 52	BAT 450 X G 4142	64	12
MUS 11	PORRILLO SINTETICO X BAT 76	61	15
MUS 15	A40 X G14026	59	15
MUS 37	BAT 304 X (BAT 304 x XAN 87)	56	15
MUS 22	PORRILLO SINTETICO X (XAN 112 X G3627)	54	15
MUS 19	A 147 X G 14026	53	15
MUS 17	XAN 112 X G 4485	52	15
TALAMANCA	VENEZUELA 44 X JAMAPA	52	12
BAT 1155	G 4792 X G 7131	11	25

Table 27. VIM nurseries distributed, 1988

Country	No. of Nurseries
El Salvador	3
Nicaragua	2
Panama	2
Costa Rica	4
Guatemala	2
Honduras	1
Mexico	1
Dominican Republic	1
Colombia	1
Rwanda	1

Table 28. Reaction of varieties from the national WB nursery in Costa Rica to inoculation with suspensions of mycelia (60,000 frags/ml).

Variety	Severity (%) *
BAT 1155	47.5 A **
HUETAR	27.5 B
REVOLUCION 81	26.2 BC
ICTA 883	23.0 BCD
MUS 47	21.2 BCD
A 237	20.7 BCD
RAB 377	20.0 BCD
RAB 408	18.7 BCD
MUS 52	18.2 BCD
TALAMANCA	16.7 CD
XAN 222	15.2 D
MUS 37	14.2 D
MUS 3	13.5 D

* Four repetitions (cv = 27.9)

** Means followed by the same letter are not significantly different Duncan's Test (p=0.05).

Table 29. Reaction of some varieties from the International WB Nursery to inoculation with suspensions of sclerotia of *Rhizoctonia solani*.

Lines	Severity (%) *
DOR 310	90 A **
BAT 1514	88 AB
MUS 56	85 ABC
BAT 450	81 ABCD
MUS 70	80 ABCDE
TALAMANCA	36 CDEF
RAB 204	25 FG
MUS 76	24 FG
NAG 217	23 FG
RAO 29	21 FG
RAB 79	16 G

* Average of six repetitions
** Means followed by the same letter do not differ significantly according to Duncan's test (p=0.05)

Table 30. Effect of inoculating soil with sclerotia and myoelia of *R. solani* on severity of mustia, Esparza, 1988

Treatment	Severity 25 DAI	Severity 60 DAI	Standard Deviation
Sclerotia*	15 A	75.0 AB	10.0
Mycelia **	8 AB	81.2 A	9.4
Check	3.2 B	55.0 B	14.72

* A suspension of sclerotia prepared by mixing 1 kg. of diseased dried plant material with sclerotia in water.
** 60,000 fragments of mycelia/ml MES BUFFER al 0.01 m.
DAI = days after inoculation

BRAZIL

Work continued as in previous years through germplasm flow, which in 1988 saw the following nurseries and segregating populations come to Brazil through CENARGEN.

1.	International Bean Golden Mosaic nurseries (requested by CNPAF and IAPAR)	188 lines
2.	Segregating populations for EMPASC populations	12
3.	Segregating populations for IAPAR populations	10
4.	BGMV nurseries for CNPAF from Breeding I	454 lines
5.	Low soil P lines	291 lines

The distribution of materials within CNPAF was as follows:

1. **Candidates for EPL, EPR of the NBERN system:**

Thirty-one outstanding lines were evaluated and selected from CAM 1987 and seed was immediately multiplied for the EPL (VEF stage) nursery. Another 55 lines, after being yield tested under central pivot systems in the wintertime, were also sent for the EPL nursery. These two shipments will become one part of the materials for the 1988-1990 National Bean Evaluation and Recommendation Network.

2. **Drought screening in the plant physiology program:**

The whole set of materials from last year's experiment that was tested under central pivot systems was screened for drought resistance. These materials comprised the following groups:

White seeded	23 entries
Carioca grain type	62 entries
Mulatinho grain type	96 entries
Precoce	44 entries
Black seeded	117 entries
Roxo	34 entries
Total	262 entries

<u>Results of EPR 87/88:</u>

Tables 1 and 2 show the 10 best lines from the EPR Carioca and Mulatinho of 1987/88 planted in the northeast by several institutions such as EPACE (Ceara), EMEPA (Paraiba), EPABA (Bahia) and IPA (Pernambuco). The yields of the Carioca nurseries were low and only a few lines outyielded the elite check. Some advanced breeding lines performed poorer than the elite check. AN 512678-0, AN 511661-0, and AN 512545-0 were the best lines and were outstanding in the three testing sites. The mulatinho grain type results were not better than the Carioca nurseries. EMGOPA 201-Ouro slightly outyielded IPA 6 in the elite check group. AN 512717-1, BZ 2518-1, and CB 511691-0 were the best lines in the northeast region. Table 3 shows the ten best purple advanced breeding lines planted by UEPAE Dourados/MS. AN 511638, TY 3361-1, AN 512737-0, and MX 1423-3 yielded over 1300 kg/ha. These lines were also outstanding in the state trial conducted by EMGOPA (Table 11).

EPR 1988:

This year, beyond the traditional grouping according to seed color (cream, carioca, and black), a new nursery, Precoce, is being distributed. Unfortunately there are not enough advanced breeding lines to set up a purple EPR 1988--producing purple pink lines is still the biggest problem in all breeding programs. CNPAF offered only 4 types of nurseries in 1988. The list of materials participating in the nurseries is presented in Tables 4 to 7.

The entries of the EPR nurseries, requested by state institutions from all over Brazil, should be reviewed every year. The outstanding lines of that year should be entered in the coming cycle as elite checks which means that materials in the coming EPR are expected to better the best lines of the last year. This process should enable breeders to avoid retesting poorly adapted materials. The disease scoring in the EPR this year took into account the testing continuance or non-continuance of materials.

The network also became more flexible in order to attend to different types of demands from the different regions in Brazil, specifically Region I (Rio Grande de Sul, Santa Catarina, and Parana) and Region II (Minas Gerais, Sao Paulo, Goias, Mato Grosso do Sul, Mato Grosso, and Rondonia). Some private seed companies joined forces with the agricultural cooperatives in bean breeding efforts, hoping for the success seen in previous cooperative efforts with maize and soybean breeding. One cooperative, COTIA, in Ponta Grossa, is emphasizing the incorporation of disease resistance in bean breeding work. The design of testing schemes must allow these non-EMBRAPA entities to participate with their best lines in the NBERN. For Region II, the Intermediate Trials (equivalent to Elite Trials in Region III, Teste Official in the State of Parana or State Trials in Santa Catarina) are where the best lines from the non-EMBRAPA entity are tested along with lines from the EMBRAPA system. The best lines from the official test can then be officially recommended in that region.

Results from these cooperative or EMBRAPA trials were presented at an annual meeting attended by all scientists involved, and recommended materials were proposed to the Commisao Tecnico Regional (CTR) which is composed of the Secretaria Nacional de Abastecimento e Producao (SNAP), the Associacao de Produtores de Sementes (ABRASEM), EMBRATER, and EMBRAPA. The working paper was then submitted to the Ministry of Agriculture to be officially published by the government and then distributed to the banks. The farmers can get credit for production from the bank when they use materials listed in the official government publication. The list (Table 8) shows the 1988/89 official lines and is divided into recommended and tolerated materials. Seed of tolerated materials, however, will rapidly decrease as not a single seed entity is multiplying them.

Results from State Trials:

EMPASC/Santa Catarina

Table 9 shows the yield trials of the colored grain type conducted by EMPASC in Chapeco/SC. The composition of the lines tested in this state trial show the diversified origins of the materials e.g. EMBRAPA, CIAT, and F.T. Seed Company. FT 83-120 has been recommended in the State of Parana since 1987. AN 512628-0, A 281, FT 84-324, FT 84-283, and A 252 yielded slightly higher than Carioca but only the first three entries yielder higher than Carioca 80.

EMGOPA/Goias

EMGOPA tested 3 groups of materials (the Carioca, black, and the red or purple seeded) during the 1988 dry season planting over 6 locations representing the major bean growing area in the State of Goias (Tables 10 to 12). In the Carioca grain type, An 511661-0, AN 512678-0, ESAL 511, and ESAL 522 yielded at least 100 kg more than the check. The black seeded materials showed many lines that yielded better than the tolerated cultivar, Rico 23, but inconsistent data to date prohibits EMGOPA from recommending a black material for the State of Goias.

In the purple and pink seeded materials only a few lines bettered the check, EMGOPA Ouro. TY 3361-1 and AN 511668-0 are worth mentioning here as their yields were very consistent over locations. These lines were also in the top 10 best of EPR 87 in the state of Mato Grosso suggesting that both are widely adapted in the central western region. The purple seeded material, EMGOPA 202-Rubi (LM 10348) which was released in November 1988 performed very well.

EPAMIG/Minas Gerais

EPAMIG conducted state trials for black beans in 3 locations within the Zona de Mata where black beans are planted and consumed (Table 13) and in 6 locations all over Minas Gerais (Table 14). There were several lines that outyielded Milionario, the local check for black lines in Minas Gerais state---Honduras 35 was the best line from the N-fixation program, while LM 21135 and CNF 290 were the outstanding yield lines. But, LM 21135, due to susceptibility to BCMV cannot be further tested in the NBERN. In the colored bean state trial MA 534559-0, RAB 96, ESAL 567, CNF 5548, and LM 10089-0 were the best lines.

UEPAE - Dourados/MS

The mulatinho and purple grain type advanced yield trials conducted by UEPAE Dourados in Mato Grosso do Sul are equivalent to state trials in other states. Tables 15 and 16 show the results of these two nurseries. The materials, tested in 3 locations, entered the State of Matogrosso through the EPR 1984. IPA 1, EMGOPA 201-Ouro, A 241, and A 377 outyielded the carioca check by more than 600 kg/ha.

In the purple seeded nurseries BAT 1458, BAT 1550, and LM 10013 also outyielded the carioca lines by more than 500 kg/ha. The poor quality of the carioca seed probably caused this low yield.

<u>EPR 1988--Preliminary Results</u>

These are the first results from the EPR 88 which has become a yearly trial due to requests from state institutions. EMGOPA planted two EPRs, the black and carioca type, in two locations, Jaragua and Anapolis/GO, in the dry season of 1988. Results are presented in Tables 17 and 18. In the carioca nursery only LR 720982 outyielded the elite check, ESAL 522 or the local check, EMGOPA 201-Ouro. Several CIAT advanced breeding lines, such as A 264, were selected under CNPAF conditions. Two lines, A 264-1 and A 264-2 came out of this. Unfortunately, they did not yield better than Carioca, the local check. This year the black EPR of 1988 was most discouraging as not a single line was able to outyield the elite check, AN 512573-0. Only a few lines (CB 720160 and LA 720165), outyielded the ICA COL 10103 . Data from other state institutions is still pending. Frost in the central western region (Mato Grosso do Sul, Mato Grosso) destroyed the EPR 88 in

June/July 1988. We expect to replant the same EPR 88 set, along with the new EPR 89 as scheduled in 1989.

Disease Nursery:

IBAT 1985/86 was sent in 1987. It was evaluated from December 1987 through February 1988 in Sao Joaquim and Lages in Santa Catarina. At these two sites anthracnose incidence is severe, and rust incidence is also very high.

Lines resistant to both anthracnose and rust are: Arguille vert, BAT 1386, A 493, EMP 90, A 411, G 2618, A 320, BAT 841, A 374, A 370, BAT 44, A 227, G 2641, G 3445, AB 136, G 2338, G 484, G 5971, and G 6040 (Table 19).

Snapbean Evaluation

Snapbeans are planted in Brazil as a crop that can either be intercropped or succeed tomatoes, taking advantage of tomato support systems. Production areas are usually limited to fertile soils with high input, and high seed costs and disease (rust) are the main constraints in most snapbean producing areas. Popular varieties are climbers grown for their fresh green pod state, yielding in excess of 20 tons/ha.

Bush snapbeans were introduced in Brazil a long time ago but due to low yield (7 - 8 t/ha) and high seed price, the climber type is still preferred. Introducing high yielding bush type snapbeans having seed that can be multiplied on-farm would be interesting for Brazil.

In early 1987 a snapbean nursery was planted in the introduction nursery (CAM) at CNPAF. The main objectives were to evaluate rust resistance under natural infection and to obtain sufficient seed to be distributed to the state institutions and other entities in Brazil. During the main growing season, December 1987 to February 1988, yield trials were conducted including the checks of the most common snapbean grown by farmers in Brazil. Seed production was also measured besides the fresh pod harvest. The Horticulture Department of EMGOPA in Anapolis and IAPAR also have the same set.

The following lines, under natural rust incidence, have proved to be tolerant to the disease:

HAB 1, 13, 66, 82, 93, 118, 119, 120, 130, 131, 136, 144, 145, 146, 160, 161, 167, 168, 175, 188, 191, 196, 199, 202

Extremely tolerant lines, in comparison to the standard check, Macarrao Rastreiro, were: HAB 133, 135, 162, 164, 166, 197.

There were only a few lines that yielded as well as the check, Macarrao Rastreiro, (960g/m2), but some of the lines are rust resistant. Outstanding lines from evaluations at CNPAF/Goiania and EMGOPA/Anapolis can be seen in Table 20.

Further evaluation of snapbeans is being carried out by:

University of Londrina/PR	148 lines
University of Brasilia/D.F.	148 lines
EMGOPA-Anapolis/GO	100 lines
PESAGRO-Itaguai/RJ	234 lines
CPATB-Pelotas/RS	100 lines

The University of Brasilia which received one set of the snapbean nursery will test these against anthracnose.

Nine selected lines of the snapbean nurseries that can be utilized as snapbean, green beans (granados), and dry seed, are being evaluated in Paraguay.

Depth of Water Table Experiments

It was reported last year that the depth of water table influenced bean yield. Yield losses were highest when beans were grown with shallow water tables (13 cm below the soil surface) and with high P levels (10g/pot TSP). Yields with low soil P treatment did not differ greatly making the depth of water table insignificant. This year research continues to focus on genetic variations among genotypes of the *Phaseolus vulgaris* L.

In general the experiment confirmed last year's results: the deeper the water table the better the yield in all lines. Significant yield loss occurred only when the water table was raised up to 13 cm below the soil surface (Table 21) causing a reduction in the number of filled pods/plant, and number of seeds/plant. The number of seeds per pod and yield per pod increased, however, when the water table was raised to 13 cm from the soil surface.The hundred seed weight did not change significantly but the number of unfilled pods/plant was the highest at the check treatment which suggests that pod filling may be influenced by water supply. Figure 1 shows the range of yields of 12 genotypes under different depths of water table. Yields of check pots varied from 6.5 to 8.5 g/plant whereas under water stress (13 cm) yields varied from 4.4 - to 7.4 g/plant. Figure 2 shows the relative yield losses (in %) at a water table of 18 and 13 cm below the soil surface. Some varieties increased their yield slightly when the water table was raised from 23 to 18 cm below the soil surface. These lines are: Porrillo Sintetico, XAN 112, TC 1558-1, and TY 3435-2. Porrillo Sintetico was reported to be the line least suffering in flooding experiments by CIAT 77. A constant water table of 13 cm below the soil surface presented greater relative yield losses where Porrillo Sintetico, XAN 112, A 176-1, EMP 84, and ICA COL 10103 suffered less than 25% yield losses. Lines, such as Rio Doce, BAT 477, EMGOPA 201-Ouro, and LM 21135 had losses varying between 35 to 48%.

The nutrient content and the nutrient absorbed by the bean plant at flowering time is also influenced by the water table (Tables 22 and 23). The concentration of N, P, and K increased when the water table was raised from 23 to 18 cm below the soil surface on pots receiving only 2 g TSP/pot. On the contrary, further raising of the water table to 13 cm did not change the concentration of nutrient compared to 18 cm. On higher P levels (10 g TSP/pot) the concentration of N and P increased by higher water tables but decreased slightly when the water table was raised to 13 cm below the soil surface.

The nutrient absorbed by the bean plant at flowering time showed a constant decrease in pots receiving either 2 or 10 g TSP, except for the quantity of N and P absorbed at 10 g TSP level with a water table at 18 cm below the soil surface--this showed higher than the checks.

It was reported last year that the yield of the bean plant was reduced by temporal inundation at the trifoliate stage. Leaf samples were taken at flowering time and tissue analysis was made. Table 24 shows the results. Forty-eight hour inundation at the trifoliate stage is sufficient to reduce the P concentration in the tissue or to increase the Ca concentration in the leaf. The absorption of all elements was reduced by almost 50% in comparison to those in non-inundated pots. Thus, inundation for just 48 hours during the trifoliate stage or later not only reduced plant growth but also the nutrition absorbed. As a consequence, yield was reduced by more than 30%.

Training and Workshops

There were 7 Brazilian participants at the International Anthracnose Meeting at CIAT held June 6-10, 1988. The purpose of this meeting was to standardize the differential lines in order to identify the physiological races of the anthracnose disease. This is important since many differential lines used by different Brazilian institutes donot relate to each other, or to those at CIAT, although they have the same name.

In November, another 7 Brazilian breeders participated in the International Breeders Workshop held November 7-11, 1988 at CIAT. The objective of this meeting was to update and interchange experiences of the Brazilian breeders with other breeders and researchers in biotechnology from all over the world.

Associated Work In Paraguay 1987-88:

Paraguay has participated in IBYAN since 1983 and about 45 lines have been evaluated. In 1987, the final tests of A 343 (cream seeded), BAT 1297 (red mottled), Carioca, and local checks were tested with large plot sizes by the farmers under farmer conditions. Table 25 shows the results. The results were discussed during the meeting held at Asuncion on February 24, 1988. It was decided that only Carioca will be promoted. It will be official released after the last test in November 1988. In the mean time, large-scale seed multiplication will be carried out. SEAG will multiply sufficient quantity (+- 4 tons) of Carioca cultivar using IAPAR/PR basic seed to ensure the seed quality.

A short course was held July 17 to 23, 1988 in Asuncion to train 25 extensionists of SEAG (Servico de Extension Agricola y Ganaderia) to set up an introduction nursery, the disease and pest evaluations, and to introduce the non-conventional seed production by small farmers with the collaboration of the seed unit.

Bean production constraints were also identified by the extensionists. Table 26 shows the constraints in the bean producing area in Paraguay.

The following introduction nurseries will be planted in the coming planting season:
1. final test of Carioca;
2. newly introduced advanced breeding lines from CIAT with carioca and cream seeded tolerance to bacterial blight and;
3. multi-purpose beans with local seed color preference.

Table 1. The 10 best lines from EPR 1987/88.

NO.	IDEN	PROGENITORS	LOCAL EMEPA	IPA	DOURADOS	MEAN
			YIELD KG/HA			
1	AN512678-0	A176*A259	419	1169	1315	968
2	AN511661-0	A287*BAT1514	341	1088	1213	881
3	AN512545-0	A247*(A262*(BAC105*BAC295)F1)F1	620	994	960	858
4	AN512785-0	A287*BAT1514	333	979	1175	829
5	AN511608-0	A240*(A176*A461)	423	1125	917	822
6	AN512561-1	A247*(A262*(BAC105*BAC295)F1)F1	395	851	1094	780
7	AN512558-0	A247*(A262*(BAC105*BAC295)F1)F1	433	689	1160	761
8	AN512804-0	A287*BAT1514	359	988	930	759
9	AN512787-0	A287*BAT1514	307	1100	734	714
10	AN511604-0	A240*(A176*A461)	426	773	930	710
X10			406	976	1043	808
	ELITE CHECKS					
1	A 281 E		472	1029	1162	888
2	CARIOCA E		369	519	775	554
X2			420	774	968	721
	LOCAL CHECKS					
1	T.LOCAL 4 L		-	954	-	-
2	T.LOCAL 2 L		-	775	-	-
3	T.LOCAL 1 L		-	733	-	-
4	T.LOCAL 3 L		-	446	-	-
X4			-	727	727	
EXP. MEAN X			384	852	957	739
L.S.D. 5%			226	883	-	-
CV (%)			14.4	32.7	-	-

Table 2: The 10 best Mulatinho lines from EPR 1987/1988.

BR.	IDEN	PROGENITORS	TIANGUA	EMEPA	IRECE	IPA	MEAN
			------------	------------	Yield kg/ha	------------	------------
1.	AN512717-0	"A176*CATU"	1268	860	889	793	953
2.	BZ 2518- 1	"A319*(A 240*PORRILLO SINTETICO)F1"	680		1393	749	941
3.	CB 511691-0	"PI 207.262 * AROANA"	1030	742	1008	913	923
4.	BZ 2231- 7	"(A175*G11890)F1 * (II61*G1805)F1"	1053	601	1179	724	889
5.	AN511648-0	"A176*A259"	594	825	1288	709	854
6.	SX 2232- 2	"A176*(BAT 336*(A 147*BAT 798)F1)F1"	810	673	1246	654	846
7.	BZ 2519- 7	"A359*(A 242*G 2528)F1"	565	576	1022	1117	820
8.	AN511646-0	"A176*A259"	804	729	952	640	781
9.	AN512648-0	"A176*A210"	785	630	993	706	779
10.	CB511679-0	"PI207.262*AROANA"	834	563	1060	656	778
X10			842	689	1105	766	856
	ELITE CHECKS						
1.	EMGOPA 201 OURO		909	625	1064	789	847
2.	IPA 6		754	335	1097	729	729
3.	CARIOCA		613	502	601	521	559
X3			759	487	921	680	712
	LOCAL CHECKS						
1.	T.LOCAL 1		800	478	1239	519	759
2.	T.LOCAL 3		657	384	807	918	691
3.	T.LOCAL 4		752	480	1211	35	620
4.	T.LOCAL 2		299	135	910	775	530
X4			627	369	1042	562	650
EXP. MEAN X			686	545	845	636	678
L.S.D. 5%			748	252	1024	344	
CV (%)			25.2	24.7	27.1	34.2	

Table 3: The preliminary yield trial 1987 of the purple bean type planted by UEPAE/Dourados MS in Bonito/MS.

Nbr.	Cod.	Ident.	Progenitors	Yield kg/ha
1	CNF 5478	AN511638-0	A176 * A210	1405
2	CNF 5466	TY 3361- 1	A297*A 375	1395
3	CNF 5476	AN512737-0	A253*BAT1510	1323
4	CNF 5479	MX 1423- 3	A63*G 3657	1316
5	CNF 5475	AN 512560-0	A247*(A262*(BAC105*BAC295)F1)F1	1213
6	CNF 5477	AN 512852-0	BAT841*BAT1449	1208
7	CNF 5474	TY 3364-15	A297*BAT 1550	1123
8	LM 10348	LM 10348	IGUACU*TAYAU	1077
9	CNF 5478	AN511638-0	A176 * A210	1030
10	CNF 5468	AN 511668-0	A287*BAT1514	1017
$\bar{X}$10				1211
CHECKS				
1	PARANA	PARANA	-	1208
2	MULATINHO	MULATINHO	-	1060
3	CARIOCA	CARIOCA		1037
4	MATEIGUINHA	MATEIGUINHA	-	631
$\bar{X}$4				984
EXP. MEAN X				1054

Table 4: The Carioca advanced breeding lines participating in EPR 1988.

TREATMENT	CODE	IDENTIFICATION	PROGENITORS	ORIGIN
01	CNF 4449	CARIOCA (T.R.)	—	IAC
02	CNF 5822	AN 720.928	AN 511439 X LM 10047	CNPAF
03	CNF 5819	MA 720.942	A 63 X EMP 117	CNPAF*
04	CNF 5824	LR 720.982	A 445 X A 246	CNPAF*
05	CNF 5821	MA 720.948	A 63 X EMP 117	CNPAF*
06	CNF 5825	LA 720.171	BAT 1658 X XAN 105	CNPAF*
07	CNF 5820	MA 720.943	A 63 X A 246	CNPAF*
08	CNF 4108	A 285	RIO TIBAJI X CARIOCA	CIAT
09	CNF 5823	LA 720.172	BAT 1658 X XAN 105	CNPAF*
10	CNF 5842	A 264-1	SELECTION NO. A 264	CIAT/CNPAF
11	CNF 5841	MA 534.551	A 63 X CARIOCA	CNPAF*
12	CNF 5843	A 264-2	SELECTION NO. A 264	CIAT/CNPAF
13	CNF 5840	AN 512.732-0	A 253 X BAT 1510	CNPAF*
14	CNF 5542	ESAL 522 (T.E.)	—	ESAL
15	—	— (T.L.)	—	—

OBS:
T.R. = RECOMMENDED CHECK
T.E. = ELITE EPR 87 CHECK
T.L. = LOCAL CHECK
*CNPAF SELECTED LINES OF F2 POPULATIONS ORIGINATING FROM CIAT.

Table 5: The cream (Mulatinho) grain type advanced breeding lines participating in EPR 1988.

TREATMENT	CODE	IDENTIFICATION	PROGENITORS	ORIGIN
01	CNF 5455	IPA 6 (T.R.)	—	IPA
02	CNF 5827	MA 720.952	A 339 X CATU	CNPAF*
03	CNF 5829	MA 720.947	A 340 X (A 154 X CARIOCA 80)F1	CNPAF*
04	CNF 5832	MA 720.949	A 63 X CARIOCA	CNPAF*
05	CNF 5837	TC 1558-1	—	CIAT
06	CNF 5836	MA 720.950	A 339 X CATU	CNPAF*
07	CNF 5833	MA 720.951	A 63 X A 246	CNPAF*
08	CNF 5830	MA 720.941	A 339 X CATU	CNPAF*
09	CNF 5828	MA 720.940	A 63 X EMP 117	CNPAF*
10	CNF 5839	AN 512.583-0-3	A 358 X (A 176 X (G 4326 X BAC 40)F1)F1	CNPAF*
11	CNF 0261	CNF 0261	—	CNPAF
12	CNF 5834	MA 720.946	A 339 X CATU	CNPAF*
13	CNF 5835	AN 711.616	AN 511439 X EMGOPA 201-OURO	CNPAF
14	CNF 5520	AN 512.717-0 (T.E)	A 176 X CATU	CNPAF*
15	—	— (T.L.)	—	—
16	CNF 5831	LR 710.301	XAN 87 X BAT 85	CNPAF*
17	CNF 5826	A 176-1	SELECTION NO. A 176	CIAT/CNPAF
18	CNF 5838	TY 3326-1	—	CIAT

OBS:
T.R. = RECOMMENDED CHECK
T.E. = ELITE EPR 87 CHECK
T.L. = LOCAL CHECK
*CNPAF SELECTED LINES OF F2 POPULATIONS ORIGINATING FROM CIAT.

Table 6: The black advanced breeding lines participating in EPR 1988.

TREATMENT	CODE	IDENTIFICATION	PROGENITORS	ORIGIN
01	CNF 2035	RIO TIBAGI(T.R)	-	IAPAR
02	CNF 5925	W 20-9	PUEBLA 152 X JAMAPA	U. WISCONSIN
03	CNF 5920	LR 710302	XAN 87 X ICA PIJAO	CNPAF*
04	CNF 5922	LA 720165	XAN 87 X XAN 94	CNPAF*
05	CNF 5924	LA 720155	XAN 87 X A 213	CNPAF*
06	CNF 3563	DOR 0012	G 3834 X G 4485	CIAT
07	CNF 5940	DOR 0352	DOR 42 X SEL 115	CIAT
08	CNF 5921	LA 720174	XAN 87 X A 367	CNPAF*
09	CNF 5932	84 VAN 52	G 4495 X XAN 117	CIAT
10	CNF 5938	LA 720130	BAT 1658 X A 218	CNPAF*
11	CNF 5923	CB 720160	XAN 87 X A 367	CNPAF*
12	CNF 5931	LA 720162	XAN 87 X A 367	CNPAF*
13	CNF 5929	LA 720164	XAN 87 X A 367	CNPAF*
14	CNF 5935	LA 720159	XAN 87 X A 367	CNPAF*
15	CNF 5919	LR 711459	AN 511439 X LM 10363	CNPAF
16	CNF 5941	LR 710280	A 297 X XAN 40	CNPAF*
17	CNF 5928	LA 720157	XAN 87 X A 367	CNPAF*
18	CNF 3130	BAT 448	(G 3664 X G 2045) X (G 4792 X G 5694)	CIAT
19	CNF 5927	LA 720163	XAN 87 X A 367	CNPAF*
20	CNF 5933	LR 720903	XAN 87 X ICA PIJAO	CNPAF*
21	CNF 5432	LM 30636	DOR 41 X SEL 131	CNPAF*
22	CNF 1082	EEP 12-547	MULATINHO C9 X ENXOFRE	CNPAF
23	CNF 5930	LA 720161	XAN 87 X A 367	CNPAF*
24	CNF 5939	LR 720930	RC3 (RICO 23 X TU)	CNPAF
25	CNF 5934	LA 720153	A 297 X XAN 40	CNPAF*
26	CNF 5936	84 VAN 38	BAT 448 X (BAT 1320 X XAN 58)	CIAT
27	CNF 5926	LA 720168	XAN 87 X ICA PIJAO	CNPAF*
28	CNF 5937	LA 720256	(LM 20771 X BAT 256)F1 X (LM 20322 X BAT 67)F1	CNPAF*
29	CNF 5483	AN 512573 (T.E)	A 358 X (A 176 X (G 4326 X BAC 40)F1)	CNPAF*
30		T.L.	F1	CNPAF*

OBS:
T.R. = RECOMMENDED CHECK
T.E. = ELITE EPR 87 CHECK
T.L. = LOCAL CHECK
*CNPAF SELECTED LINES OF F2 POPULATIONS ORIGINATING FROM CIAT.

Table 7: The precoce advanced breeding lines participating in EPR 1988.

TREATMENT	CODE	IDENTIFICATION	PROGENITORS	ORIGIN	GRAIN COLOR
01	CNF 6288	PR 711263	AN 511390 X LM 10363	CNPAF	CARIOCA
02	CNF 6300	AN 512666-1	A 176 X A 259	CNPAF*	CARIOCA
03	CF 840081	ENXOFRE	—	CNPAF	YELLOW
04	CNF 6299	AN 512666-0	A 176 X A 259	CNPAF*	CARIOCA
05	CNF 5621	ROXAO RG	—	CNPAF	PURPLE
06	CNF 3415	82 PVBZ 1865	BAT 332 X G 2858	CIAT	CREAM
07	CNF 0246	EEP 437/75	—	CNPAF	CREAM (G.M.)
08	CNF 6301	AN 512669-0	A 176 X A 259	CNPAF*	CARIOCA
09	CNF 6297	TY 3361-2	A 297 X A 375	CIAT	PURPLE
10	CNF 6296	PR 710315	XAN 87 X XAN 94	CNPAF*	DARK PURPLE
11	CNF 3137	QUARENTENHO	—	CIAT	BLACK
12	CNF 3367	82 PVBZ 1783	BAT 561 X (PERU 69 X T 042)F1	CIAT	CREAM
13	CNF 6294	PR 710291	A 395 X XAN 94	CNPAF*	DARK PURPLE
14	CNF 6293	PR 710290	A 395 X XAN 94	CNPAF*	DARK PURPLE
15	CNF 6286	PR 711093	LM 10034 X A 321	CNPAF*	CARIOCA
16	CNF 3416	82 PVBZ 1866	BAT 332 X G 2858	CIAT	CREAM
17	CNF 6295	PR 710314	XAN 87 X XAN 94	CNPAF*	BLACK
18	CNF 6298	TY 3361-3	A 297 X A 375	CIAT	PURPLE
19	CNF 0546	G. PRECOCE (T.G.)	--	—	CREAM
20	CNF 4540	HUETAR	—	CIAT	DARK PURPLE
21	CNF 6292	PR 710284	A 317 X XAN 40	CNPAF*	CARIOCA
22	CF 840743	VERMELHINHO	--	CNPAF	RED
23	CNF 3776	DOR 202	IN 17 X SEL 72	CIAT	SPECKLED
24	CNF 3268	82 PVMX 1554	MEXICO 222 X BAT 76	CIAT	CREAM
25	CNF 3781	BAT 1258	G 13922 X BAT 950	CIAT	SPECKLED
26	CNF 3700	POMPADOUR	—	CIAT	SPECKLED
27	CNF 6289	PR 711410-1	AN 511390 X EMGOPA 201-OURO	CNPAF	CARIOCA
28	CNF 6285	PR 711078	LM 10034 X A 482	CNPAF*	CARIOCA (PURPLE)
29	CNF 6291	PR 711611	AN 511439 X EMGOPA 201-OURO	CNPAF	CREAM
30	CNF 6290	PR 711410-2	AN 511390 X EMGOPA 201-OURO	CNPAF	CARIOCA
31	CNF 6287	PR 711133	[(BAT 477 X GOIANO PRECOCE)F1 X (IPA 7419 X EMGOPA 201-OURO)F1] F1 X [(LM 10034 X A 321)F1 X (CNF 0010 X BAT 1387)F1]F1	CNPAF*	PURPLE
32	CNF 4449	CARIOCA (T.N.)	—	--	CARIOCA
33	—	— (T.L.)	—	--	—

OBS:
T.G. = GENERAL CHECK
T.N. = NORMAL CYCLE CHECK
T.L. = LOCAL CHECK
* = CNPAF SELECTED LINES OF F2 POPULATIONS ORIGINATING FROM CIAT.

Table 8. Recommended cultivars in Brazil for 1987-1988.

STATE	RECOMMENDED	TOLERATED
GOIAS	EMGOPA 201 (OURO)* CARIOCA EMGOPA 202 (RUBI)	JALO EEP 558 RICO 23 CARIOCA 80
SAO PAULO	CARIOCA 80 SH AROANA 80 MORUNA 80 AYSO AETE 3 CATU	CARIOCA 80
M. GROSSO DO SUL	CARIOCA CARIOCA 80 RIO TIBAGI OURO (EMGOPA 201) OURO (EMGOPA 201)	FT-120 CARIOCA 80 SH JALO EEP 558
RONDONIA	IPA 7419 CARIOCA	RIO TIBAGI ROSADO
MINAS GERAIS	NEGRITO 897 MILIONARIO 1732 RICO 1735 CARIOCA 80 MINEIRO PRECOCE	CARIOCA RIO TIBAGI JALO EEP 558 CARIOCA 80 SH
DISTRITO FEDERAL	OURO (EMGOPA 201) CARIOCA RUBI (EMGOPA 202)	JALO EEP 558 RICO 23 CARIOCA 80
MATO GROSSO	CARIOCA JALO EEP 558 RIO TIBAGI	ROSINHA G-2
RIO DE JANEIRO	BR 1 - XODO BR 2 - GRANDE RIO BR 3 - IPANEMA PORRILLO SINTETICO CAPIXABA PRECOCE	MORUNA CARIOCA

* RECOMMENDED IN MORE THAN 1 STATE.

Table 8 (cont.). Recommended cultivars in Brazil for 1987-1988.

STATE	RECOMMENDED	TOLERATED
ESPIRITO SANTO	RIO DOCE RIO TIBAGI CARIOCA ESAL - 1 RIO NEGRO	CAPIXABA PRECOCE VITORIA IPA 1
RIO GRANDE DO SUL	TURRIALBA 4 RIO TIBAGI GUATEIAN 6662 MAQUINE CARIOCA TAHYU IRAI EMPASC 201-CHAPECO RIO NEGRO CAPIXABA PRECOCE	
SANTA CATARINA	EMPASC 201-CHAPECO FT 83-120 RIO TIBAGI CARIOCA CARIOCA 80 CARIOCA 80 SH	TURRIALBA 4
PARANA	CARIOCA RIO TIBAGI IAPAR 8 - RIO NEGRO IAPAR 14 IAPAR 16 IAPAR 20 FT TARUMA FT 83-120	IAPAR 3 - RIO IVAI FT - PAULISTINHA
BAHIA		
- BARREIRAS	EPABA 1 CARIOCA OURO RIO TIBAJI	IPA 74-19 MULATINHO V.ROXA
- NORTHEAST	BAGAJO FAVINHA CACHINHO CARIOCA PITOCO	IPA 6 MULATINHO V.ROXA

* RECOMMENDED IN MORE THAN 1 STATE.

Table 8 (cont.). Recommended cultivars in Brazil for 1987-1988.

STATE	RECOMMENDED	TOLERATED
BAHIA (CONT.)		
- PARAGUACU VALLEY	IPA 74-19 EPABA 1 IPA 1 CARIOCA	PITOCO MULATINHO V.ROXA ROSINHA SANTA ROSA
- IRECE	IPA 6 EPABA 1 CARIOCA	MULATINHO V.ROXA IPA 74-19
SERGIPE	IPA 6 IPA 1 BAGAJO CARIOCA RIM DO PORCO OURO (EMGOPA 201)*	IPA 74-19 FAVINHA MULATINHO V.ROXA CACHINHO MILAGRE DE STO.ANDRE BICO DE OURO
ALAGOAS	IPA 6 OURO (EMGOPA 201)* JALO EEP 558 BAGAJO CARIOCA MULATINHO V.ROXA	IPA 1 RIM DO PORCO DE SANTANA DO IPANEMA COSTA RICA RIQUEZA
PERNAMBUCO	IPA 6 IPA 1	IPA 3 IPA 5 GORDO FAVITA BAGAJO HF 465-63-1 VAGEM ROXA COSTA RICA CARIOCA
PARAIBA		
- AGRESTE	IPA 1 CARIOCA	IPA 74-19 RIM DO PORCO
- SERTAO CURIMATAU	IPA 6 IPA 1 IPA 3 IPA 5	FEIJAO DE CACHO

* RECOMMENDED IN MORE THAN 1 STATE.

Table 8 (cont.). Recommended cultivars in Brazil for 1987-1988.

STATE	RECOMMENDED	TOLERATED
CEARA		
- SERRA IBIAPABA	IPA 1 IPA 6	IPA 74-19 CARIOCA MULATA GORDA
PARA	ROSINHA JALINHO CARIOCA JALO	—
RIO GRANDE DO NORTE	NO RECOMMENDATIONS MADE	
MARANHAO	NO RECOMMENDATIONS MADE	
AMAZONAS	NO RECOMMENDATIONS MADE	
ACRE	NO RECOMMENDATIONS MADE	
AMAPA	NO RECOMMENDATIONS MADE	
RORAIMA	NO RECOMMENDATIONS MADE	

Table 9: Yield trial of colored grain type conducted by EMPASC in CHAPECO/SC 1987/88.

NBR	CODE	IDENTIFICATION	PROGENITORS	GRAIN YIELD KG/HA
1	CNF 5550	AN 512628-0	A 176 X A 259	1673 A
2	A 281		CARIOCA X RIO TIBAJI	1603 AB
3	FT 84-324		—	1579 ABC
4	CARIOCA 80		—	1496 ABCD
5	FT 84-283		—	1480 ABCD
6	A 252		CARIOCA X G 2618	1439 ABCD
7	CARIOCA		—	1399 ABCD
8	CNF 5545	AN 512785-0	A 287 X BAT 1514	1387 ABCD
9	FT 84-125		—	1378 ABCD
10	CNF 5544	ESAL 511	—	1314 BCDE
11	FT 84-867		—	1268 CDE
12	CNF 5555	AN 512668-0	A 247 X (A 262 X (BAC 105 X BAC 295)F1)F1	1230F DE
13	CNF 5542	ESAL 522	—	1047F E
14	CNF 5556	AN 512810-0	A 287 X BAT 1514	1046F E
15	FT 84-293A		—	1025F E
16	FT 84-301		—	948F
MEAN				1331
C.V. (%)				12.62

VALUES FOLLOWED BY THE SAME LETTER DO NOT DIFFER SIGNIFICANTLY AT 5% LEVEL (TUKEY'S TEST).

Table 10: Carioca grain type state trial conducted by EMGOPA during the dry season in 1988 in 6 locations.

IDENTIFICATION	GOIANIA	BRASILIA	ITAPURANGA	PIRENOPOLIS	MOSSAMEDES**	ANAPOLIS	MEAN
	KG/HA*						
AN 511661-0	1601 a	2709 ab	2574 a	2084 a	1708	816 a	1941 a
AN 512678-0	1257 ab	2891 a	2134 abcdef	2104 a	1983	1188 a	1919 a
ESAL 511	1432 ab	3047 a	2060 abcdef	2087 a	509	1046 a	1845 a
ESAL 522	1933 ab	2189 abcde	2139 abcde	1710 a	2302	1054 a	1836 a
AN 511608-0	1259 ab	2474 abc	2109 abcdef	1817 a	2012	1084 a	1765 a
CARIOCA	1599 ab	2370 abc	2187 abcd	1681 a	1600	896 a	1738 ab
ESAL 514	906 b	2943 a	1987 abcdef	1388 a	2258	1116 a	1705 ab
FT 84023	1155 ab	2943 a	2057 abcdef	1846 a	1011	749 a	1703 ab
FT 84-206	979 ab	2474 abc	2092 abcdef	1950 a	1577	871 a	1667 ab
ESAL 513	1356 ab	2241 abcd	2459 ab	1446 a	1530	818 a	1656 ab
AN 512513-0	799 b	3126 a	1818 bcdef	1835 a	1386	718 a	1642 ab
FT 84-292	1134 ab	1928 abcde	2235 abc	1841 a	901	926 a	1568 abc
RIO DOCE	1564 ab	938 de	1995 abcdef	2273 a	2008	880 a	1560 abc
AN 512537-0	1404 ab	1953 abcde	1795 bcdef	1761 a	1639	817 a	1552 abc
FT 84-3790/11	800 b	2969 a	1527 cdef	1486 a	1397	961 a	1539 abc
BZ 2180-1	1063 ab	1173 cde	1676 cdef	1764 a	1717	993 a	1358 bc
AN 512561-0	1079 ab	1849 abcde	1474 ef	1708 a	728	879 a	1356 bc
AN 512545-0	1399 ab	1224 cde	1491 def	1550 a	1697	879 a	1340 bc
AN 512717-0	627 b	1407 bcde	2029 abcdef	1411 a	1817	778 a	1335 bc
FT 84-1390	900 b	885 e	1428 f	1480 a	2191	958 a	1196 c
MEAN	1225.38	2186.54	1963.26	1761.20	1598.50	923.29	1611.09
CV%	25.34	19.52	11.68	22.15		18.48	19.87

* MEANS FOLLOWED BY THE SAME LETTERS DO NOT DIFFER SIGNIFICANTLY AT 5% LEVEL (TUKEY'S TEST).
**RESULTS FROM ONE REPETITION.

Table 11. Black seeded state trials conducted by EMGOPA at 6 locations during the dry season 1988.

IDENTIFICATION	GOIANIA	BRASILIA	ITAPURANGA	PIRENOPOLIS	MOSSAMEDES	ANAPOLIS	MEAN
	KG/HA*						
AN 512567-0	1305 a	1896 ab	2496 a	2399 ab	2280 a	1304 a	1947 a
AN 512573-0	947 a	2063 a	1737 ab	2627 a	2039 a	1149 a	1761 ab
HONDURAS 35	1051 a	1604 abcd	2492 a	1982 ab	1876 a	1311 a	1719 abc
AN 512637-0	1269 a	1750 abc	2020 ab	2088 ab	2053 a	1068 a	1708 abc
AN 511619-0	834 a	1823 ab	1904 ab	2104 ab	2167 a	1330 a	1694 abcd
AN 512575-0	959 a	1615 abcd	2465 a	1995 ab	1806 a	1268 a	1685 abcd
AN 512474-0	1223 a	1636 abcd	2316 a	1768 ab	1844 a	1184 a	1662 abcde
84 VAN-18	1289 a	1198 cde	2207 a	2072 ab	2107 a	1016 a	1648 abcde
W 22-24	942 a	1638 abcd	2075	1675 ab	1838 a	1067 a	1547 bcdef
RICO 23	775 a	1500 abcde	2282 a	1857 ab	1660 a	1023 a	1516 bcdef
FT 84-10220	1021 a	1199 cde	1864 ab	1937 ab	1875 a	1135 a	1505 bcdef
FT 84-10258/5	1171 a	1739 abcd	987 b	2115 ab	1819 a	1173 a	1501 bcdef
FT 84-184	574 a	1781 abc	1744 ab	1973 ab	1693 a	1048 a	1469 bcdef
AN 3508	895 a	1146 de	1683 ab	1945 ab	1719 a	1165 a	1425 bcdef
FT 84-430	927 a	917 e	2106 a	1669 ab	1634 a	1146 a	1399 bcdef
W 22-52	917 a	1209 cde	1483 ab	1791 ab	1888 a	961 a	1375 cdef
AN 512646-0	1032 a	954 e	1839 ab	1695 ab	1533 a	911 a	1327 def
W 22-27	773 a	1302 bcde	1809 ab	1446 b	1557 a	943 a	1305 ef
FT 84-1251	559 a	1404 bcde	1442 ab	1544 b	1482 a	1131 a	1261 f
ELITE CHECK							
ICA COL 10103	1450 a	1479 abcde	2115 a	1727 ab	1645 a	635 a	1519 bcdef
MEAN	995.77	1495.13	1953.20	1920.49	1825.84	1100.75	1548.53
CV%	29.89	12.87	17.97	17.82	20.62	22.33	19.87

*MEANS FOLLOWED BY THE SAME LETTERS DO NOT DIFFER SIGNIFICANTLY AT 5% LEVEL (TUKEY'S TEST).

Table 12: Purple and pink seeded state trials conducted by EMGOPA in the dry season 1988 in 6 locations.

IDENTIFICATION	GOIANIA	BRASILIA	ITAPURANGA	PIRENOPOLIS	MOSSAMEDES	ANAPOLIS	MEAN
	KG/HA*						
TY 3361-1	1114 ab	3543 abcd	2088 ab	2414 a	2369 a	952 a	2080 a
AN 511668-0	1346 ab	3387 abcd	2144 a	2138 a	2181 ab	963 a	2027 ab
EMGOPA 202-RUBI	1343 ab	3333 abcd	1883 abc	1836 a	1661 ab	1128 a	1864 ab
AN 512852-0	972 ab	2708 cdef	2044 ab	2256 a	2097 ab	983 a	1843 ab
FT 84-895	801 ab	3438 abcd	2083 ab	2040 a	1802 ab	858 a	1837 ab
AN 512655-0	1403 ab	3255 abcde	1617 abc	1864 a	2024 ab	858 a	1837 ab
AN 512907-0	1574 a	2318 def	2152 a	1927 a	2029 ab	955 a	1826 ab
FT 84-325	1031 ab	4115 ab	1489 abc	1659 a	1535 ab	1082 a	1818 ab
AN 511638-0	1208 ab	3229 abcde	2058 ab	1859 a	1447 ab	1108 a	1818 ab
FT 84-326	1066 ab	3412 abcd	1800 abc	1542 a	1983 ab	1919 a	1787 ab
MX 1423-3	1124 ab	3750 abc	1747 abc	1669 a	1252 b	1181 a	1787 ab
AN 512737-0	1291 ab	2918 abcdef	1943 ab	1869 a	1729 ab	899 a	1775 ab
TY 3364-15	902 ab	2839 bcdef	2136 a	2056 a	1742 ab	793 a	1745 ab
CF 840312	610 b	4167 a	1533 abc	1509 a	1453 ab	1119 a	1732 ab
AN 511637-0	1073 ab	3048 abcdef	1125 c	1964 a	1981 ab	1070 a	1710 ab
AN 512843-0	1283 ab	2031 ef	1547 abc	1714 a	1664 ab	915 a	1526 ab
FT 84-324	629 b	2552 cdef	1505 abc	1837 a	1454 ab	665 a	1440 ab
AN 512560-0	859 ab	1823 f	1679 abc	1567 a	1893 ab	792 a	1436 ab
AN 512821-1	887 ab	2627 cdef	1286 bc	1428 a	1404 ab	656 a	1381 b
LOCAL CHECK							
EMGOPA 201-OURO	1419 ab	3203 abcde	2063 ab	1994 a	2001 ab	791 a	1912 ab
MEAN	1096.66	3084.71	1796.06	1857.19	1784.96	934.13	1758.95
CV%	27.03	13.41	14.54	17.16	20.12	23.29	18.05

* MEANS FOLLOWED BY THE SAME LETTERS DO NOT DIFFER SIGNIFICANTLY AT 5% LEVEL (TUKEY'S TEST).

Table 13. State trial of black seeded material conducted by EPAMING in 1987/88.

	WET SEASON		DRY SEASON		
	1987	1988	1988	1988	
IDENTIFICATION	VICOSA	VICOSA	P. NOVA	LEOPOLDINA	MEAN
HONDURAS 35	-	2092	2676	1932	2233
LM 21135	1684	1411	2292	1926	1828
CNF 290	1589	1738	2190	1695	1803
AN 512-634-0	1302	2156	1909	1717	1771
RICO	1336	1335	2338	1782	1698
MILIONARIO	1063	1620	2140	1763	1646
DOR 241	1280	1388	2266	1589	1631
VI 2259(RICO23*TO)	1041	1441	2368	1660	1627
LM 30074	1311	1657	1949	1568	1621
LM 30030	1560	1639	1751	1413	1591
W 22-50	1323	1340	2015	1636	1578
SX 1574-2	1335	1298	1883	1785	1575
RICO 23*TO	990	1158	2162	1951	1565
VI 3702	1003	1199	2265	1763	1557
BZ 1480-8	1306	1701	1455	1641	1526
FT 83-86	1298	1644	1495	1586	1506
84 VAN 166	857	1789	1693	1598	1484
LM 20785	1304	1303	1551	1614	1443
FT 120	789	1617	1596	1684	1421
LM 20816	1164	1239	1337	1695	1359
MEAN	1239	1538	1967	1700	1623

Table 14. State trial of colored bean conducted by EPAMIG in 1987/88 in 7 locations.

	WET SEASON	DRY SEASON						
	1987	1988	1988	1988	1988	1988	1988	
IDENTIFICATION	VICOSA	LEOPOLDINA	VICOSA	JANAUBA	MACHADO	VIRGOLANDIA	P. NOVA	MEAN
MA-534559	-	1511	1716	2141	-	-	1975	1836
RAB-96	1035	1728	2150	1995	1087	-	2175	1695
ESAL 567	1477	1981	1910	1837	1261	1474	1817	1679
BZ 2180-1	1147	1451	1546	2478	1391	1354	1934	1614
LM10089-0	1362	1978	1716	1891	1033	1267	2173	1613
AN 512678-0	1239	1793	2035	1680	1511	1002	2031	1613
LM103767-0	1296	1951	1713	1658	1457	1089	2007	1596
Vi 2172	1134	1698	1660	-	1766	1207	2101	1594
MA-534554	1009	1666	1941	1799	1685	1307	1670	1582
RAB-94	1465	1929	1781	1522	1587	700	2037	1574
A 295	1055	1538	1854	1897	1462	1163	1979	1564
AN 511608-0	1031	1782	1555	1516	1500	1563	1821	1536
ESAL 564	1324	1834	2024	1538	1473	1020	1510	1532
ESAL 563	1402	1823	1539	1804	1440	846	1840	1528
ESAL 565	1069	1696	1868	1277	1473	1183	2048	1516
AN 511672-0	1044	1744	1598	1543	1440	1076	1981	1489
LM30013-0	1422	1257	1863	1614	1169	991	2078	1485
LM21303-0	1284	1753	1918	1652	1163	967	1656	1447
AN 512513-0	1239	1228	1732	1484	1386	-	-	1414
ESAL 566	1044	1723	1602	1701	1446	663	1716	1413
AN 512706-0	1296	1902	1552	816	1267	841	2210	1412
AN 511661-0	1196	1453	1825	1375	1641	770	1589	1407
AN 512561-0	907	1468	1363	1419	1478	-	1751	1398
BZ 1185-1	761	1402	1680	1527	1267	-	1722	1393
Vi 1958	1450	1114	1432	1370	1456	761	1540	1303
LM21322-0	1184	1533	1098	1647	1006	807	1606	1269
$\bar{X}$ 26	1195	1651	1718	1647	1394	1050	1879	1519
				LOCAL CHECKS				
CARIOCA	1117	1470	1762	2065	1027	1011	-	1409
MILIONARIO MUL	1026	1633	1830	1696	1538	1252	1153	1451
$\bar{X}$ 2	1072	1552	1796	1881	1283	1132	1153	1430

TABLE 15: ADVANCED YIELD TRIAL OF THE MULATINHO GRAIN TYPE MATERIALS THE STATE MATO GROSSO DO SUL IN 1987

NBR.	IDENTIFICATION	DOURADOS	PONTA PORA	INDAPOLIS	MEAN
		kg/ha			
1	IPA 1	1192	883	1653	1233
2	EMGOPA 201 OURO	1009	548	1948	1168
3	A 241	1013	682	1590	1095
4	A 377	886	638	1527	1017
5	A 255	1144	436	1468	1016
6	HGB	885	435	1686	1002
7	A 353	768	855	1357	993
8	A 75	971	326	1672	990
9	BAT 336	883	442	1424	916
10	A 251	849	606	1278	911
11	A 372	757	524	1364	882
12	A 352	865	529	1159	851
13	A 338	1134	325	898	786
$\bar{X}$13		950	556	1463	989
CHECK					
1	CARIOCA (T)	478	-	904	463
EXP. MEAN		917	556	1423	952
L.S.D. 5%					
CV (%)					

Table 16. Advanced yield trial of the purple seed type materials conducted in the state mato grosseo Do Sul in 1987.

NBR.	IDENTIFICATION	DOURADOS	PONTA PORA	INDAPOLIS	MEAN
		kg/ha			
1	BAT 1458	999	701	1574	1091
2	BAT 1550	1046	697	1177	974
3	LPM 10013	841	782	1182	935
4	BAT 258	693	570	1121	794
5	BAT 363	724	222	1031	659
6	LPM 10034	842	177	926	648
7	IPA 74-19	733	221	943	632
8	LPM 10033	567	80	849	498
9	LPM 10100	522	-	762	430
$\bar{X}$9		774	431	1063	740
CHECK					
1	CARIOCA (T)	308	-	318	318
EXP. MEAN		728	431	988	698

Table 17. The results of the preliminary yield traial (EPR) of the Carioca grain type conducted by EMGOPA in two locations during the dry season 1988.

NO.	IDENTIFICATION	ANAPOLIS	JARAGUA	COMBINED ANALYSIS
1	LR 720982	1946 a	1984 a	1965 a
2	A 285	2015 a	1141 a	1578 a
3	LA 720172	2106 a	906 a	1506 a
4	MA 534551	2006 a	944 a	1475 a
5	AN 720928	1224 a	1694 a	1459 a
6	MA 720943	1632 a	1282 a	1457 a
7	AN 512732-0	1399 a	1495 a	1447 a
8	MA 720942	1482 a	1329 a	1405 a
9	A 264-1	1815 a	963 a	1389 a
10	A 264-2	1632 a	1007 a	1319 a
11	MA 720948	1557 a	1051 a	1304 a
12	LA 720171	1374 a	750 a	1062 a
ELITE CHECK				
	ESAL 522	1723 a	1485 a	1604 a
LOCAL CHECKS				
1	EMGOPA 201 (OURO)	1240 a	2037 a	1639 a
2	CARIOCA	1199 a	1389 a	1294 a
MEAN		1623	1297	1460
CV%		33.6	39.9	36.4

MEANS FOLLOWED BY THE SAME LETTER DO NOT DIFFER SIGNIFICANTLY AT 5% LEVEL (TUKEY'S TEST).

Table 18. The results of the preliminary yield trial (EPR 88) of the black grain type conducted by EMGOPA in two locations during the dry season 1988

NO.	IDENTIFICATION	ANAPOLIS	JARAGUA	COMBINED ANALYSIS
1	IA 720164	1471 abcd	2110 a	1790 ab
2	CB 720160	1945 ab	1614 abcde	1780 ab
3	IA 720165	1430 abcd	2086 ab	1758 abc
4	IA 720159	1528 abcd	1778 abc	1658 abcd
5	IA 720161	1663 abcd	1608 abcde	1635 abcd
6	IA 720163	1762 abcd	1474 abcde	1618 abcd
7	W 20-9	1771 abcd	1435 abcde	1603 abcde
8	IA 720256	1746 abcd	1312 abcde	1529 abcdef
9	IR 720903	1455 abcd	1390 abcde	1422 bcdefg
10	IA 720157	1721 abcd	1087 cdef	1404 bcdefg
11	IA 720155	1081 cd	1677 abcd	1379 bcdefg
12	EEP 12-554	1554 abcd	1198 bcde	1376 bcdefg
13	DOR 12	1638 abcd	1069 cdef	1353 bcdefg
14	84 VAN-52	1239 abcd	1425 abcde	1332 bcdefg
15	IA 720174	1363 abcd	1278 abcde	1320 bcdefg
16	IR 711459	1114 bcd	1473 abcde	1294 bcdefg
17	IA 720162	1554 abcd	1344 cdef	1254 bcdefg
18	BAT 448	1463 abcd	1020 cdef	1241 bcdefg
19	DOR 352	1463 abcd	987 cdef	1225 bcdefg
20	IA 720130	1596 abcd	1265 def	1219 bcdefg
21	IR 720930	1430 abcd	1460 cdef	1213 bcdefg
22	84 VAN-38	1604 abcd	1226 def	1210 bcdefg
23	IM 30636	1255 abcd	1065 cdef	1160 cdefg
24	IR 7103302	1386 abcd	1255 def	1111 defg
25	IA 720168	1047 cd	1445 cdef	1004 efg
26	IR 710280	1189 bcd	1137 ef	972 fg
27	IA 720153	1347 abcd	428 f	816 g
ELITE CHECK				
	AN 512573-0	2078 a	2023 ab	2051 a
LOCAL CHECKS				
1	ICA COL 10103	1854 abc	1563 abcde	1708 abcd
2	RIO TIBAGI	989 d	1164 ef	881 g
MEAN		1492	1262	1377
CV%		21.1	25.7	23.2

MEANS FOLLOWED BY THE SAME LETTER DO NOT DIFFER SIGNIFICANTLY AT 5% LEVEL (TUKEY'S TEST).

Table 19. IBAT 1985/1986 evaluated in Sao Joaquim and Lages Santa Catarina in 1988 by EMPASC.

Identification	São Joaquim		Lages	
	Anthrac.	Rust	Anthrac.	Rust
COCO A LA CREME	1	7	1	6
IMUNA	1	3	1	5
KABOON	1	4	1	6
EVOLUTIE	1	-	6/6	5
PI 167349	1	-	1	1
SANILAC	1	-	1	8
A 177	1	-	4/4	5
TO	1	-	1	4
G 3807	5	-	7/7	6
G 8050	1	-	1	4
A 360	8	-	4/4	7
AIGUILLE VERT	1	-	1	1
TOP CROP	7	-	6/7	5
PI 165426	1	-	1	7
A 463	1	-	1	7
BAT 1428	1	-	1	5
DIACOL CALIMA	1	-	1	6
MICH.DARK.RED K.	1	-	1	7
BAT 1583	1	-	1	6
ICA LINEA 24	1	-	1	3
BAT 1345	1	-	1	5
BAT 1386	1	-	1	1
A 484	1	-	1	4
BAT 1275	1	-	1	3
A 475	1	-	1	5
K-2	1	-	1	5
A 493	1	-	1	1
A 107	1	-	1	8
A 293	1	-	1	5
CATU	7	-	1	1
AETE 3	8	-	1	6
A 188	7	-	2	7
APN 18	1	-	1	7
EMP 90	1	-	1	1
A 381	1	-	1	3
XAN 43	1	-	1	4
A 193	1	-	1	3
BAT 527	1	-	1	6
BAT 448	1	-	1	6
CORNELL 49-242	1	-	1	9
PERRY MAROW	1	-	4	4
MICHELITE	3	-	6	8
MEXICO 222	1	-	1	5
G13811	1	-	1	5
G 4360	1	-	1	2

Identification	Sao Joaquim		Lages	
	Anthrac.	Rust	Anthrac.	Rust
A 483	1	-	1	3
A 411	1	-	1	1
G 2618	1	-	1	1
G 2575	1	-	1	7
GLORIABAMBA-APETI	1	-	1	5
A 343	7	-	6	8
A 342	7	-	6	6
A 336	7	-	5	8
A 320	1	-	1	2
A 316	1	-	1	1
A 267	1	-	1	5
A 252	1	-	1	3
PI 207262	1	-	1	5
5-7148	1	-	1	4
CARIOCA	5	-	1	6
A 393	1	-	-	-
BAT 841	1	-	1	1
A 374	1	-	1	1
A 370	1	-	1	1
FLOR DE ABRIL	1	-	2	5
G 5653	1	-	1	7
BAT 44	1	-	1	1
BAT 795	1	-	1	2
G 6975	1	-	1	5
A 227	1	-	1	1
BAT 304	8	-	6	3
G 4108	1	-	2	3
G 8510-19	1	-	1	2
G 7199	1	-	1	2
ECUADOR 1056	1	-	1	5
G 4032	1	-	1	9
G 811	1	-	1	5
G 2641	1	-	1	1
G 3991	1	-	2	7
G 7303	1	-	3	2
G 2331	1	-	1	6
V 79118	1	-	3	4
G 11060	1	-	3	5
V 7918	1	-	1	2
G 3445	1	-	1	1
AB 136	1	-	1	1
G 2333	1	-	1	5
G 2338	1	-	1	1
G 6342	1	-	1	3
G 984	1	-	1	1
G 5971	1	-	1	1
G 6040	1	-	1	1

* 1=Resistent
9=Susceptible -death

1/4 = 1 in leaves
4 in stems

Table 20. The outstanding snap bean lines with high pod and seed yield, evaluated in 1987-1988 in Brazil.

		INTRODUCTION NURSERY (May-July 1987)					YIELD TRIAL - CNPAF (Dec. 87 - Feb. 88)				YIELD TRIAL - EMGOPA (ANAPOLIS) (Dec. 87 - Feb. 88)					
NUM	IDENT.	DAYS TO FL.	RUST	ALS FL.	ADP PHYS MAT.	SEED YIELD g/m2	DAYS TO FL.	ADP FL.	SEED YIELD g/m2	POD FRESH YIELD g/m2	DAYS TO FL.	ADP FL.	BAC. BLIGHT	NUM PL/ m2	POD /PL	POD FRESH YIELD g/m2
1	HAB 145	31	4	5	5	233	30	5	42	679	35	5	7	14	4	1495
2	HAB 128	29	5	6	5	163	29	6	38	563	34	4	3	15	4	1360
3	HAB 19	28	6	6	7	138	27	4	92	910	32	3	3	16	4	1315
4	HAB 56	29	5	6	5	148	27	5	61	838	34	4	4	14	5	1300
5	HAB 61	29	5	7	7	152	27	5	75	673	32	5	6	16	6	1164
6	HAB 59	29	5	6	6	120	27	5	70	863	33	4	5	16	4	1090
7	HAB 196	31	4	6	7	130	29	6	85	663	34	4	4	11	5	1070
8	HAB 1	30	4	6	0	107	27	4	43	968	33	5	4	10	8	1010
9	HAB 55	29	5	5	6	115	27	5	76	942	33	4	4	13	5	980
10	HAB 166	31	3	6	7	118	28	6	58	854	32	4	3	10	4	968
11	HAB 136	30	4	5	7	123	29	6	52	813	35	3	2	9	3	965
12	HAB 24	29	5	7	6	138	27	5	76	760	33	4	4	10	3	917
13	HAB 74	30	5	5	7	95	30	6	48	683	36	4	3	9	3	892
14	HAB 135	30	3	5	7	127	29	7	55	748	34	3	4	13	4	890
15	HAB 202	29	4	6	7	88	27	6	66	836	32	3	6	12	5	880
16	HAB 197	31	3	5	6	122	29	6	75	637	36	6	4	10	4	875
17	HAB 23	28	5	6	7	125	26	5	79	728	32	4	6	14	5	870
18	HAB 90	28	5	4	7	153	29	6	28	611	34	3	4	10	3	865
19	HAB 65	29	5	5	7	142	27	6	44	868	34	5	5	15	5	860
20	HAB 70	30	5	5	6	165	27	6	56	793	33	2	5	16	4	845
21	HAB 164	28	3	6	7	122	27	7	46	625	31	6	5	10	6	840
22	HAB 199	29	4	6	6	157	27	7	47	663	34	4	5	9	6	817
23	HAB 142	29	5	5	6	100	28	6	76	867	34	5	3	11	4	808
24	HAB 160	29	4	5	8	128	30	6	26	503	34	4	3	15	4	800
25	HAB 144	30	4	5	5	267	29	5	58	935	34	6	6	11	4	785
26	HAB 117	29	5	7	5	112	28	6	42	681	34	4	4	12	4	783
27	HAB 176	30	5	5	5	120	28	6	52	650	33	4	4	11	4	775
28	HAB 149	30	5	6	6	110	28	6	50	803	36	6	4	10	5	775
29	HAB 161	28	4	5	8	120	28	6	50	588	34	5	4	9	5	775
30	HAB 66	29	4	6	7	112	27	6	49	712	34	5	6	13	6	765

Continued

Table 20. The outstanding snap bean lines with high pod and seed yield, evaluated in 1987-1988 in Brazil.

(Continuation)

NUM	IDENT.	INTRODUCTION NURSERY (May-July 1987)					YIELD TRIAL - CNPAF (Dec 87-Feb 88)				YIELD TRIAL - EMGOPA (ANAPOLIS) (Dec 87-Feb 88)					
		DAYS TO FL.	RUST	ALS FL.	ADP PHYS MAT.	SEED YIELD g/m2	DAYS TO FL.	ADP FL.	SEED YIELD g/m2	POD FRESH YIELD g/m2	DAYS TO FL.	ADP FL.	BAC. BLIGHT	NUM PL/ m2	POD /PL	POD FRESH YIELD g/m2
31	HAB 190	30	5	6	6	140	28	6	58	623	34	6	4	8	6	710
32	HAB 203	29	5	5	6	155	27	6	46	713	34	5	4	12	6	710
33	HAB 62	29	5	6	8	112	27	5	58	793	33	5	4	16	5	707
34	HAB 156	30	5	6	6	170	28	6	65	817	32	4	4	13	5	685
35	HAB 118	29	4	7	6	97	28	6	51	834	33	4	5	13	5	684
36	HAB 175	30	4	5	7	100	28	6	63	917	32	3	4	15	4	666
37	HAB 177	30	5	6	5	117	28	5	54	808	34	4	5	9	5	648
38	HAB 178	30	5	6	6	170	28	6	54	779	34	5	4	11	4	648
39	HAB 168	30	4	6	7	132	28	6	47	697	34	5	5	10	4	627
40	HAB 125	29	5	6	6	100	28	6	62	721	33	2	4	13	5	575
41	HAB 12	28	5	6	6	105	27	5	38	849	32	4	6	9	7	575
42	HAB 186	29	5	6	7	130	28	6	50	683	34	6	4	8	5	573
43	HAB 191	30	4	6	6	160	28	6	64	779	33	6	5	11	6	565
44	HAB 187	30	5	6	6	170	28	6	61	793	32	4	5	13	4	557
45	HAB 68	29	5	5	7	118	27	6	56	777	32	6	5	9	6	548
46	HAB 104	29	5	7	6	115	28	6	54	863	33	5	6	11	6	547
47	HAB 167	30	4	5	7	145	28	6	55	780	34	4	3	13	4	542
48	HAB 119	29	4	6	5	117	28	6	59	883	32	5	4	12	6	540
49	HAB 102	30	5	6	5	120	28	6	51	813	34	4	5	11	4	535
48	HAB 119	29	4	6	5	117	28	6	59	883	32	5	4	12	6	540
49	HAB 102	30	5	6	5	120	28	6	51	813	34	4	5	11	4	535
50	HAB 174	30	5	6	6	108	28	6	43	611	34	4	4	16	4	515
51	HAB 86	29	5	5	7	132	27	6	47	817	34	4	5	7	5	500
52	HAB 121	29	5	6	7	92	28	6	43	r08	34	3	5	11	5	500
Checks:																
Mac.Rast.			6	6	6	72	28	5	54	962	0	0	0	0	0	0
Teresopolis			5	5	5	124	38	5	0	262	0	0	0	0	0	0
Mant.maravilha			4	5	6	163	38	6	0	229	0	0	0	0	0	0

Table 21a. Yield parameter of 12 bean genotypes as affected by different depths of water table.

Iden.	YIELD (g/PLANT)			POD YIELD (mg/POD)			100 SEEDS WEIGHT (g)		
	CHECK	18cm	13cm	CHECK	18cm	13cm	CHECK	18cm	13cm
TC 1558-1	6.5	6.7	4.5	977	1117	887	21.9	20.8	18
TY 3435- 3	7.0	8.1	4.5	1020	1177	793	19.8	21.3	18.1
LM 21135	8.3	7.8	4.4	997	1123	897	19.9	20.1	18.5
A 176-1	6.2	6.0	5.0	823	1133	1030	17.6	21.6	19.0
EMP 84	7.7	7.0	6.1	877	1047	970	22.8	22.1	21.1
ICA COL 10103	7.5	6.9	5.9	903	950	863	21.4	19.7	19.0
XODO	7.7	7.4	5.2	903	1043	913	19.6	20.1	20.3
POR.SINTETICO	7.7	7.9	7.4	1033	1120	1100	18.4	19.2	20.0
A 247	8.5	8.4	5.3	1010	993	797	19.3	19.2	18.6
EMG.OURO-201	7.8	6.8	4.5	1040	1040	900	21.4	20.5	19.8
BAT 477	7.6	6.4	4.6	1093	1197	920	21.0	22.6	19.7
XAN 112	6.9	7.2	5.8	760	1000	807	21.9	20.8	18.7
MEAN	7.5	7.2	5.3	953	1078	906	20.4	20.7	19.3
L.S.D. VAR. (5%)		1.7			179			2.1	
L.S.D. W.TABLE (5%)		0.5			52			0.6	
C.V.(%)		15.3			11			6.4	

Table 21b. Yield parameter of 12 bean genotypes as affected by different depths of water table.

	# FILLED POD/PLANT			# UNFILLED POD/PLANT			# SEEDS /PLANT			# SEEDS /POD		
Iden.	CHECK	18cm	13cm	CHECK	18cm	13cm	CHECK	18cm	13cm	CHECK	18cm	13cm
TC 1558-1	6.7	6.1	5.2	3.2	0.8	1.2	30	32	24	4.5	5.3	4.8
TY 3435- 3	6.9	6.9	5.5	2.6	1.5	2.4	35	38	24	5.1	5.5	4.4
LM 21135	8.3	6.9	5.0	4.2	2.0	1.2	41	39	24	5.0	5.6	4.8
A 176-1	7.7	5.3	4.9	2.9	1.2	1.5	36	28	26	4.7	5.3	5.4
EMP 84	8.8	6.7	6.2	3.1	0.0	0.6	34	31	28	3.8	4.8	4.6
ICA COL 10103	8.3	7.3	6.9	2.4	0.7	1.5	35	35	31	4.2	4.8	4.5
XODO	8.5	7.1	5.6	2.5	1.6	1.6	39	37	26	4.6	5.2	4.5
POR.SINTETICO	7.5	7.0	6.7	3.0	1.5	1.2	42	41	37	5.6	5.8	5.5
A 247	8.5	8.4	6.7	4.3	2.9	2.2	44	43	29	5.2	5.2	4.3
EMG.OURO-201	7.4	6.5	4.9	3.3	1.3	1.7	36	33	22	4.8	5.1	4.5
BAT 477	7.0	5.3	5.0	4.3	1.1	0.0	36	28	23	5.2	5.3	4.7
XAN 112	9.1	7.2	7.3	2.9	1.8	1.5	32	35	31	3.5	4.8	4.3
MEAN	7.9	6.7	5.8	3.2	1.4	1.4	37	35	27	4.7	5.2	4.7
L.S.D. VAR. (5%)		1.7			1.0			8			0.7	
L.S.D. W.TABLE (5%)		0.5			0.3			2			0.2	
C.V.(%)		15.7			16.0			15			8.7	

Table 22. Nutrient content in bean leaf (phaseolus vulgaris L.) at flowering time as affected by different depths of water table.

P LEVEL*	DEPTHS OF WATER LEVEL	N	P	K	Ca	Mg	Zn	Cu	Mn	Fe
		%					ppm			
2	CHECK	4.59	0.40	3.00	1.87	0.38	66	16	162	675
	18	5.59	0.43	3.42	1.37	0.38	60	15	132	670
	13	5.48	0.42	3.55	1.22	0.36	61	13	142	547
10	CHECK	4.13	0.39	2.85	1.57	0.36	61	12	167	747
	18	5.14	0.47	2.82	1.53	0.34	59	10	167	745
	13	4.53	0.42	2.80	1.46	0.34	63	9	190	742

*P LEVEL = g OF TRIPLE SUPER PHOSPHATE IN 6 KG SOIL/POT.

Table 23. The amount of nutrient absorbed by bean leaf (Phaseolus vulgaris L.) at flowering time as affected by different depths of water table.

P LEVEL*	DEPTHS OF WATER LEVEL	N	P	K	Ca	Mg	Zn	Cu	Mn	Fe
		mg/plant					Ug/plant			
2	CHECK	124	10.8	81	50	10.3	178	43	437	1822
	18	117	9.0	72	29	8.0	126	31	277	1407
	13	104	8.0	67	23	6.8	116	25	270	1039
10	CHECK	181	17.2	125	69	15.8	268	53	735	3287
	18	221	20.2	121	66	14.6	254	43	718	3203
	13	145	13.4	90	47	10.9	202	29	608	3274

*P LEVEL = g OF TRIPLE SUPER PHOSPHATE IN 6 KG SOIL/POT.

Table 24. Nutrient content and the amount of nutrients absorbed by bean leaf (Phaseolus vulgaris L). At flowering time as affected by 48 hour inundation on varzeas soil during the 3rd trifoliate stage.

TREATMENT	N	P	K	Ca	Mg	Zn	Cu	Mn	Fe
	NUTRIENT CONTENT								
	%					ppm			
CHECK	4.27	0.37	2.3	1.75	0.39	35	14	150	593
INNUNDATED	4.59	0.23	2.9	2.59	0.45	37	10	160	583
	AMOUNT OF NUTRIENT								
	(mg/pl)					(u/pl)			
CHECK	106	8.9	55	43	9.6	86	34	369	1434
INNUNDATED	46	2.1	26	26	4.3	34	9	146	525

Table 25. Final tests of a 343 (cream seeded), BAT 1297 (Red mottled) and Carioca in Paraguay 1987.

IDENT.	LOCATION: ALTO PARANA (5)*	ITAPUA NORTE (11)	COLONEL BOGADO (8)	S.J. NEPOMUCENO (9)	CAAGUAZU (10)	SAN PEDRO (9)	MEAN (8)
	YIELD KG/HA						
A 343	376	341	669	396	732	1268	630
BAT 1297	365	333	502	372	755	1172	583
CARIOCA	576	715	750	545	818	1412	803
MEAN	439	463	640	438	768	1284	672
LOCAL CHECK	—	311	622	200	630	785	510

(15)* = NUMBER OF FARMERS PARTICIPATED.

Table 26. The bean production constraints claimed and expressed in % of total all farmers interviewed.

CONSTRAINTS:	LOCATION						
	ALTO PARANA (17)*	ITAPUA NORTE (30)	COLONEL BOGADO (20)	S.J. NEPOMUCENO (20)	CAAGUAZU (20)	SAN PEDRO (15)	MEAN (20)
DISEASE VIRUS	—	65	85	75	55	70	70
OTHER DISEASE	88	40	10	—	—	40	45
DIABROTICA/EMPOASCA	76	80	90	40	45	75	68
LOW SOIL FERTILITY	—	17	10	—	15	30	18
MARKETING DIFFICULT TO SELL	76	66	45	100	80	80	75
NO SEED	—	50	25	40	40	53	42
CLIMATIC FROST	100	—	10	10	—	—	40

(15)* = Number of farmers interviewed.

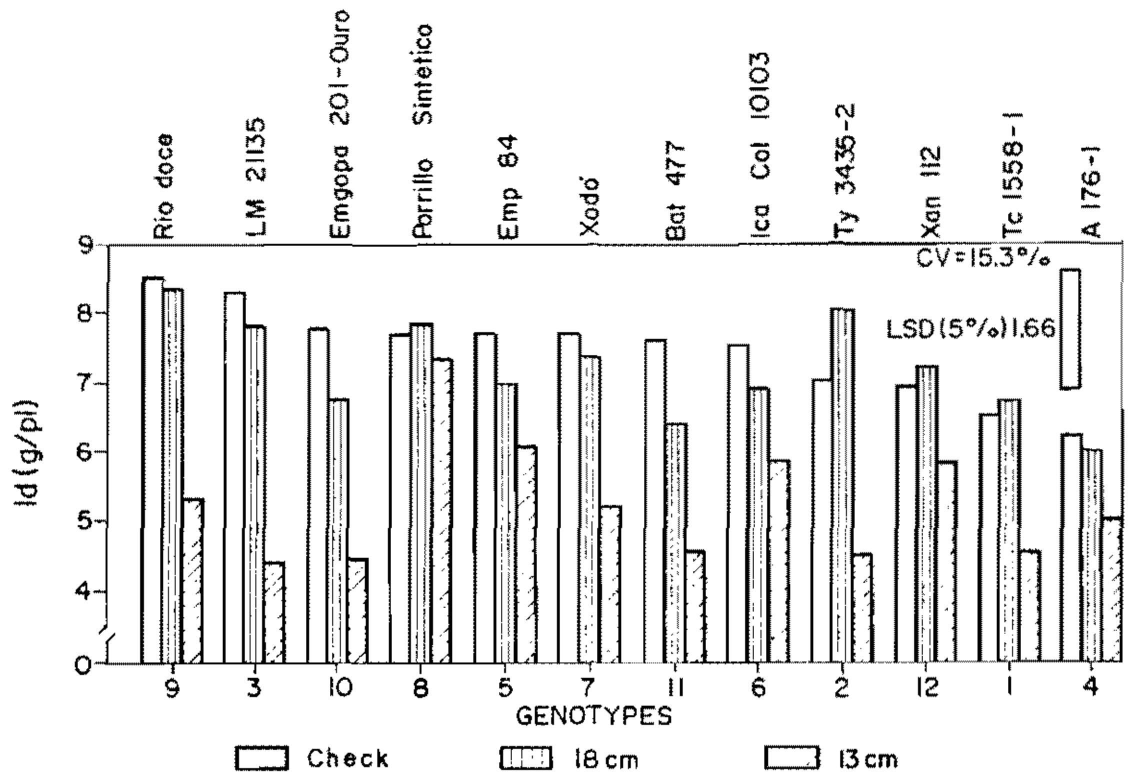


Figure 1. Bean yield (g/plant) of 12 genotypes as affected by different water table depths.

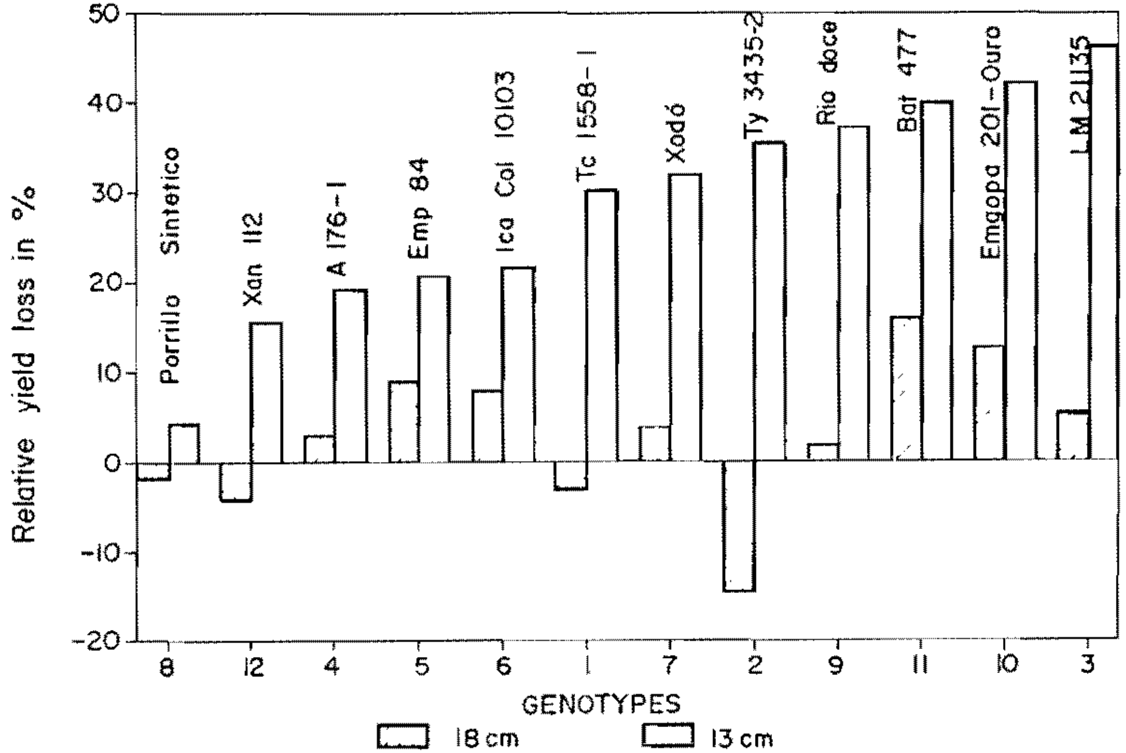


Figure 2. Bean yield losses of 12 genotypes as affected by different water table depths.

AFRICA

INTERREGIONAL COOPERATION

Very close collaboration exists among the separately funded regional projects for the Great Lakes, Eastern Africa and Southern Africa regions. Mechanisms used in integrating these three projects were described in last year's report.

Recruitment earlier this year of the bean economist (based in Kawanda, Uganda) and entomologist (based in Arusha, Tanzania) is intended to strengthen the entire Africa bean network in their disciplines. Overall coordination of the Africa bean network is provided by the regional coordinator for Eastern Africa, while the locally-recruited accountant, also based at Debre Zeit, Ethiopia, visits other regional offices to assist in training support staff.

Pan-African network activities during 1988 included three workshops. The first meeting, held in Harare, Zimbabwe, inaugurated a Drought Research Working Group on Beans. Concerted efforts on several fronts were agreed. One of these activities is an Africa Bean Drought Nursery, assembled in Ethiopia from materials identified as promising either in that country or in Latin America, and now sent to 16 locations in 9 countries.

The second workshop, on Soil Fertility for Bean Cropping Systems in Africa, was held in Addis Ababa, Ethiopia. Participants included 21 agronomists and soil scientists from 11 countries in the network, and regional scientists from the International Council for Research in Agro-Forestry (ICRAF) and CIAT. Recommendations made for NARS and for CIAT emphasized sustainable and relatively low-input methods for maintaining and increasing soil fertility in areas where beans are an important component of production systems.

The third Pan-African workshop this year discussed research methods and priorities for biological nitrogen fixation in beans. It was held in Butare, Rwanda.

A monitoring tour for bean breeders visited four stations in Ethiopia. Participants from Ethiopia, Kenya, Malawi, Tanzania, Uganda and Zambia discussed the organization of the Ethiopian national program, which is relatively well developed but faces the task of improving productivity of the crop across a wide range of ecological zones and cropping systems.

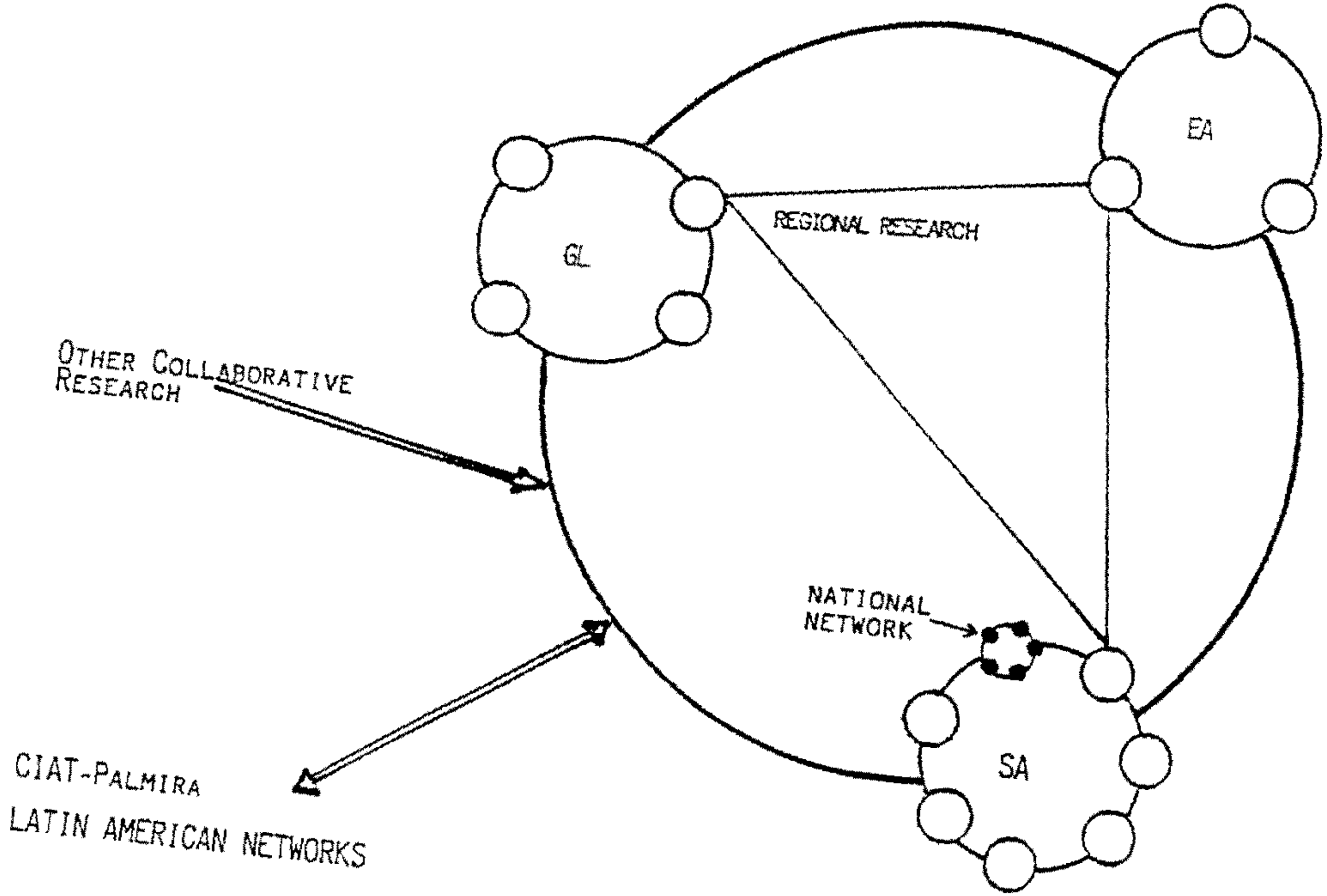
Collaboration of regional research (subprojects) among network members increasingly requires communication across regions on common topics. As a result of contacts made at workshops or other network activities, national scientists are more frequently contacting each other directly, and reciprocal visits are assisted by the regional programs. A mid-year meeting of all CIAT Bean Program staff working in Africa also proved useful in exchanging information and ideas.

The African Bean Yield and Adaptation Nursery (AFBYAN) concluded its first round this year; the 25 entries have now been grown in 10 countries, in some cases at several locations. During 1988 a second series trial was assembled and distributed from Ethiopia, initially to 11 countries. AFBYAN-II comprises 25 advanced materials contributed by 9 countries in Africa.

Although most training courses continue to be organized at the national level or within a single region, a short course in bean breeding methods for technical assistants at Arusha benefitted technical assistants from both Eastern and Southern regions.

Regional bean projects in Africa work in the same ecological zones, through the same NARS, and sometimes with the same researchers, as a number of other IARC regional programs. Our objectives of improving the bean crop and the capabilities of NARS to continue this research in the longer term cannot be divorced from the efforts of other IARCs. CIAT therefore took the lead in calling a meeting in Nairobi this year for the coordinators of regional agricultural research programs and networks in Eastern Africa; CIMMYT provided logistical support and ILRAD provided the venue. Thirteen programs spent two days exchanging information on their activities, and potential areas were identified for increased collaboration among them. In addition to the collaboration already occurring in short-course training across commodities, participants agreed that their effectiveness would be enhanced by collaborating in the production of training materials, in field surveys, and in certain kinds of technical meetings.

FIGURE 1. AFRICA BEAN NETWORK



EA: EASTERN AFRICA REGION
GL: GREAT LAKES REGION
SA: SOUTHERN AFRICA (SADCC) REGION

AFRICA
THE GREAT LAKES

The regional bean program has as its goal to develop minimum input technology for the benefit of poor farmers, based on improved disease and pest resistant varieties, together with bean based cropping systems for soil conservation and improvement. The work is done by a network of collaborating scientists in the national programs of Zaire (PNL), Burundi (ISABU) and Rwanda (ISAR), in partnership with regional scientists of IRAZ and CIAT. The long-term sustainability of the program is obtained through training and workshops, which build on the research capability of individual scientists, and develop stronger collaborative ties between scientists of neighboring countries. The sustainability of the technology generated is ensured by encouraging national programs to involve the farmer in the research process, and by working with development projects in on-farm research aimed at combining improved productivity with soil conservation.The mechanisms for achieving collaboration in technology generation are the regional variety improvement nurseries, and the sub-projects.

HIGHLIGHTS

The following introductions from CIAT were named in Rwanda in 1988: G 2333 = 'Mubanomwiza', which means in the Kinyarwanda language "good relations", reflecting the spirit of regional collaboration; G 685 = 'Unuinkingi', meaning "heavy" because it needs strong stakes to support its vigorous growth and heavy yield; G 858 = 'Muhondo 6'; G 3444 = 'Puebla'.

All of these are climbers, and part of the strategy of the national program is to extend more widely the use of climbers because of their higher productivity. Rwanda has the highest population density of any country in Africa, making sustainable intensification of agricultural production imperative. The use of soil improving leguminous shrubs, together in some cases with non-leguminous species such as Pennisetum purpureum, Tythonia diversifolia and Sambucus africana, provides a continuous source of staking material as well as erosion control.

In addition, a bush bean introduction, G 4391, has proved very promising in on-farm trials particularly in the dry eastern plains of Rwanda, near the Karama research station. Studies on the diffusion of bean seeds are leading to improved strategies for introducing new varieties, and methods of artesan seed production are being investigated. This has helped the widespread diffusion among farmers of G 2333 in the area of the 'Projet Kigali Nord'.

Field days for farmers were introduced this year at Rubona, Karama and Cyata experiment stations in Rwanda. Small groups of farmers, particularly women, were invited to evaluate varieties in the advanced yield trials, as part of an effort to include farmers in the research process, and to inform the local population of what goes on at the experiment station.

In Zaire, G 2333 and G 3444 (Puebla 444) are also achieving success. Puebla 444 is very popular for its desireable seed color in the markets of Goma and Kinshasa. On-farm trials and seed distribution are carried out by a cooperative program (UCOOPANOKI), a seed production program (CAPSA), and the Baptist Church (CBK = Communauté Baptiste au Kivu) in the department of North Kivu.

The CBK have also been producing and distributing seed of bush bean varieties: 'Rubona 5' (=ICA-Palmar from Colombia), now cultivated by more than 200 farmers in the Kalungu area; 'Doré de Kirundo', introduced from Burundi by the regional program and now said to be grown by 60% of the farmers in the target area; A 197 from CIAT is cultivated especially in the area of Kabati; 'D6', an old variety introduced by CBK only four years ago and now the most widely grown variety in Bwisha and Rutshuru. There remains a need for improved varieties with medium to large white seeds for North Kivu, and the national program and CIAT have emphasized introducing and testing these this year.

In Burundi, A 410 has been named 'Khaki', and is achieving widespread diffusion in the lowland plains of the Imbo Nord. 'Calima', released several years ago in Burundi after its introduction from Colombia in the 1976 IBYAN, is widely grown in middle altitude areas, often mixed with local varieties. 'Aroana', originally from Brazil and introduced by CIAT, has been named 'Nsosera' for middle altitude areas. 'Flor de Mayo', a climber originally from Mexico and introduced by CIAT, has been named 'Inambumburi'.

An exceptionally promising new line has been identified in on-farm trials, A 321, which is resistant to anthracnose and halo blight. A new initiative in on-farm research was started this year in Burundi, in the Buyenzi area, in collaboration with the Société Régional de Développement (SRD). This is one of the areas where A 321 is particularly promising. Other problems being investigated in Buyenzi are bean fly control, and low soil fertility.

TRAINING AND WORKSHOPS

Training activities fall into five categories: **advanced degree training; trainees who go to CIAT headquarters; training courses held in the region; in-service training in Rwanda; developing training materials.**

A man from ISAR will begin his PhD studies at Wye College in England shortly. His field work will be done in Rwanda, on nutrient cycling in bean based agroforestry systems. Four trainees were sent from Rwanda to CIAT for in-service training this year.

The principal needs for training courses in the region are for technicians, especially those working in the development projects. **A technician training course** was held at Ngozi, Burundi, on 23 - 24 May 1988, for 20 technicians and 'moniteurs' working in the following development projects: SRD Buyenzi; SRD Kirimiro; PADC Isale-Mubimbi. Resource persons were from ISABU and CIAT. The objective was to start the process of developing a group of people capable of establishing a two-way relationship with farmers, and carrying out on-farm trials. Basic skills in recognizing soil constraints, diseases and pests were taught, together with basic concepts of on-farm research and methods of dialogue with farmers.

In-service training in Rwanda is reserved normally for students from schools for technicians, and occasionally from the university. A total of seven students from technicians' schools have completed practical training courses or thesis work in on-farm research, supervised by CIAT and ISAR or development project staff.

Training materials are being developed with INADES (Institut Africain de Développement Economique et Social) for extension workers: on disease identification and seed dressings; artesan seed production by small farmers; and climbing bean production.

A Pathology Workshop was held in Kigali from 14 to 16 November 1987. There were 16 participants from Burundi, Botswana, Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda, and Zaire; plus six CIAT staff; also present were Dr. John Taylor of NVRS, England (halo blight collaborative project); and Dr. T. Gerlagh, invited expert on Ascochyta from the Institute for Plant Protection, Wageningen. This workshop formed part of a series of events organised jointly by the three African regional programs. The objective was to exchange information on major diseases and their control, and to devise means of further sharing responsibilities for research between the Regions. Diseases emphasized were anthracnose, angular leaf spot, ascochyta, rust, and bacterial blights.

The Third Regional Seminar was held in Kigali from 18 to 21 November. There were 64 participants, including three from CIAT headquarters, and three from the other African Regional Programs. As well as the national programs, many of the development projects in the region were represented. The meeting was opened by the Minister of Agriculture of Rwanda, and included sessions on regional collaboration, breeding, plant protection, agronomy, on farm research, seed production, and future developments. There was also a field visit to Rubona. A set of conclusions was agreed upon and read to the Director of ISAR, who then formally closed the meeting.

A travelling workshop of four ISAR researchers to ISABU was arranged for 12 - 15 January. The ISAR researchers were shown the ISABU scheme of variety selection in the field. They visited on-farm trials in the Imbo Nord, and observed the promising performance of A 410. They evaluated together regional nurseries at Moso and Kisozi experiment stations. In conclusion, they noted that the exchange of genetic material between ISAR and ISABU was highly beneficial, as was the exchange of experiences and methodologies for bean improvement.

A return visit was carried out from 30 May to 4 June, when four researchers from ISABU and two from PNL visited Mulungu, Zaire, and ISAR stations in Rwanda. An excellent exchange of views occurred in the field, and the benefits of regional exchange of materials and information were clear. There are now many varieties in common at the advanced stages of testing in the three national programs.

An On-Farm Research Seminar was organized jointly by CIAT, CIMMYT and ISAR (EMSP department), and held at Butare from 9 to 14 May 1988. There were 38 participants, including four from Zaire. The remainder were from ISAR and a few development projects. The purpose was to discuss the planning, follow-up and evaluation of on-farm trials, and to establish a common strategy. Excellent collaboration between international centers has been achieved, particularly in the area of training and workshops.

A PRELAAC Workshop to discuss results of the regional nursery was held at Mulungu, Zaire, on 24 - 25 August 1988. Participants from the three countries compared results, and a table compiling all results was put together. Based on the combined results, a set of varieties was selected by consensus for the next stage of testing at a regional level. This meeting was felt to be a particularly useful brainstorming session for scientists involved in variety selection and testing.

A Workshop on Soil Fertility Problems in Bean-Based Cropping Systems was held in Addis Ababa as part of the Africa wide series of workshops, organized jointly by the three Regional programs.

CIAT staff participated actively in planning meetings at ISAR and ISABU. Steering committee meetings were held in December 1987 (Rubona), April (Bujumbura), and August (Mulungu).

GERMPLASM INTRODUCTION

The VEF Nursery of advanced lines from CIAT is evaluated in the region normally every year. This provides a major source of new material for the variety development scheme in each country. In addition the EP group 25 (large red seeded bush) trials from CIAT were grown at Rubona and Mulungu in 1988, out of which 46 lines were selected for the 'Essais de Triage'. Selected results of these trials are shown in Table 1.

Other introductions include the international disease nurseries, especially for angular leaf spot (BALSIT), anthracnose (IBAT), halo blight (IBHBN) and ascochyta. These provide entries for the variety development scheme, and the best entries are also selected for the regional disease nursery (PRER).

The third group of introductions is early generation hybrid material, in the form of F_2 populations and backcross populations. A total of 98 F_2 populations was introduced to Rubona in the first season, and F_3 bulks of these were distributed to Burundi in the second season. Also in the second season, 50 F_2 populations were introduced to Mulungu, Zaïre. These were crosses made at CIAT by a Zairian trainee who will now follow through the selection process in his home country. A further 50 F_2 populations were introduced to Rubona in the second season. The backcross populations are normally introduced as part of the sub-projects, and will be described in that section of the report.

REGIONAL NURSERIES

The regional nurseries are formed every year out of the materials in the three national program variety testing schemes (Fig. 1). They form the nucleus of all collaborative research projects between countries, and also serve to encourage collaboration between disciplines within national programs. Finally, at the level of the AFBYAN, they serve to bring together the efforts of all three African regional programs through a systematic interchange of the best varieties.

PRELAAC

The 'Pépinière Régionale de Lignées Avancées de l'Afrique Centrale' is formed every year in September from the varieties entering the preliminary yield trials ('Essais Comparatifs' or 'Essais préliminaires') of each country in the regional network (Rwanda, Burundi and Zaire). Its position in the overall scheme for variety development is shown in Fig.1. It forms the nucleus of the regional testing scheme, and is the basis of the regional sub-projects. Thus, the varieties in the PRELAAC are evaluated for the individual traits which are studied in the sub-projects.

Seeds of the PRELAAC are multiplied at Rubona in the first season, and distributed in December to the various sub-projects. The results were compiled a meeting held at Mulungu on August 25-26, 1988.Representatives from the three countries participated in collecting the data and selecting the best varieties for the regional yield trials (ERGL).

By bringing expertise from neighboring countries to bear on the same group of materials, much more information can be generated than would otherwise be possible by any individual national program. Out of 100 bush bean and 49 climbing bean varieties in the 1988 PRELAAC, 14 of each were selected for the 1989 regional yield trials. PRELAAC results for the selected varieties are shown in Tables 2 and 3.

This nursery brings together the efforts of pathologists, entomologists, breeders and agronomists of the national programs. In this way it encourages an inter-disciplinary approach to variety development, which is expected to improve the quality of new varieties recommended by the national programs, and to provide an early warning of possible problems with new varieties. For example, varieties susceptible to halo blight, like PVA 779, may pose a problem for seed multiplication. Most selected new varieties, however, are resistant to halo blight. The same is true for anthracnose.

Improved evaluation of anthracnose was achieved this year by screening lines at diverse locations. Lines available in Colombia were also screened with Colombian anthracnose isolates to obtain an idea of screening efficiency in Colombia for the GLR of Africa. In addition, lines are now tested in Colombia for their reaction to BCMV.

Bush beans:

For halo blight, there is generally excellent agreement between the results in the glasshouse in England (NVRS) with race 3 and the field observations in Kisozi, where race 3 is known to predominate, as in the rest of the region.

The situation for anthracnose is more complex. A 321 and AND 303 were resistant in all four test sites. Ecuador 299 was resistant everywhere in the field, but susceptible in the growth chamber at Bujumbura. This result would need to be confirmed. RWR 45 was not tested at CIAT, but was resistant at all sites in the Great Lakes. PVA 1438 and PVA 779 were resistant at Rubona, but susceptible at Kisozi.

For angular leaf spot, there was mostly good agreement between the results at Rubona and Mulungu. The best were A 364, A 74, Ecuador 299, G 2858 and XAN 68.

For ascochyta, the results were not very consistant between locations. The best line at Rwerere and Kisozi was XAN68.

For bean fly, there were significant differences in wilting among varieties, and the pressure was extremely high in the nursery. Some of the varieties in the nursery (not selected) suffered up to 98% wilting. Of the selected varieties, the best was A364.

The best yielding varieties at Rubona were XAN 68, Ecuador 299 and BAT 1448, all indeterminate varieties. The highest yielding determinate varieties were PVA 779 and AND 303.

Climbing beans:

There was a much higher frequency of race 1 resistance in the climbers than in the bush beans, but race 3 resistance was only positively identified in ZAV 83052 and ACV 83031. Most selected lines showed reasonable field tolerance at Kisozi.

For anthracnose, all selected lines were resistant at Kisozi, and many were also resistant in the growth chamber at Bujumbura, and at CIAT: AFR 229, VAMY-127-310-S5, VNB 81010, ZAV 83052.

For ascochyta the results were again rather inconsistent, and there was not much resistance available.

For angular leaf spot, the best was ACV 83031, and for bean fly the best were AND 10, G 5173, RWR 78, and VAMY-130-31-S6.

The highest yielding lines at Rubona were VNB 81009 and VNB 81010, both black seeded. Of the colored seeded types, the best was ZAV 83052, which is also resistant to BCMV.

ERGL

The 'Essais Régionaux des Grands Lacs' were formed initially out of the varieties already being distributed by the national programs. In 1988 these trials were incorporated into the scheme for variety development. The 1988 ERGL was selected from the 1987 PRELAAC, but seed had to be multiplied in the first season of 1988, and so yield results are only available so far from Rubona and Rutshuru (Table 4 and 5). Rubona (Rwanda), is at 1700 m altitude, and Rutshuru (Zaïre) is at 1100 m altitude.The best bush bean lines at Rubona were PVA 15, PVA 1438 and AND 303. The best bush bean lines at Rutshuru were PVA 800A, PVA 15, PVA 1432, PVA 1438 and AND 303. The best climbing bean lines were AFR 13 and ZAV 83052. Although the yield gains for the bush beans were not very spectacular, the new varieties are more resistant to anthracnose, to which Rubona 5 is extremely susceptible. The yield gains for the climbers are quite significant. ZAV 83052 is also resistant to BCMV, Anthracnose and Halo Blight.

Simple lattice designs were used for both the ERGL and PRELAAC trials, and these were found to give improved efficiency at most locations. At Rubona, angular leaf spot severity was negatively correlated with yield, each step up on the 1-9 scale resulting in 60 kg/ha yield loss. Vigor, estimated visually at flowering time, was strongly correlated with yield. Preliminary observations suggest that this correlation improves on poor soils.

PRER

PRER includes the best resistant sources to major diseases provided by each national program. The origin of the material is the International Disease Resistance Nurseries from CIAT, and the PRELAAC. Like the PRELAAC, this regional nursery is evaluated for specific diseases at local "hot spots" with inoculation, but over a number of seasons and sites to evaluate the stability of resistance, and to evaluate sources for multiple disease resistance. The new PRER was planted at four sites last season in Burundi, Rwanda and Zaire.

SUB-PROJECTS

The sub-projects are the mechanism for encouraging collaboration among national program scientists on topics of regional importance. The assignation of the sub-projects is based on requests from the individual programs, which are subsequently processed in the steering committee meetings. Normally, the leadership for a particular sub-project is assigned to one scientist or institute. There are varying degrees of active participation of CIAT staff in the individual projects, and these can form the basis for ongoing training and upgrading of scientific capability.

The sub-projects can be grouped into those concerned with plant protection; cropping systems and soil fertility; farmer participation and diffusion of new technology.

PLANT PROTECTION:

The steering committee has agreed that the priority projects in plant protection should be: **anthracnose and bacterial blights** (as the major seed-borne diseases which can cause severe problems in seed multiplication programs); **angular leaf spot** (as the most widespread and yield-reducing foliar disease); **bean fly** (as the most widespread and devastating insect pest). Of local importance are: BCMV, ascochyta, floury leaf spot and root rots.

Anthracnose:

The Anthracnose sub-project is based at ISAR. Anthracnose is probably the most important seed-borne pathogen in the region. Studies on the pathogenic variability of anthracnose in Burundi and in Rwanda have shown the presence of four and seven different races respectively of anthracnose. In both countries Cornell 49-242, which contains the much used ARE gene, was susceptible in the field. It demonstrates the existence in the two countries of considerable pathogenic variation of *Colletotrichum lindemuthianum*. In order to better define the distribution of the variation, studies are needed on the pathogenic variability of anthracnose within farmers' fields and over regions.

In addition to routine screening of the regional nurseries at several sites in the region, the sub-project includes a breeding program whose objective is to develop stable resistance in well adapted local germplasm.Varieties included in the crossing program are: Mutiki 2, Tostado, Karama 1/2, Rubona 5, Urubonobono and Gisenyi 2-Bis. The sources of broad based resistance used to date are: BAT 1386, A 475, A 483, A 484, A 240, A 30, A 252 and PVMX 1535. Screening of hybrid populations is carried out in parallel at Rubona and Rwerere, to ensure exposure to a wide range of pathogenic variation. The resistance sources used are known to be resistant to all races currently known in the region, but most of them derive their resistance from major genes. One strategy to improve the stability of resistance would be to mix advanced lines derived from different resistance sources. G 2333 offers excellent resistance to all known races, and preliminary findings indicate that this is based on several genes.

Halo Blight:

The halo blight (Pseudomonas syringae pv. phaseolicola) sub-project is based in Burundi (ISABU) and field work is carried out at Kisozi. It was initiated in 1986. From work done in England (NVRS), it is known that race 3 predominates at Kisozi, as elsewhere in the region. Race 1 is also present but does not seem to be very important. Race 2 is not known to occur in the Great Lakes Region, but it is found in the SADCC region. Resistance to race 2 is much less common than race 3.

The first objective of the halo blight project, therefore, is to incorporate resistance to race 3 into improved germplasm, and the second longer-term objective is to develop race non- specific resistance. Most varieties currently available to farmers are susceptible to halo blight, and this poses a serious problem especially for seed multiplication.

The 1988 PRELAAC was screened both at Kisozi and in England. Table 6 shows the lines resistant to races 1 and 3. There was one line, A204, which showed race non-specific resistance, and this should be used as a parent in future crosses.

A breeding program is also underway to develop improved resistance in varieties from the region. Crosses were made at Rubona based on halo blight evaluations at Kisozi. Advanced lines selected out of this program and promoted to 'Essai de Triage' are shown in Table 7. It is encouraging that there is already a resistant line descended from Kilyumukwe, a promising but susceptible variety.

Angular leaf spot:

The Angular leaf spot (Phaeoisariopsis griseola) sub-project is run by PNL at Mulungu. Routine field screening of the regional nurseries is carried out in the field, where suitable field techniques have been developed to ensure adequate pressure. Laboratory and glasshouse facilities are also being developed to enable studies of pathogenic variation and selection of the best isolates for screening to be carried out.

A breeding program has been underway since initiation of this sub-project in 1986. Considerable progress has been made in selecting resistant lines out of crosses including local germplasm, and the first group of these lines has been promoted to 'Essai de Triage'.

Research by PNL Zaire over four seasons was carried out on the ability of resistant varieties, added at various proportions to mixtures, to control foliar disease. Angular leaf spot was used as an example, as it is the most prevalent and possibly the most economically important disease in the region. It also serves as an example of a pathogen which is wind dispersed and for which high levels of quantitative, but not qualitative, resistance exists. Results obtained in the first two seasons are presented in Tables 8 and 9. They suggest that proportions as low as 25% partial resistance in local mixtures can significantly reduce disease on susceptible components under moderate disease pressure. Under high disease pressure similar proportions of resistance are ineffective.

Similarly, yield increases over the expected were obtained with proportions of resistance as low as 25% in three out of four seasons.

Bean fly:

The bean fly sub-project is based at ISABU, and field work is done mostly at Kisozi. The project was initiated in 1987. The PRELAAC nursery is routinely evaluated for tolerance to bean fly. A number of varieties show promising tolerance at Kisozi. BAT 1373 was the most tolerant variety, and has shown consistent performance two years running. Ikinimba has also shown high levels of tolerance. BAT 1373, in particular, was able to support larger numbers of larvae and pupae in the stem before suffering wilting. However, on average, fewer larvae and pupae were found in the stems of BAT 1373. Therefore, there appear to be two mechanisms of tolerance/resistance operating. The differences among varieties for the number of larvae and pupae appears to be based mostly on preference rather than antibiosis, meaning unfortunately that this effect may disappear when a tolerant variety is planted in pure stand.

BAT 1373 did not perform as well in Rwanda as expected from results obtained in Burundi. It is noteworthy that this variety did not withstand the heavy early attack at Rubona, but the plants which survived were at later stages more vigorous than those of Ikinimba and Rubona 5. Ikinimba withstood early attack the best but fared poorly at later stages. Nevertheless it yielded the most at both sites. The mechanism may be tolerance to beanly as Ikinimba hosted significantly more pupae than the other varieties at Rubona. Systematic, Africa-wide screening will be reinforced particularly with the arrival of the CAIT entomologist based in Tanzania, who will coordinate activities.

Studies were also conducted in the region on the biology, ecology, and minimal use of chemicals as seed treatments for controlling the insect.

Studies on the dynamics of beanfly populations are being carried out by ISABU and the National University of Rwanda (UNR). The species Ophiomyia spencerella predominates in both countries. However, O. phaseoli and O. centrocematis are present, particularly at lower altitudes. Exploratory studies in Zaire indicate the dominance of O. spencerella in south and north Kivu, and the dominance of O. phaseoli in Lower Zaire. Similarly, in Cameroon O. phaseoli was the only species found.

Temporal differences in population numbers exist. Both in Burundi and Rwanda studies indicate that beanfly populations are reduced in the dry season and increase rapidly during the rainy season. This explains the high levels of attack when beans are planted late. In both studies, natural parasitoid attack varied but in Burundi infection of close to 100 % of beanfly pupae was recorded during the March to June rainy season. So far, up to 33% infection has been recorded in Rwanda. Hence, beanfly populations are being regulated by natural predators. Whether biological control can be manipulated to work more effectively is still unclear.

Research on the effectiveness of cultural control methods was also carried out. Increasing the fertility decreased the severity of symptom expression but not the number of pupae per plant. Presumably, increased plant vigor in fertilized plots is responsible for the reduction of symptoms. Unfortunately the limited availability of manure and compost, the variability of the effect of fertilizers, the limited means of farmers, and the lack of effect of such a treatment on the beanfly population limits the usefulness of this approach.

The effectiveness of heaping soil around the base of the plants, as is practiced by farmers in many regions, was also studied. At the first weeding this increased the number of plants surviving (ISAR 1985). Subsequent studies at the UNR indicated that the timing of the treatment may be important in reducing the severity of attack by beanfly. In another study, sowing date was shown to significantly influence the severity of attack. Early-sowed beans were less attacked than those sown later.

Seed treatments with 'endosulfan' (Thiodan) have been shown to be effective in Zambia, and with 'lindane' in Burundi. Of these, endosulfan has been used in preference as a presowing treatment and it's effectiveness has been demonstrated in the GLR by ISABU. In addition, studies conducted by ISABU in liason with Gembloux, showed that negligible residue levels of the compound were present on the first trifoliate leaves. Results in Table 10 confirm the effectiveness of endosulfan for improving plant stand (density) by eliminating bean fly attack during the vegetative growth stage (V4).

The effectiveness of seed treatments was also tested in Rwanda in on-farm trials on the Central Plateau, where yield increases of 100 kg/ha were obtained under moderate beanfly pressure.

Station trials at Karama (1300 masl), where beanfly is considered a key problem to bean production, show the influence of season and sowing time on the effectiveness of the seed treatments. For later planted crops in the second season, endosulfan seed treatments increased yield by over 300 Kg/Ha, whereas for early planted crops yield increases of only 60-100 kg/ha were obtained. In certain regions like the north of Rwanda, where beanfly populations are negligible, no positive effects of endosulfan were obtained. This emphasizes the need to consider seed treatments only in high risk areas or seasons. They do not need to be used routinely.

Integration of genetic resistance and seed treatments was investigated at Rubona, to estimate the amount of yield increase attributable to resistance/tolerance of BAT 1373 and Ikinimba, compared with susceptible check Rubona 5, by comparing these varieties with and without endosulfan. Unfortunately the pressure of bean fly attack was such that it overcame the relatively low level of tolerance available, so that the only significant effect was of seed treatment (Table 10).

BCMV:

The objective of the BCMV sub-project is to develop germplasm resistant both to mosaic and black root symptoms. Materials are screened in the field at Rubona (ISAR) under natural infection, using spreaders of infected seed. Laboratory and glasshouse techniques have not yet been developed in the region for screening germplasm under controlled conditions. The project relies at present on CIAT headquarters for making crosses, backcrosses and early generation screening with a mixture of Florida and NL-3 strains of BCMV. The BCMV present in the Great Lakes Region is believed to be mostly of the necrotic type, represented by the NL-3 strain.

The problem of BCMV has been particularly severe in climbers, because one of the objectives of the regional program has been to promote the use of climbers in medium altitude areas where they have not been traditionally cultivated. The most promising varieties (e.g. G 2333, G 685) are all susceptible to BCMV and often show severe mosaic symptoms. Eight new advanced lines of climbers were coded and entered the Rwandan 'Essai de Triage' in 1988 (Table 11). These lines are known to possess the dominant 'I' gene for resistance, and they do not suffer black root symptoms, indicating the presence of a recessive protector gene. GLB 1, for example, is a resistant line descended from a cross with C 10, a well known Rwandan climbing bean variety. GLB 6 is a mosaic resistant version of G 2333.

A similar program is underway for the bush beans, using backcross material received from Dr. Drijfhout (IVT, Holland) and from CIAT and incorporating different combinations of genes
(bc-3; I+bc-1_2; I+bc-2_2; I+bc-2_2+bc-3 etc).

Ascochyta:

Phoma blight (Ascochyta) is important mainly at high altitudes, above 1800 m. The sub-project is led by ISAR at its Rwerere research station. Research in Burundi, Colombia and in Rwanda indicate that reactions of varieties to the pathogen, *Phoma exiqua* var. *diversispora* are similar. In collaboration with IPO, Wageningen, samples from the region were identified and tested for pathogenic variation. All samples from Burundi, Rwanda, Zaire, and other African countries were identified as *P. exigua* var.

diversispora. Little evidence was observed of significant variation in pathogenicity. Reactions in Rwanda of varieties in the ascochyta international nursery are shown in Table 12.

Unfortunately, only relatively moderate levels of resistance are available, and some sources, such as G 4603 and A 182, are susceptible to anthracnose. However, recent work at Rwerere reveals that the heritability of resistance in crosses is reasonably high, and therefore it can be selected for as a quantitative character. A large number of breeding lines have been selected for tolerance to ascochyta under heavy disease pressure, and these are now proceeding to advanced trials. In addition, the PRELAAC nursery is evaluated at Rwerere and Kisozi as part of the sub-project activities.

Floury leaf spot:

Floury Leaf Spot is one of the most prevalent diseases in the GLR as shown by diagnostic trials (CIAT 1986). ISABU
(Perreaux and Nkubaye, 1987) evaluated both the dwarf and climbing PRELAAC varieties for resistance (Table 13). The resistance has been confirmed in Rwanda, and this to our knowledge marks the first report of resistance to floury leaf spot.

Of note is the susceptibility of G 2333 to FLS in Cameroon, which indicates the presence of pathogenic variability in *Mycovellosiella phaseoli* (= *Ramularia phaseoli*).

Root rots:

Particularly *Fusarium solani*, and *Rhizoctonia* sp. were associated with the important root rot problem in Rwanda and Burundi. Initial screenhouse screening in soil from problem areas indicated that high levels of resistance are available (Table 14). The results are now being verified in the field in two regions in Rwanda while varieties are being screened for adaptation.

Cropping Systems and Soil Fertility

See the section entitled ON-FARM AGRONOMY--AFRICA.

On-Farm Research in Buyenzi:

This sub-project was started by ISABU in 1988, and is based at the SRD-Buyenzi (Société Régionale de Développement de Buyenzi) in Ngozi, Burundi. The purpose of the sub-project is to carry out on-farm adaptive research and verification trials, which will provide feed-back to research on the experiment stations of ISABU and the national programs of Rwanda and Zaire; and feed-forward to the extension services. The sub-project has already served as the site for a training course (see section on Training and Workshops).

Diagnostic survey work has begun. The results of 48 trials carried out in three communes of Buyenzi are now coming in. Fertility (Phosphorus) is clearly limiting, as shown by a 50% yield increase when DAP fertilizer (110 kg/ha) was applied. Bean fly is also limiting in most seasons, and observation indicates that this season's attack was less severe than in the first season of the year. Improved fertility is known to reduce the effect of bean fly, but control with endosulfan seed dressing added an additional yield of 100 kg/ha to the effect of the fertilizer. The seed treatment is likely to move into the extension phase shortly, subject to careful warnings on toxicity. The fertilizer is probably too expensive for most farmers, and the trials serve to demonstrate the need for work on green manures and soil conservation measures.

<u>Biological nitrogen fixation in beans:</u>

This is a new sub-project, which began at ISAR in 1988. The purpose of the project is to follow work done by ISAR and FAO on the selection of efficient strains of <u>Rhizobium</u>, and work demonstrating large differences in nodulation between Tostado, which has been shown to fix up to 75 kg/ha of N, and Rubona 5, which nodulates very poorly. The new sub-project will, therefore, initiate a screening procedure for varieties in the regional nurseries, to permit the selection of varieties which nodulate well and fix nitrogen efficiently. The emphasis of the project is, therefore, on the host, and in particular its ability to nodulate with a wide range of strains.

A small breeding program is also underway to incorporate early nodulation into some well known varieties, such as Mutiki-2. Backcrosses and selection 3 weeks after planting have been done at CIAT, and the progeny are tested in the field at Rubona.

Farmer participation and diffusion of new technology:

Farmer evaluations of on-farm variety trials were initiated in Rwanda in 1985, and have provided essential information on: 1) overall farmer varietal selection criteria; 2) the rationale for acceptance or rejection of specific varieties and; 3) the means by which farmers themselves experiment to determine the plasticity of a new seed. As such, on-farm evaluations have served as an important guide for influencing on-station breeding priorities. Currently, the time lag between the first testing of a variety on-station and its testing on a farmer's field is relatively long, 9-16 seasons. In order to incorporate farmer expertise and criteria of acceptability at an earlier stage, a new program of farmer participatory research was started by CIAT/ISAR in 1988.

Farmer seed experts, generally women, are now being brought to experiment stations to evaluate the performance of varieties in the 'Essais Multilocaux'. Projecting from their performance there, farmers then select the varieties they feel most suited to their own planting conditions.To date, farmers (n=24) have evaluated two bush bean and one climbing bean trials, evaluations taking place at low (1300m, Karama), medium (1700 m, Rubona) and high altitude (2250 m, Cyata) sites.

Preliminary findings show that:

a.Farmers are in considerable agreement as to which varieties do well on-station. Accord is even greater, however, on which varieties they find perform poorly--and why.

b.Farmers assessments do not strictly follow yield figures. Varieties selected had good yields (generally not the highest), but also incorporate other critical features such as an erect architecture (which helps varieties escape rain damage).

c.The varieties farmers judge as superior on station are not always the varieties they want to try on their own fields: while about 60% chose the same 3 varieties for their farms, 20% chose 2 of the 3, and 20% 1 of the 3. Farmers' planting conditions vary from those on-station; farmers are able to take account of these differences. Particular divergence came from farmers' choosing varieties for poorer soils (they select smaller grains) and farmers choosing varieties which they felt would prosper under bananas.

d. Some farmers select different varieties according to season. Crop associations, and type of soil seem to figure prominently in their assessments, but most particularly, intensity of rainfall. During times of greater stress (more rain) the choice of varieties becomes more conservative: farmers choose the sturdier varieties, not necessarily the earliest maturing or those with greatest yield potential.

e. Farmers are eager to try a wide range of varieties on their fields. They categorically reject a relatively small number of varieties in on-station evaluations. The range of varieties selected appears to reflect the diversity of planting conditions as well as personal preferences.

Such on-station evaluations will be expanded during 1989 to encompass at least 4 locations and 60 farmer participants. Evaluation criteria will be refined and the interview format simplified.

The program aims ultimately to integrate farmers' selection criteria earlier in the breeding process so as to increase the percentage of improved varieties acceptable to farmers for long-term use. It has already served to promote closer collaboration between on-station researchers and surrounding communities by encouraging direct dialogue between breeders, pathologists, and station personnel on the one side and local expert farmers on the other.

Variety diffusion studies:

Several studies were initiated to determine the longer-term farmer use of CIAT/ISAR varieties and to trace the paths along which they had been diffused. These varieties were followed in the regions in which they were most appreciated (according to previous farmer evaluations): Kilyumukwe on the Central Plateau; Ikinimba in the Bugasera; and G2333 was the variety followed in the region known as Kigali Nord. For comparative purposes, Ikinimba was also followed on the Central Plateau, where its performance and appreciation by farmers were considerably less than in the Bugasera.

The majority of farmers (53%) in our sample continue to grow the varieties they have received. However, results show that, for each variety, use declines with time....that is, farmers slowly abandon new seed. In 63% of cases, varieties are abandoned because of inherent varietal characteristics. That is, poor disease resistance, low yield, or perhaps unappreciated superficial traits. In the remaining 37% of cases, farmers site facts not specific to the variety in their rationale for abandoning use. These reasons stem from socioeconomic constraints or agroecological stresses.

Table 19 summarizes the "life expectancy" of new varieties in the region in which they were studied. We defined this parameter as the point in time in which 50% of the collaborating farmers are still growing the variety. Note that in most cases the decline in use follows closely an exponential decay. Thus, fifty percent of those who received G2333, which is judged very favorably by farmers in the region of Kigali Nord, are expected to be still growing it after 9.2 seasons. In contrast, the 50% cut-off point is reached by Ikinimba in the Central Plateau after a short 3.3 seasons.

Paths of Distribution

It is often supposed that improved varieties will be widely distributed by the people who receive them. The study results cast doubt on this supposition:

First, the starting time for diffusion is relatively late. Most farmers distribute the variety only after two, more often three, seasons of testing. As many farmers plant only in the September-January season, varietal diffusion may not start until three years have passed.

Second, the circle of diffusion is socially narrow. Best friends, close family, and particularly important neighbors may get seed---but certainly not all who ask for it.

Third, the majority of farmers who give away some of their seed, give only to 1-3 others.

Table 19 below provides further evidence of these findings. Here we have calculated the distribution per season and "adult season", the latter supposing distribution will not start until after the second season. In all cases, farmer to farmer dissemination of varieties is slow---G2333, the fastest moving variety is given to an average of 0.83 people per adult season, with Ikinimba on the Central Plateau being diffused among a mere 0.17 others per adult season. It is interesting to note that the two parameters of speed of distribution and varietal longetivity are correlated.

Rwandan households are relatively independent production units, and future diffusion strategies must rely on more than simple farmer to farmer exchange, sale or theft to spread new varieties.

Diffusion studies are also showing the importance of a critical mass of seed in order for farmers (cultivating often <0.8 Ha) to keep it in their stock. There are many reasons why an appreciated variety can be lost during the early stages of testing, when farmers may have 1-5 kilos of a novel seed. For example:

1. A particularly bad rain (which farmers equate with disease attack), can wipe out much of the harvest.

2. Weevils may attack the small quantity of stored seed.

3. A farmer may fall ill (a very common occurrence) and be unable to properly care for her plots.

4. The seed may be stolen (perhaps a diffusion among neighbors, but certainly lost for the original farmer).

5. A poor farmer may eat the seed as green beans or green seed, especially if it is early maturing.

In all of these instances, the farmer needs the chance to re-stock, in order to keep growing the variety. Local varieties are often re-acquired from neighbors, but access to improved varieties is limited.

Research on bean purchase and sale in the Central Plateau area of Rwanda (n= 54 farmers) showed that it is particularly the small landholders who often fall below the "stock threshold" mentioned above. In Rwanda, this refers to families with holdings of less than 0.8 Ha. Families with 0.8 Ha - 2 has are considered as "middle" and anything above 2 Ha as "relatively wealthy". Such figures are only approximate estimates, as subsistence viability also depends on the fertility of any given plot, outside sources of income, etc.

Preliminary surveys indicated that most farmers buy beans to eat. Poorer farmers, however, also buy beans for seed, while the wealthier draw bean seed from household stocks (Table 16).

The desired characteristics of beans destined for consumption are different from those to be used for seed (Table 17).

For consumption, farmers primarily prefer beans that are quick cooking, have not been stocked long (< 4 months) and are little damaged. (As farmers directly correlated short storage time with rapid cooking, most farmers (93%) gave one or both of these responses as being the most important characteristic.) Farmers seem not to care about the variety of bean, the composition of a mixture or the origin of the seeds.

For seed, farmers look for the same mixture as they normally use, often from a neighbor who has similar soil, and seeds which have little damage but that have been stocked between about 4 months and a year.

It is not surprising that the sources for buying beans for consumption and seed differ markedly (Table 18). For consumption, farmers go to the market or to a local boutique.They do not generally buy from neighboring farmers who either have too little to sell, or sell at too high a cost. For seed, the majority of farmers get grains from their neighbors. If they go to the market or the local kiosk, they buy a mixture which contains varieties they already know. Farmers often personally know the people from whom they obtain seed. They generally do not trust market merchants who may mix seeds from different regions, that have been stocked for varying periods, or that are suitable for very different soils.

This work on both diffusion and bean purchase patterns indicates the need for the program to formulate more precise strategies for seed multiplication and its diffusion: improved seed must move more quickly and it must be more continually available for those who have few grains to store. The program is discussing initiatives to

1) stimulate decentralized multiplication of improved seed, possibly by small farmers

2) identify more effective channels for distributing (and keeping up a stock) of seed. The 'Service de Semences Selectionées', collaborating development projects and local kiosks are all being considered as distribution outlets.

Small scale artesan seed production:

The objectives of this study were to evaluate the potential of improving traditional methods of disease control and to evaluate methods seed quality and bean yield.

Earlier results demonstrated the effectiveness of combining and improving certain cultural methods on the development of anthracnose and angular leaf spot, and the effectiveness of fungicide presowing seed treatments on seed borne diseases (CIAT 1986, ISAR 1987). These methods were combined with good agronomic practices and plant selection in farmer small seed multiplication plots to improve the seed quality of farmers' own seed, and also to facilitate the production of better quality disease free seed of improved varieties.

Five farmers participated in the study. Levels of close to 100% unblemished seed using seed from multiplication plots were recovered with the added practice of rejecting heavily diseased plants and an improved seed selection method which removes any seed with blemishes. The traditional method only selectively removes some of the blemished seed, resulting in more blemished residue in the seed stock.

The performance of multiplication plot seed in farmer fields over two seasons resulted in a trend of increased production which after the second season was significant at the 80% level and indicated a yield increase of 117 kg/ha. Pròblematic was the heterogenity of work quality among the 5 farmers.

A follow-up survey on the reaction of farmers to the treatment indicated that all farmers felt the seed was cleaner (n=5). Not all saw an increase in yield, but all wanted to continue using the multiplication plots. Since the last season of testing had not been a good one, one farmer apologized that she had not stored the seed of the previous season. She had sown this seed in preference to her traditionally selected seed. She did not have enough for the multiplication plots. In practice, farmers may need to sow multipication plots each season, rather than during the first season, most favorable for beans, which serves as the traditional season for sowing seed as commonly the seed source does not suffice for the year. Following these results, arrangements have been made for more farmer meetings, the production of a training program with literature for the extension of the methodology.

Seed treatments:

The use of chemicals was considered in an integrated strategy for the control of diseases and pests difficult to control by genetic means alone. The only form of chemical control used was as seed treatments to minimize the quantities of chemicals used, and to maximize the chances of affordability by farmers. Considered was a presowing seed treatment to control both seed borne and root diseases, as well as beanfly (*Ophiomyia spencerella*, and *O. phaseoli*).

Studies at ISAR have been going on since 1986. Numerous chemicals have been tested and the best have been shown effective on-farm over three consecutive seasons. Yield increases between 200 and 300 Kg/Ha have been obtained using a combined treatment for seed borne diseases and beanfly (ISAR 1986,1987). Subsequent work on seed treatments has concentrated on determining the lowest effective concentrations of chemicals needed, evaluating the effectiveness of the technology in diverse regions, and integrating it with the use of resistance and cultural methods, such as in the small seed multiplication plots, and developing safe methods for extension.

Regional differences exist in the effectiveness of seed treatments. At the higher altitudes, larger yield increases were obtained than in the central plateau (ISAR 1987,1988). At lower altitudes, only seed treatments for beanfly were used (see beanfly section). Scope exists for tailoring treatments for regions.

The work on seed treatment procedures has focused during this period on proper information dissemination: to ensure that farmers use pesticides both safely and in the minimal effective quantities. In collaboration with ISAR, INADES (Institut Africain de Développement Economique et Social), and participating development projects, the program has initiated an information campaign in several directions.

First, we monitored farmer comprehension of on-farm seed treatment trials during the 1988b season. As a result of such inquiries, the collaborative group proposed that "social protocols" accompany all technical instructions. When installing trials, project personnel now receive guidelines suggesting 1) what key issues to discuss with the farmer and 2) how to explain complex technical issues. Among the prominent themes presented: how to identify various diseases, possible cultural methods of disease control, and safe use of chemicals.

INADES, ISAR pathologists and the CIAT team have designed an information pamphlet to be widely disseminated to extension workers, community leaders and participating farmers. It elaborates the benefits and dangers of seed dressing, and suggests how, when (and when not) to use such treatments. The preliminary pamphlet is in an edition of 100; after testing for a season (1989a), it will be run off in an edition of 3000 copies (in January 1989). The present edition is in French. It is currently being translated into Kinyarwanda.

Table 1. The best varieties in the EP Group 25, large red or mottled seeds.

a) At Rubona, Rwanda.

Variety	Growth Habit	Yield, Kg/Ha	Seed type
AND 419	III	1495	Red
AND 627	II	1132	Red mottled
AND 629	II	1168	Red mottled
AND 632	II	1480	Red mottled
AND 633	I	1155	Red mottled
AND 636	II	1115	Red mottled
AND 660	I	1178	Cream mottled
AND 665	I	1320	Light Red Kidney
AND 671	I	1258	Red mottled
AND 683	II	1500	Dark Red Kidney
AND 696	I	1215	Red mottled
AFR 244	II	1180	Cream mottled
AFR 246	II	1128	Cream mottled
AFR 313	II	1115	Pink mottled
HAL 7	I	1290	Red mottled
HAL 8	I	1220	Red mottled
Calima (control)	I	728	Red mottled

b) At Mulungu, Zaire.

Variety	Growth Habit	Yield, Kg/Ha	Seed type
AND 623	I	1423	Red mottled
AND 665	I	1358	Light Red Kidney
HAL 7	I	1550	Red mottled
HAL 8	I	1370	Red mottled
Munyu (control)	I	1213	Red mottled

Table 2. Results of the best bush bean lines in the 1988 PRELAAC

Variety	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A 321	III	91	2P	I	69	3	5	2	TR	1	1	R1+3	1	5	6	1577
A 364	II	93	4P	I	49	6	7	1	S	5	5	R1+3	1	2	2	1441
A 74	II	94	2/4P	I	74	6	4	1	S	3	4	(R3)	2	2	3	2055
AFR 198	I	96	6/1M	i		6	7	3	(TR/MS)	5	3	R1		6	7	1806
AND 303	I	92	6/1G	i			6	3	TR/R	3	3	S		6	7	1835
BAT 1448	II	96	2P	I	68	7	4	2	S	3	5	R3	2	3	6	2396
ECUADOR 299	III	94	6M	i	72	3	5	2	S	1	1	R1	3	2	2	2398
G 2858	II	96	2P	I	65	6	5	1	S	3	5	R3	1	2	1	2186
GUANAJUATO	III	97	8P	I/i	74	5	5	2	MS	5	5	R1+3	2	3	5	1801
PVA 1438	I	94	6/1G	i			6	2	MS	1	6	S		6	7	1516
PVA 779	I	91	6/1M	i	74	3	8	3	S	1	4	S	6	5	5	1840
RWR 252	II	90	6/1M			6	8		S	5	5			7	7	1962
RWR 45	I	93	2/6G				4		TR	1	1			6	6	1503
XAN 68	II	94	5P	I	54	4	4	2	S	5	6	R1+3	1	2	3	2819
											LSD,	p≤0.05				694

Seed size: P= small, M= medium, G= large BCMV: I= dominant resistance
1-9 scale used for most evaluations

Anthracnose: TR= very resistant, R= resistant, MS= moderately susceptible, S= susceptible

Halo, NVRS: R1= resistance to race 1, R3= Resistant to race 3, S= susceptible.

Traits:

1= Growth Habit
2= Days to Maturity, Rubona
3= Seed Color, Size
4= BCMV, CIAT
5= Bean Fly % Wilted Plants, Kisozi
6= Ascochyta, Rwerere
7= Ascochyta, Kisozi
8= Anthracnose, CIAT
9= Anthracnose, Bujumbura
10= Anthracnose, Rubona
11= Anthracnose, Kisozi
12= Halo, NVRS
13= Halo, Kisozi
14= Angular Leaf Spot, Rubona
15= Angular Leaf Spot, Mulungu
16= Yield Kg/Ha, Rubona

Table 3. Results of the best climbing bean lines in the 1988 PRELAAC

Variety	1	2	3	4	5	6	7	8	9	10	11	12	13
5.700	102	8P		85	5	3	2	TR	1		1	4	2570
ACV83031	101	2P	I		7	4	1	MS	1	R1+3		3	2102
AFR 13	103	3M	i	82	7	6	4	TR	1	R1	2	6	2553
AFR 229	101	6M	I		8	5	1	TR	1	R1		5	1633
AND 10	103	2/6G	i	43	5	3	2	S	1	R1	3	6	2005
G5173	102	8P		40	6	4		MS	1	R1	4	7	2652
IZ 222-1	102	6G		59	5	5		S	1		4	4	2372
RWV 78	102	2/5G	i	40	5	4	5	S	1		3	4	2215
TO-1	103	1M		53	6	3			1	R1	3	6	2530
VAMY-127-310-S5	103	2/5G	i/I	69	5	3	3	TR	1	R1	6	4	1508
VAMY-130-31-S6	103	2/5G		43	5	5		R	1	R1	5	5	1177
VNB 81009	101	8P	i		6	3	3	MS	3	R1	2	7	3357
VNB 81010	103	8M	I/i	82	7	4	1	(TR)	1	R1	2	5	3167
ZAV 83052	102	6M	I		6	5	3	TR	1	R3		5	2723
LSD, $p \leq 0.05$													1004

Traits:

1= Days to Maturity, Rubona
2= Seed Color, Size
3= BCMV, CIAT
4= Bean Fly % Wilted Plants, Kisozi
5= Ascochyta, Rwerere
6= Ascochyta, Kisozi
7= Anthracnose, CIAT
8= Anthracnose, Bujumbura
9= Anthracnose, Kisozi
10= Halo, NVRS
11= Halo, Kisozi
12= Angular Leaf Spot, Mulungu
13= Yield Kg/Ha, Rubona

Table 4. 1988 ERGL, bush bean regional trial

Variety	Growth Habit	Seed Color Size	Yield Kg/Ha Rubona	Yield Kg/Ha Rutshuru
PVA 800A	II	6/1M	236	2150
PVA 15	I	6G	1263	2250
ZAA 99	I	6/2M	1120	1650
PVA 1216	I	6/2G	1037	1850
PVA 1432	I	6/1G	1318	2250
PVA 1438	I	6/1G	1437	2050
AFR 4	III	6P	912	600
AFR 8	III	6P	756	1800
AFR 9	III	6P	451	600
AND 303	I	6/1G	1355	2000
AFR 198	I	6/1M	1147	1550
PVA 781	I	6/1M	814	1400
CONTROL	I	6/1M	1127	2150
		LSD, $p = \leq 0.05$	517	

Table 5. 1988 ERGL, climbing bean regional trial, Rubona.

Variety	Seed Color Size	Yield Kg/Ha	
AFR 13		3M	3031
9042-61(B)G		1P	2128
IZ 284-1		1P	2606
ACV 83030		6P	2161
ZAV 83052		6M	3398
ACV 83031		2P	2396
AND 10		2/6G	1697
AND 220		2/6G	1655
RWV 59		7/1M	2689
GISENYI 2 BIS(CONTROL)	2/8M	2133	
	LSD, $p \leq 0.05$	642	

Table 6. Varieties in the 1988 PRELAAC resistant to halo blight races 1 and 3.

Variety	Growth Habit	Seed Color Size	Kisozi	Race 1	Race 3	Race 2
A 204	III	9/2P	1	1	1	4
A 302	II	2P	3	1	1	9
A 321	III	2P	1	2	1	7
A 364	II	4P	1	1	1	9
A 387	II	2P	3	1	1	7
G 5272	III	8P		1	1	7
GUANAJUATO	III	8P	2	1	1	7
PAD 1510	II	4P	2	2	1	9
RAB 211	II	6P		3	1	9
RIZ 34	III	2P	1	1	1	9
RIZ 43	II	2P	1	1	1	9
XAN 68	II	5P	1	2	1	7
ACV 83030	IV	6P		3	1	7
ACV 83031	IV	2P		1	1	6
V 79022	IV	8P	1	1	1	7
V 79026	IV	8P	1	1	1	7
V 80015	IV	8P	1	1	1	8

Race 1 isolates= 1281A(UK), 1375A(KYA)
Race 2 isolates= 882(USA), 1299A(TZA)
Race 3 isolates= 1301(TZA), 1302A(RWA)

Table 7. Advanced lines from the halo blight sub-project promoted to 'Essai de Triage'.

Variety	Parents	Growth Habit	Seed Color	Treatment No.
GLH 8	G15821 x G952	III	4P	24
GLH 9	Kilumukwe x G76	III	2G	41
GLH 10	G15821 x G952	III	4P	18
GLH 11	G15821 x G952	IV	4P	16
GLH 12	G15821 x G952	IV	4P	23
GLH 13	G15821 x G952	III	4P	17
GLH 14	G15821 x G952	III	4P	25
GLH 15	G15821 x G952	III	4P	15
GLH 16	G15821 x G952	II	4P	19
GLH 17	ZAA12 x ZAA14	I	7/2M	28
GLH 18	G15821 x G952	IV	4P	21

Table 8. Effectiveness of various proportions of resistance in local mixtures on angular leaf spot development.

	%Surface area infected							
Node on susceptible plant	3		5			7		
Development Stage	R6	R6	R7	R8	R7	R8	R7	R8
TREATMENT:								
100% Local mixture(LM)	5.9A	2.1A	6.3A	4.2A	1.4A	2.6A	4.0A	14.0A
75% LM+25% RV	4.5AB	2.0A	4.1B	2.4B	1.3A	1.6AB	5.3A	3.0B
25% LM+75% RV	5.1AB	1.7A	3.5BC	2.5B	1.0A	1.5AB	5.3A	1.5B
100% Resistant variety(RV)	1.2B	1.4A	1.8C	0.7C	0.4B	0.3B	3.0A	1.5B

* Numbers with the same letter do not differ significantly (p=0.05) using Duncans multiple range test.

Table 9. Effect of adding resistant varieties to a local mixture on the development of angular leaf spot

	% Surface area infected							
Node on susceptible plant	3	5		7		7		
Development Stage	R6	R6	R7	R8	R7	R8	R7	R8
TREATMENT:								
100% Local Mixture(LM)	16.6A	0.8A	19.0A	20.4A	9.6A	12.1A	32.2A	37.5A
90% LM+10% RV	16.9A	0.8A	19.0A	19.0A	8.1A	10.9A	27.2A	33.3A
80% LM+20% RV	18.6A	0.9A	19.1A	20.8A	8.3A	11.8A	20.3AB	29.2A
100% Resistant Variety(RV)	3.1B	0.5B	5.1B	5.9B	0.3B	0.4B	11.3B	11.3B

* Numbers with the same letter do not differ significantly (p=0.05) using Duncans multiple range test.

Table 10. Effect of seed treatments on plant density, and bean fly attack, Rubona 1988.

Variety	Treatment	Plant Density at Harvest X 1000/Ha	Beanfly Pupae per plant V4
BAT 1373	Nil	40	5.3
	Endosulfan	111	0.0
Rubona 5	Nil	74	5.3
	Endosulfan	139	0.0
Ikinimba	Nil	110	9.3
	Endosulfan	131	0.0
LSD p=0.05		16	5.5

Table 11. Advanced lines of climbing beans from the BCMV sub-Project promoted to 'Essai de Triage'.

Variety	Parents	Reaction to Florida + NL-3 Strains
GLB 1	C10 x ACV 83034	N
GLB 2	G12709 x ZAV 83024	N
GLB 3	Productivo 2 x ZAV 83013	N
GLB 4	ACV 15 x ACV 83034	N
GLB 5	ACV 15 x ACV 83034	N
GLB 6	G2333 x ACV 83034	N
GLB 7	ACV 26 x ACV 83034	N
GLB 8	Productivo 2 x ZAV 83024	N

Table 12. Sources of resistance to Ascochyta

Bush		Climbers	
Identification	Phoma blight	Identification	Phoma blight
Local susceptible	6.3	Local suscept.	6.3
BAT477	6.0	AND244(contr.2)	6.0
BAT1225	5.5	VRA81058	5.5
BAT1416	5.5	ASC6	4.8
EMP117	5.5	ZAV21	4.8
CATU	5.3	ASC4	4.5
BAN6	5.0	VRA81018	4.3
PAI119	4.5	ZAV21	4.3
BAT1569	4.0	AFR223	3.8
G17098	4.0	G12307	3.5
BAT795	3.5	ASC1	3.3
A182	3.5	G12582	3.0
G4603	2.8	G10747	3.0
		VRA81051	3.0
		G35182	2.0

LSD (P=0.05) = 1.6

Table 13. Sources of resistance to floury leaf spot

Dwarf/Semi-climbers	Climbers
KABANIMA	V 7940-138-17
EMP 87	DECELAYA
EMP 143	PUEBLA CRIOLA
RAB 212	G 2331
RAB 214	G 2333
DOR 308	ACV 8331
	VNB 81009
	VNB 81005

Table 14. Reactions in the screenhouse of the lines from the International Bean Root Rot Nursery to root rots in Zaire Nile Crest soils.

Variety	Evaluation	Variety	Evaluation
A70	8.85	CG82-79	5.00
BAT336	8.35	PORRILLO S.	5.00
ICA TUI	8.24	SANILAC	4.86
V8025	8.24	BAT868	4.86
CG182-27	8.00	CG/22-101	4.86
CG182-110	7.85	R1Z30	4.59
OJO DE CABRA	7.33	IPAT	4.33
TOP CROP	7.00	A295	4.33
MORTINO	7.00	A211	4.00
XAN112	6.85	BAT332	3.67
A195	6.85	A55	3.67
RIO TIBAGI	6.67	ICA PIJAO	3.67
G5059	6.41	BAT447	3.33
BAT1753	6.35	BAT300	3.00
EQUADOR605	6.33	ARGENTINO	3.00
BAYO RIO G.	6.00	WAF9	2.86
CG/82-67	5.85	CG/82-108	2.86
EMP81	5.67	LM-21525-0	2.86
BAT	5.50	EMP86	2.86
NIMA	5.33	BAT400	2.77
S.CHRISTOBAL	5.33	DIACOL CALIMA	2.36
ROSINHA	5.00	CORNELL 49242	1.67
G3807	5.00		
EQUADOR 1056	5.00		
CG/82-70	5.00		

LSD = 2.59
CV = 24.74

Table 15. Area planted under climbing beans cvs. Giseni 2-bis and C 10 in 1988A (second bean growing season after having received climbing bean seed), Rwanda 1988

Village	Climbing Beans	Bush Beans
Karama*	1.57 ares	26.8 ares
Rukondo	2.49 ares	27.9 ares
Ntazo	6.5 ares	59.3 ares
Ntongwe	3.5 ares	38.1 ares

5 farmers per village

Table 16. Bean seed distribution after farmer purchase by economic class.

	FOR CONSUMPTION %	FOR SEED %
Wealthy (n=22)	91	23
Middle (n=15)	100	87
Poor (n=17)	100	94
All Groups (n=54)	96	63

Table 17. Preferred characteristics of purchased beans.

FOR CONSUMPTION n=52		FOR SEED n=34	
Characteristic	% Farmers who cited	Characteristic	% Farmers * who cited
Rapid cooking	77	Mixture with same varieties and proportions as their own	71
Short storage time	60	Mixture from neighbor "who has same kind of soil"**	29
Not Damaged few weevils not rotted	73	"Well stocked" mixture few weevils not rotted not new/not too old	38
Inexpensive mixture	9		
Large Grains	10		
Not treated with pesticide	4		
Good Taste	4		
Treated with ashes	2		
Low Price	2		
Not Black	2		

* Farmers were permitted to give multiple responses.
** The first and second answers are nearly the same: for seed, farmers are seeking to find a mixture they know. Nearly all farmers cited one or the other reason.

Table 18. Farmer sources for purchasing beans.(%)*

	FOR CONSUMPTION n=52	FOR SEED n=34
Town market	50	21
Local kiosk	44	15
Neighbors	10	65
Oprovia (state-run seed store)	2	0

*Some farmers gave multiple answers.

Table 19. Patterns of varietal use and distribution

Region	Variety	Life Expectancy	Distribution (seasons)	
Central				
	Kilyumukwe	6.7	0.40	0.49
	Ikinimba	3.3	0.12	0.17
Plateau				
Bugasera	Ikinimba	5.1	0.23	0.30
Kigali Nord	G2333	9.2	0.79	0.83

Figure. 1. Scheme for linking regional and national bean variety trials in the Great Lakes Region of Africa.

```
         National                              Regional
Introductions/Breeding  <---------           PRER
         !                                      !
         !                                      !
         !                                      !
  'Essais de Triage'                            !
         !                                      !
         !                                      !
         !                                      !
 'Essais comparatifs'   ---------->          PRELAAC
         !                                      !
         !                                      !
         !                                      !
'Essais multilocaux'   <---- 'Essais Régionaux' (ERGL)
         !                                      !
         !                                      !
         !                                      !
'Essais en milieu réel'                       AFBYAN
         !
         !
         !
    'Diffusion'
```

SOUTHERN AFRICA

The 12 months since the last report has been a period of establishment for the bean component of the SADCC/Grain Legume Improvement Program. The headquarters in Arusha now enjoys its full complement of senior staff: and only the Malawi position remains vacant. Considerable progress has also been made in filling other regional staff positions both in Arusha and elsewhere.

Two Steering Committee Meetings were held, attended by 6-7 of the 9 National Coordinators and representatives of SACCAR, the donors (CIDA) and the Regional Program. Equipment needs are being met; overseas training is in progress; funds have been allotted for research; and training courses, monitoring tours and workshops have been organized. SADCC participants have also attended training courses and workshops organized by CIAT HQ and the Eastern African and Great Lakes regional programs.

Meetings and Workshops

The following workshops were held within the region : the SACCAR workshop on Integration of Research, Training and Extension (Arusha, Tanzania); SPAAR Workshop on developing a Tanzania Agricultural Research Masterplan,(Arusha); national planning meetings (Tanzania and Zambia), the latter including attendance of the Groundnut/Grain Legume Seminar; the 7th Bean Research Workshop (Morogoro, Tanzania), and the CIMMYT/TARD Intercropping Workshop (Arusha); CIAT-organized meetings included: a breeders' workshop in Colombia, a pathology workshop and regional seminar in Rwanda; a drought working group in Harare, Zimbabwe; an agronomy/soil fertility workshop in Ethiopia; and a biological nitrogen fixation workshop in Rwanda.

Workshops being organized include a breeders' workshop in Colombia in November and in Lesotho in February, 1989 with 2 and 9 SADCC participants respectively. A CIMMYT/CIAT cereal/legume workshop is also planned for January 1989. The Steering Committee has also approved a SADCC Regional Bean Research Workshop in alternate years outside of Tanzania, with continued support for the Morogoro workshop.

Two group tours were conducted to monitor and discuss research activities in the field. In March, regional and national scientists from Malawi, Tanzania and Zambia travelled together in those three countries. In May, scientists from three Tanzanian institutions concerned with bean research toured Tanzania to monitor and discuss their research programs in company with regional staff. Four scientists from Malawi, Tanzania, and Zambia participated in a tour in Ethiopia in September.

The SC allots RP funding for the participation of SADCC national scientists in most of these activities, which form a vital means of strengthening and integrating intra and inter-regional bean research.

CIAT Materials in Distribution in the SADCC Region

A wide range of materials, comprising some 3000 samples, was sent to Tanzania but only 2 were released due to delays in plant quarantine checks. As a result of improved procedures, the prospects of renewed introduction seems promising. Materials distributed to other national programs were as follows:

Lesotho

Large white seeded lines
International Sugar Bean Nursery
International Large Red Kidney Nursery
Bean Team Nursery (VEF)
International BCMV Nursery

Malawi

International Snap Bean Nursery
International Drought Resistance Nursery

Swaziland

International Sugar Bean Nursery
International BCMV Nursery
Black root resistant materials
International Halo Blight Nursery

Zambia

International Large Red Kidney Nursery
International Sugar Bean Nursery
International Snap Bean Nursery
Bean Team Nursery (VEF)
Germplasm materials
International Ascochyta Blight Nursery
International Bean Anthracnose Nursery
International Angular Leaf Spot Nursery
International BCMV Nursery
Anthracnose differentials
Rust differentials

Regional and National Research

Significant progress is occurring in most national programs in the region. Notable are the large yield improvements being demonstrated over local materials in Lesotho, Swaziland, Zambia and Zimbabwe. Some of these have already given rise to improved cultivars, like Lyamungu 85 and Uyole 84 in Tanzania and Carioca and ZPV 292 in Zambia. The following attempts to summarize research progress made during the 1987/1988 season, based on summaries received from the national programs in Angola, Tanzania, Zambia and Zimbabwe.

ANGOLA

Production estimates obtained from the Ministry of Agriculture show that 4,875 t and 3,469 t were produced from 13,928 ha and 9,250 ha in 1986/87 and 1987/88, respectively. Data from the national seed company, Angosementes, indicate that 45 t, 33 t and 66 t were sold in 1987 from the provinces of Bie, Malange and Huambo, respectively. Angosementes also import significant amounts of bean seed.

Some 42 local germplasm accessions were evaluated and 20 of these were added to the collection held at Chianga. Preliminary evaluation of 94 entries in unreplicated plots at Chianga led to the identification of early maturing material. Anthracnose was considered the major constraint in the central highlands. The FAO-supported National Seed Program identified RAB 64, A 321, RAB 59, RAB 30 and PVMX 1591 from among IBYAN entries growing in Malange, with mean yields exceeding 1100 kg/ha. The local check Ervilha yielded 794 kg/ha and the trial mean yield was 960 kg/ha (cv = 30.3 %).

TANZANIA

Lyamungu 85 performed excellently in all series of Variety Trials and no other entry was significantly better in combined analysis, though a few were at individual locations.

In Uniform Trials, EMP 86, Carioca Sel 2, G 5621 (Diacol Calima) and LB 110 (selected from the CIAT cross G 4494 and BAT 1582) performed well and have been promoted to on-farm variety trials next season. In advanced and preliminary trials, LB 279 (PVAD 1146), P 449 Sel 1, Carioca Sel 1 and LB 588 (Horsehead x YC-2-3) also performed well. Some 800 accessions (mostly VEF 87 materials) were introduced via Uganda and were grown in open quarantine near Moshi. They will enter the testing system in 1989.

Further progress was made in the development of National Variety Trials which are now being organized by TARO with the assistance of the regional program.

An evaluation of sixty-three bean accessions for sources of resistance to halo blight showed that the majority of land races had intermediate levels of resistance to the disease. Other studies attributed losses of up to 82% to diseases (halo blight and anthracnose) at Selian.

An experiment on the effect of sowing date on bean fly and Ootheca damage showed that early sown materials escaped heavy infestations of beanfly but were exposed to high infestations of Ootheca. In another experiment endosulfan was shown to be superior to dimethoate in the control of Ootheca and pod borers, and 4 foliar applications covering both pre-and post flowering growth stages were optimal at Selian.

Trials at Lyamungu confirmed the critical period for weed control to be 2-5 weeks after plant emergence. Pre-emergence herbicide application of Galex followed by post-emergence application of Flex gave the best results.

A trial on the effect of sowing beans in association with single or paired rows of maize relative to performance in monoculture was conducted at 3 sites (Lambo, Lyamungu and Selian, respectively 1030, 1280 and 1350 m asl) in northern Tanzania over 3 seasons (1986-88). Mean seed yield over sites, seasons and cultivars of bean were 688 and 1133 kg/ha in single and paired rows, respectively, compared with 1414 kg/ha in the sole crop Maize yields were significantly decreased at all sites in 1988 by pairing rows. Mean LER pooled over locations and years, was 1.63. The recommendation from the trial is to plant beans between single rather than paired maize rows.

The effect of sowing one to five plants/hill, at the same plant density, in association with maize was investigated at two locations (Lambo and Selian) for three seasons. Seed yields for 1, 2, 3, 4 or 5 plants/hill, averaged over locations, years and cultivars, were 751, 726, 694, 647 and 703 kg/ha respectively. There were no significant differences among the treatments. For practical purposes, 2-3 plants/hill is recommended.

In an on-farm trial of 6 varieties (including one local check) in 13 locations, Lyamungu 85 was the highest yielder, producing 26% more yield than the local check.

ZAMBIA

In the national variety trial grown across 8 locations, BAC (=XAN) 76 and DOR 335 again out-yielded the check entry, Carioca, by 7 and 12%, respectively. BACT 76, which possesses combined disease resistance under Msekera and Mbala conditions, is proposed for pre-release testing in 1988/89. Among the 100 entries in a preliminary variety trial/disease resistance nursery over 2 locations, PAI 77, A 429, PAI 78 and PAT 10 put-yielded Carioca by 5-16%. Similarly, PAT 10 out-yielded Carioca by 14% in the Zambia bean yield and adaptation nursery (ZABYAN) of 27 entries. In the AFBYAN, grown at Msekera and Mbala, BAC 76 and A 197 were superior to the check, ZPv 292 (=Gayaza 8), by margins of 116 and 60%.

Several promising materials were also identified in the red Kidney, sugar bean and snap bean nurseries at Msekera. Evaluation of the VEF and EP, consisting of 445 advanced lines, led to the identification of 18 materials that out performed Carioca. The 3 best lines were MUS 9, HAB 237 and DOAR 367. Among the 18 entries in the national climbing bean variety trial over 5 sites, VRA 81054 is a candidate for pre-release testing.

The heavy rain that fell in February, following the preceeding dry spell, led to water-logging at Msekera. This may have accounted in part for the rather light BCMV pressure during the season. However, the BCMV resistance of Amand, IVT 7214, IVT 7224, AFR 173 and ZPV 292 was confirmed, and 4 partially resistant lines (PI 150414, PAT 10, BAC 76 and PVA 263) also outyielded the BCMV resistant check, ZPV 292, by margins of 42-75%. Alternaria leaf blight was severe at Msekera where differences in susceptibility were noted. Web blight was also recorded during the season. At Mbala, at least 30 lines were found to possess combined resistance to the main diseases, which were angular leaf spot, anthracnose, ascochyta blight, rust and scab; all these entries also yielded in excess of 900 kg/ha. G 6040 was top-yielder at Mbala for the second time but, owing to its unacceptable (black) seed, its value will be limited to use as a parent in future breeding. Two other lines, G 1098-1C and BAT 1510, are promoted to the national variety trial.

Among entries in the African beanfly resistance nursery (ABFRN), A 74 was most promising. The use of insecticides was found to give a cost: benefit ratio of 1:3.

ZIMBABWE

Among the 36 entries in the Food Bean Intermediate Variety Trial, grown in the 1987/88 season at 3 sites in the highveld (Harare, Gwebi and Henderson), all 35 test entries significantly out-performed the local check, Natal Sugar, and all produced mean yields in excess of 2 t/ha. The best 5 entries were RAB 263 (mean yield across locations 3 t/ha), XAN 191 (2.93 t/ha), PAN 131 (2.93 t/ha), RAB 303 (2.92 t/ha) and CAN 31 (2.91 t/ha). BCMV pressure at Harare was heavy and black root incidence was very variable. Entries least affected by black root were MOC-20-5X, MOC 21, Natal Sugar and PAN 131, and the worst entries were RAB 307, RAB 290 and RAB 263.

The Food Bean Advanced Variety Trial of 25 entries was also grown at these same 3 sites, and again all test entries consistently outperformed the control variety, Natal Sugar, by margins of 26-141%. The heaviest yielders were Puebla 152-Cafe, A 86, BAT 37, PAN 10, ICA Tui, P 326 and Carioca. The entry PAD 10 was the only line that developed neither BCMV mosaic nor black root.

An experiment in which 9 chemicals were evaluated for beanfly control was carried out at Panmure Experiment Station, a beanfly "hot spot", but results were inconclusive. Preliminary findings from a special project between Braunschweig and CIAT has demonstrated the presence of cucumber mosaic virus in beans in Zimbabwe.

Interregional Collaboration and Activities

To further strengthen research, the SC have allotted funds for three regional collaborative research sub-projects, on angular leaf spot and biological nitrogen fixation (both Malawi) and drought (Malawi, Tanzania and Zambia). A fourth project, on rust (Tanzania) was approved at the 5th SC. These and other subproject proposals are summarized in Table 9.

The joint project on drought was developed at the recent drought working group in Harare. Care is also being taken to maintain links with research sub-projects being conducted in other regions to complement rather than duplicate research effort.

Inter-regional cooperation is especially important in the establishment of Africa-wide nurseries. An African Bean Yield and Adaptation Nursery (AFBYAN) and the

African Beanfly Resistance Nursery (ABFRN), both composed of cultivars contributed by national programs from all three regional projects, are already in progress and a Drought Resistance Nursery and disease resistance nurseries are being assembled.

Some 20 nurseries comprising over 3000 samples were requested from CIAT by Lesotho, Malawi, Zwaziland and Zambia. After delays due to quarantine in Tanzania about 1000 samples have been cleared for growing in isolation out of season (Note - CIAT takes stringent measures to ensure clean seed is distributed, but to enable rapid dissemination of seeds and reduce the risks of spreading infection, close collaboration with national plant quarantine authorities is essential). However, considerable variability already exists in the region among local and previously introduced materials and still remains to be exploited, notably in Malawi.

In addition to plant improvement, attention is also being given to other improved technology, such as emphasizing reduced dependence on inorganic chemicals. Sustainability of new technology is also being emphasized, for example by the use of leguminous tree species to maintain soil fertility, reduce erosion and provide support for climbing beans.

Regional and national staff are placing much greater emphasis on on-farm testing and extension. The field staff we are employing at the moment will be engaged principally in on-farm research and work has already been expanded in Tanzania - in Arusha, the Usambara Mountains of Lushoto, and in Kagera -and will be expanded in northern Zambia next season, all in collaboration with national organizations. These activities are obviously vital if new technologies are to have impact on our main target, farmer production.

Table 1. REGIONAL WORKSHOPS, 1988-89

Subject	Venue	Date	Participants (supported by SADCC/CIAT)	Country	Remarks
7th Bean Res. Workshop in Tanzania	Morogoro,TZ	28-30 Sept. 88	Dr. J. Kannaiyan	ZA	Organized by SUA/CRSP with input from SADCC/CIAT. CIAT participants:
			E. C. Caliengue	AN	
			R. Kamala	TZ (TARD)	
			P. Ndakidemi	TZ (TARD)	D. J. Allen (Arusha) O. T. Edje (Arusha) J. B. Smithson (Arusha)
			C. Mayona	TZ (UAC)	J. K. Ampofo (Arusha)
			Dr. M. Mmbaga	TZ (univDar)	
Nitrogen Fixation Workshop	Kigali,RW	27-29 Oct, 88	Dr. S. Mughogho	MW	Organized by CIAT/Great Lakes.CIAT particip. :
			Dr. M. P. Salema	TZ (SUA)	O. T. Edje (Arusha)
			Dr. P. Davis	ZW	J. Kipe-Nolt (Palmira)
Workshop on Research Methods for Cereal/Legume Intercropping	Lilongwe,MW	23-27 Jan 89	Max 23 Participants		Organized jointly by CIAT/CIMMYT O. T. Edje (CIAT-Arusha) S. Waddington (CIMMYT-Harare)

Table 1. REGIONAL WORKSHOPS, 1988-89

Subject	Venue	Date	Participants (supported by SADCC/CIAT)	Country	Remarks
Groundnut/Grain Legume Seminar	Mfuwe,ZA	9-11 March 88	O. Venge	ZW	Organized by Zambia National Program
					CIAT participants
					D. J. Allen (Arusha)
					J. B. Smithson (Arusha)
Drought Working Group	Harare,ZW	May, 88	Dr.J. Mulila - Mitti	ZA	Organized by SADCC/CIAT
					CIAT participants:
			O. Venge	ZW	O.T. Edje (Arusha)
			M. Manthe	BD	J. White (Palmira)
			P. Ndakidemi	TZ (TARD)	
			Dr. A.B.C. Mkandawire	MW	
			Ms. Mafoka	LD	
Agronomy and Soil Fertility Workshop	Addis Ababa Ethiopia	5-9 Sept.88	K.L. Haule	TZ (TARD)	Organized by CIAT E. Af.
					CIAT participants:
			C. Mayona	TZ (UAC)	O.T. Edje (Arusha)
					R. A. Kirkby (DebreZeit)
			Dr. J. Semoka	TZ (SUA)	C. Wortmann (Kampala)
					W. Graf (Rubona)
			P. Ndakidemi	TZ (TARD)	J. Lynch (Palmira)
			Dr. M. Piha	ZW	
			Dr. E. Shumba	ZW	
			A. Sereno	AN	
			Dr. S. Mughogho	MW	
			G. Mitti	ZA	

Table 1. REGIONAL WORKSHOPS, 1988-89

Subject	Venue	Date	Participants (supported by SADCC/CIAT)	Country	Remarks
Breeders Workshop	Maseru,LD	30 Jan-2 Feb. 89	F. M. Marcelino	AN	Organized by SADCC/CIAT J. B. Smithson (Arusha)
			T. Motsoene	LD	
			T. Namane	LD	
			Dr. G. Massey	LD	
			S. Moima	LD	
			J. Bokosi	MW	
			M. Moraes	MD	
			J. Pali-Shikhulu	WD	
			Dr.O.Mwandemele	TZ (UNIDAR)	
			Dr. S. Nchimbi	TZ (SUA)	
			C. Madata	TZ (UAC)	
			O. Venge	ZW	
			Dr.J.Mulila-Mitti	ZA	
Entomology Working Group	Nairobi KE?	7-8 Aug 89	Dr. D. P. Giga	ZW	Organized by SADCC/CIAT J.K. Ampofo (Arusha)
			L. Kantiki	MW	
			Dr. S. Sithantham /P. Sohati	ZA	
			M. L. Pomela	LD	
			S. Slumpa	TZ (TARD)	
			D. Kabungo	TZ (UAC)	
First SADCC Regional bean research workshop	Mbabane,WD	Sept.Oct,	?		Organized by SADCC/CIAT D. J. Allen (Arusha)

Table 2. Monitoring Tours

Participants	Locations	Time	Purpose	Remarks
Dr. S. Mughogho (MW) Dr. A.B.C. Makandawire (MW) Mr. L. Kantiki (MW) Mr. C. Mayona (TZ) Mr. G. Mitti (ZA)	Malawi, N. Zambia S. Tanzania	Mar 88	To visit the main research sites in this small, diverse and important area of bean production spanning three countries at peak season	Accompanied by D. J. Allen, J. B.Smithson, (CIAT-Arusha) J. Tohme (CIAT-Palmira)
Dr. J. Mulila -Mitti (ZA) Ms. R. Kamala (TA)	Ethiopia	Sept.88	To give opportunity for breeders to visit key sites where local and introduced in a well-structured program.	Accompanied by J. B.Smithson, (CIAT-Arusha) and A. Acosta (CIAT-Kampala)
?	Mozambique	April 89	To cover the main research sites used for grain legumes nationally, with emphasis on bean cultivar development.	

Table 3. Regional collaborative research sub-projects

Topic	Investigators	Country	Linkages	Status
Angular leaf spot resistance/ germplasm evaluation	Msuku & Bokosi	MW	Mulungu, Zaire (Pyndji)	Approved by 3rd SC & 3rd SC & funded. Sites to incl. Bunda (MW), Mbala (ZA) and Mbeya (TZ).
Screening for nodulation relative to nitrogen fixation	Mlozi-Banda, Mkandawire & Mughogho	MW	Rwanda (Athanase)	Approved by 3rd SC
Drought	Mkandawire, Kamenga, Ndakidemi & Mbewe	MW/ ZA/ TZ	Members of Drought Work Group; and Nazret, Ethiopia (Kidane)	Approved by 4th SC
Rust Race Identification	Mmbaga	TZ	Nazret, Ethiopia (Habtu)	Approved by 5th SC; funding subject to confirmation Dr. Mmbaga *in situ*
Thresher design	Shemsanga	TZ	-	Deemed inappropriate by SC and rejected.
Storage	Shemsanga	TZ	-	Deemed inappropriate by SC and rejected.

Table 3. Regional collaborative research sub-projects

Topic	Investigators	Country	Linkages	Status
Bean Commom Mosaic Virus Resistance Evaluation	Lana, Kannaiyan & Venge	TZ/ZA /ZW	Makerere, Uganda (Owera)	5th SC requested revision and merger with Owera's sub-project. To Be re-submitted at 6th SC.
Aphids	Sithanantham et al.	ZA/TZ/ SW	-	To be revised & resubmitted at 6th SC.
Carioca Improvement	Mulila-Mitti, Mbewe, Kamala & Venge	ZA/TZ SW	Nazret, Ethiopia (Amare) CIAT/HQ	Supported by 5 th SC, so that start can be made; but proposal/ budget to be revised.

Table 4a. TRAINING: Status of academic scholarships awarded to professionals.

Degree	University	Discipline	Starting Date	Name	Country
MS	Gainesville, Florida	Agron	Jan 88	O.S. Mbuya	TZ
PhD	Davis, California	Breed.	Sept.88	E. M. K. Koinange	TZ
PhD	Cambridge, UK	Breed	Jan 89	Olivia Venge	ZW
PhD	Cornell	Breed	Jan 89	G. Maphanyane	BD
PhD	Iowa State	Weed Sci	Jan 89	H. Mloza-Banda	MW
PhD	Utah State?	Entom	?	M. L. Pomela*	LD
MSc	Reading, UK	Agron	89?	C. Camarada**	AN

* Firm PhD place not yet secured
** Place sought

Table 4b. TRAINING: Status of short-term training of professionals at CIAT Headquarters, 1988-89.

Discipline	Period	Name	Country
Agron	Feb-May 88	Castro Camarada	AN
Agron	Feb-May 88	Alberto Massamba	MD
Breed.	Sep. 88	Dr. Joyce Mulila -Mitti	ZA
Breed.	Oct-Dec 88	Peter Dimoso	TZ
Breed.	Oct-Dec 88	Betty Marenge	TZ
Pathol.	Mar-June 89	Ermelinda C. Caliengue	AN
Soil Sci	Mar-June 89	Jose Alberto Sereno M.	AN
Breed.	Mid 89	Antonio Francisco Castame	AN
Physiol.	July-Aug 89	Dr. A.B.C. Mkandawire	MW

Table 4c. TRAINING: Status of short-term multidiscipline training of technicians within the SADCC region, 1987-89.

Period	Location	Co-sponsors	Name	Country
14-28 March 87	Lilongwe,MW	CIAT/IITA	E. Kgetse	BD
			T. Nkago	BD
			P. Choana	LD
			T. Saiwa	MW
			C. Kapunda	MW
			D. Jere	MW
			P. Mwaighogha	MW
			S. Elikunda	TZ
			H. Kwilabya	TZ
			B. Marenge	TZ
			E. Ngowi	TZ
			E. Mosha	TZ
			L. Matemu	TZ
			H. Runkulatile	TZ
			H. Kiozya	TZ
			P. Chilembo	ZA
			K. Muimui	ZA
			G. Mutale	ZA
			Z. Mathias	ZA
			C. Kundembe	ZW
			C. Ndebele	ZW
23 May-1 July 88	Arusha, TZ	CIAT	M. T. Lepheana	LD
			C. Kapunda	MW
			K. Muimui	ZA
			P. Chilembo	ZA
			A.R.M.Gamaha	TZ
			M.S.Chitemo	TZ
			D.J.Mugunda	TZ
9-28 March 89	Maputo, MO	CIAT/IITA/ ICRISAT	(Max 20 particip.)	MO AN

EASTERN AFRICA

The Eastern Africa region comprises Ethiopia, Uganda, Somalia and Kenya. A coordination office is located at Debre Zeit, Ethiopia, where a cropping systems agronomist/regional coordinator is attached to the Institute for Agricultural Research (IAR) and the International Livestock Center for Africa (ILCA).

Remaining regional staff positions were filled during 1988, and three team members (a breeder, a second cropping systems agronomist and an economist) are based at Kawanda , Uganda next to the Ministry of Agriculture's bean program. However, the regional breeder resigned for family reasons and the position is again unfilled.

Administrative services to the regional network were strengthened early in 1988 by the local recruitment of an accountant/administrative assistant based in Debre Zeit, and by reorganizing of support for Kawanda-based operations.

Layout and numbering of this report are in accordance with the Annual Workplan approved by the Steering Committee.

<u>Regional Steering Committee</u>

The full annual meeting of the committee was held at Mogadishu, Somalia on 7 and 8 March, 1988. All four countries and the regional coordinator participated as usual, and USAID/REDSO was represented. CIDA was unable to send a representative. Somalia's national coordinator chaired the meeting.

The continuation of three regional research projects was approved, as also was the initiation of three new projects on drought, BCMV and bruchids. Regional project budgets were also allocated for training, workshops and national program equipment purchases.

A draft workplan for the regional program for April 1988 to March 1989 was discussed and approved with minor modifications.

Project Objective 1: Develop improved varieties of beans in collaboration with national programs.

1. New introductions of bean germplasm

a) from CIAT

Ethiopia: Introduction in late 1987 of nurseries of large kidney and speckled sugar types, and for resistances to rust, anthracnose, angular leaf spot (ALS), common bacterial blight (CBB) and drought were evaluated in the field in the July - October 1988 main season. Further introductions received into open quarantine during the reporting period were: 41 food bean crosses in F_2 generation made for Ethiopian conditions, and white-seeded materials from EP88.

Kenya: Out of several hundred materials selected CIAT by a Kenyan breeder visiting in late 1987, only 20 snap bean lines were released from local quarantine in time for planting in April 1988. More were expected to be available for the second season.

Somalia: Nurseries for leafhopper and drought resistance, two sources of resistance to beanfly, and white-seeded dry bean and snapbean nurseries, were introduced during the year. Planting was scheduled for the October season.

Uganda: Introductions in late 1987 of nurseries of large kidney and speckled sugar types, and for resistances to rust, anthracnose, ALS and CBB were evaluated in the field in the March-July season. Further introductions received during the period were F_2 seed of 11 crosses specifically made for Uganda, including backcrosses of Ugandan landraces with sources of multiple resistance against diseases. Selections were regrown in the second season.

b) from the region

(i) The second round of the African Bean Yield Adaptation Nursery (AFBYAN-2) was multiplied under disease-free irrigated dry season conditions at Melkassa, Ethiopia during Feb-June 1988. The 25 entries contributed by national programs include released varieties from nine countries in Africa. Seed was packaged and distributed to eleven other countries in the Africa bean network. During the Ethiopian main season the new trial was evaluated at Melkassa, where further multiplication will enable more countries to receive seed in 1989.

(ii) Fifty climbing bean varieties requested by Ethiopia from CIAT (Great Lakes) were planted at Bako in June 1988. Initial performance suggested that these high-altitude materials are not well adapted in this mid-altitude area. This attempt to intensify production in the dominant maize crop of humid areas of western Ethiopia is continuing with evaluations of Type III materials under a uniform maize crop.

(iii) An African Bean Drought Resistant Nursery (ABDREN) was assembled and multiplied at Melkassa, Ethiopia during the off-season. Entries comprise 10 materials identified by CIAT and Latin American collaborators, 10 materials identified in Ethiopia in 1986-87 during periods of severe drought, and check treatments of cowpea, tepary bean and local beans. Sets were despatched to Kenya (Katumani), Somalia, and six countries of the Southern Africa region through the Africa Bean Drought Working Group.

2. Advancing of Pre-1987 Introductions Within National Programs

Good progress is being made, especially in Ethiopia and Uganda bean germplasm introduced during the period 1984-86.

In Ethiopia, two white peabean and three food-bean varieties, all introduced from CIAT, have been proposed by IAR's bean breeding program for release nationally, and the decision of the Seed Release Committee is awaited. The performances of these candidate varieties are compared below with the presently recommended varieties, which were released during the 1970s.

There were also several very promising materials progressing rapidly through the successive stages of evaluation, and a continuing series of releases is confidently expected in coming years.

A three-season screening for beanfly resistance, which started with 1600 CIAT introductions, has confirmed very good levels of resistance this season in replicated, paired compari sons of protected & unprotected plots at Awassa. Lines showing the highest level of resistance were: G2005, G2472, G3844, G5253, G5773 and EMP81. This result from a PhD thesis study may be a breakthrough for other countries seriously affected by this species of beanfly (O. phaseoli). As most resistant lines were small black-seeded types from Central America, they will now be used as parents for crossing with locally preferred varieties.

In Uganda, five varieties introduced through the AFBYAN regional nursery in 1986 appear particularly promising for early release. These varieties and their origins are:

ZPV 292	Zambia
Kilyamukwe	Rwanda (export type only, due to color)
T 3	Tanzania
Urobonobono	Burundi
Rubona 5	CIAT via Rwanda (= ICA Palmar)

Other varieties currently in on-farm trials with 40 farmers (10 in each of four agroecological zones) in Uganda are: Carioca and G13671 (also introduced through the AFBYAN), BAT 1220 and the four Ugandan landraces, Kampulike Yellow, White Haricot, Namunye Red and Muhinga. K20 is the locally bred check.

In Somalia, progress has been slowed by the loss of almost all previous introductions in an extremely severe attack by beanfly in 1987. With information accumulated from three seasons' observations on bean germplasm in this country, new introductions are more closely targetted.

3. Development of national systems for variety development

Ethiopia: IAR's well-developed program for germplasm evaluation uses three main stations representing principal ecological zones and 18 other locations (Table 2). However, cach-cropping areas are better covered than food bean areas. An important development, therefore, was this season's start of collaborative research on beans by Alemaya University of Agriculture, located in the eastern highlands food bean production area. Several hundred CIAT introductions were transferred from IAR Melkassa; selection for adaptation to this cool, dry environment will lead to a separate series of multilocational trials. The intention of filling the other major gap in food bean research coverage, for the densely populated, wetter southern area of Wollaita, was only partially successful this season. Variety evaluation in maize intercropping was introduced at Awassa, but delayed development of IAR's new research site at Areka prevented its use this season.

Kenya: CIAT Regional staff and KARI bean researchers from Thika jointly toured all bean research locations in Kenya in June/July 1988. A detailed draft workplan for regional/national collaboration was drawn up and submitted to KARI HQ, for implementation if an agreement is signed. In the meantime, the regional program has been responding to requests on germplasm and its utilisation from Thika and Katumani stations and from Egerton University.

Somalia: Extension of present collaboration to and Bonka stations awaits return of trainees. Extension to Aburein station was prevented by insecurity in the northwest.

Uganda: A second national yield trial series was launched in 1988B. Southern areas are now well covered, but insecurity around Serere still prevented extension of work to drier areas (Table 3). On-farm testing, started only this year, is receiving particular attention from this national program. The main limitation remains the poor economic situation of national scientists and extension staff; a large number of trials are being run both on and off station, but evaluations are sometimes hampered by lack of time.

4. Specialist input in germplasm evaluation and techniques

(a) CIAT's regional bean breeder, based in Uganda, made regional visits to Kenya and Ethiopia for planning, training and data collection purposes. Assistance was also provided by field visits from the CIAT/SADCC regional bean breeder and from the regional coordinator.

(b) Training in computerized data handling analyses was provided by a short course for scientists in Ethiopia and another for technicians held at Arusha. Microcomputers are now available through the regional program for use by national scientists at Kawanda in Uganda and at Melkassa and Awassa stations in Ethiopia.

5. Economic study of bean export market potential.

This study, of interest to several countries is being planned by the new regional economist. In Uganda, food beans are important in informal trade with neighboring Rwanda and for international barter, while Ethiopia's longstanding export trade in white peabeans (navy beans) is a primary source of income generation for many small farmers in the dry Rift Valley area.

6. Technical input by CIAT/SADCC bean entomologist

This new regional position, working across Eastern and Southern Africa from the Arusha base and funded under the CIDA/SADCC agreement, was filled from June 1988. Dr Ampofo made one visit to Eastern Africa to discuss beanfly research and to plan further collaboration. The importance of making quick progress in this area was emphasized this season when beanfly wiped out trials at Jima, Ethiopia and was severe in parts of Uganda; last year almost all germplasm at Afgoi, Somalia was wiped out. Recent identification of resistant sources in Ethiopia and Burundi provides a jumping-off point for more intensive regional collaboration.

7. Regional research sub-projects through NARS

a) **Rust** (Ethiopia): Continuing with screening at two locations. Better incidence this year, but more effort is needed to collect results from other countries and assemble a regional nursery.

(b) **CBB** (Uganda): the new CIAT VIB nursery was added to work in progress. Correspondence between pathologists to identify lines that show resistance across countries. Spreader row technique is in use for experiments, and identification of Mabuku as a semi-arid,irrigated site may permit progress on disease control through clean seed production.

(c) **Ascochyta** (Uganda): Evaluation of the CIAT resistance nursery and of other materials in 1988 A season has led to a new nursery for the October season. Work is concentrated in the cooler S.W. area of Uganda; results are expected to warrant regional testing in 1989. Some crosses have been made in Uganda.

(d) **Drought** (Ethiopia): This new project started by assembling an Africa Bean Drought Resistance Nursery (ABDREN) from 10 promising selections provided by CIAT and its Latin American collaborators, and 10 selections noted for their good performance under drought conditions in Ethiopia. As well as being distributed regionally, this trial was grown at four locations in Ethiopia. However, rainfall this year was the highest for 15 years, and no information on drought tolerance was obtained.

(e) **BCMV Virus** (Uganda): A strong regional component developed this season with collaborative surveys of all major producing areas of Ethiopia by Ugandan and Ethiopian virologists. Subsequent laboratory work is being shared between Makerere University (Uganda) and the GTZ-supported collaborative project at Braunschweig (W.Germany). Surveys of Uganda were also conducted this season.

(f) **Bruchids** (Somalia): An entomologist and a breeder were trained at CIAT in Oct-Dec 1988 in preparation for this new project focussed on storage problems that are important throughout the region and which constitute Somalia's primary constraint to grain legume production.

Project Objective 2: Develop improved cropping systems and agronomic practices, with NARS

1. Diagnostic surveys in important areas not yet surveyed.

Ethiopia: IAR Agricultural Economics surveyed the Wollaita maize-bean system. A survey with Alemaya University of the Chercher Highlands sorghum-bean system is planned for late 1988.

Uganda: The national bean program surveyed Luwero district. Invaluable information on varietal preferences was also obtained from farmers' meetings around on-farm verification trials. Grain color and size affect adaptability mostly in areas serving local markets. The prostrate habit and indeterminacy of G13671 will prevent adoption of this high-yielding variety in Rakai and Mpiji Districts, where farmers wish to harvest only once, but these characteristics posed no problem to farmers in the land-scarce highlands of Kabale, where high yield is of greatest importance. Slimy leaves of Carioca are an impediment to consumption; ability to make a thick red soup with bananas was considered by farmers to be an advantage of BAT 1220 in many areas; Rakai farmers found that the poor keeping quality of boiled White Haricot could be overcome by frying. Surveys of the banana-bean system were started in Uganda and, jointly with CIAT/SADCC program, in the border area of Kagera, Tanzania. Two Makerere undergraduate projects focus on farmer practices.

2. Assist NARS in planning research related to farmers'needs

Visits to local research stations in all countries have focussed upon identifying farmers' needs and planning trials that would best meet them.

Ethiopia: An IAR/CIAT/CIMMYT workshop brought together all graduate crop agronomists and agricultural economists for planning of new trials for 1989. CIAT's regional coordinator and the regional economist assisted. New proposals on beans included:

- herbicide verification, compared with farmers'high seeding rate for weed control (on-farm, Melkassa area);
- study of market price factors;
- evaluation of traditional agroforestry for sustainability of production in the Rift Valley;
- further exploratory research on yield-limiting factors on Rift Valley farms--varietal screening for nitrogen uptake on infertile soils (Melkassa);
- verification of broadcasting beans into maize (Bako, on farm);
- coffee pulp, bone meal and inorganic fertilizer trial (Awassa);
- maize-bean intercropping patterns x fertilization (Jima).

Uganda: Trials started on feasibility of using cereal stover for relayed climbing beans in the S.W. highlands. Initial results were inconclusive as bean growth was reduced by drought and aphids this season; however, the maize stover persisted well.
A separate trial series examines the management needs for a new maize/climbing bean intercrop association, for many areas of Uganda where beans are the more important component and farmers wish to avoid dominance by the taller are maize crop. Exploratory trials are in progress in soil fertility management in Luwero district.

3. Collaborate with NARS in agronomy research on station

Trials continuing in Ethiopia, Somalia and Uganda as planned. At Kawanda, Uganda, bananas were established in advance of a new study on cropping system by genotype interactions of beans grown under bananas and in pure stand. In a continuing study there, herbicides were evaluated as a tool to reduce costs of running large areas of germplasm evaluations, and may have potential for certain groups of farmers.

4. Collaborate with NARS in on-farm trials

Trials are continuing in Ethiopia and planned; these have been described above or in previous reports. In Uganda, two new on-farm trials were planted this season to study the management of beans grown under bananas. One trial was doing well at last report but the other suffered damaged from chickens and low soil fertility. Collection of information on soils in Uganda has started so as to classify the major bean growing soils into fertility management units using the Fertility Capability Soil Classification System. Using this system, most soils in Southwestern and Central Uganda would be classified as loams with loam or clay sub soil, with moderately low pH being the main modifier. Most appear not to have "low K reserves". Others may have "high P-fixation by iron" and/or "aluminum toxicity", but soil analyses on these characteristics await completion of Kawanda lab renovations. It appears that these soils will be classifiable into relatively few management units. This work is to be followed with nutritional screening trials beginning in 1989.

5. Regional agricultural economics research.

Soon after agreement was reached in April/May 1988 with the Ministry of Agriculture and CIDA to locate the regional position in Agricultural Economics in Uganda, Dr William Grisley was appointed. He took up his duties (for Eastern and Southern Africa) on 1st September, and has made visits to on-farm research locations in Ethiopia, Tanzania and Uganda with national scientists. He will follow the workplan approved by the steering committee, giving initial emphasis to Uganda within this region.

Project Objective 3: Strengthen national programs through training

1. **Regional and in-country courses**

    a) In-country Course in On-Farm Trial Management for Extension Staff, Uganda, 29 February-5 March 1988. CIAT/Ministry of Agriculture.

    Approximately 20 participants who are responsible for day-to-day management of the newly-developed on-farm trials program in Uganda. Course content : overview of on-farm research, selection of farmers and sites, involvement of farmers in priority-setting, laying out experiments, farmers' role in evaluations, identification and rating of diseases, etc.

    b) In-country course on statistical procedures and M-Stat was held by CIMMYT/CIAT/ILCA for all masters-level researchers in IAR, Ethiopia. These researchers subsequently trained all other graduate-level staff at a series of in-station courses. This has transformed the analyses of data in Ethiopia.

    c) Sponsorship to CIAT (or other) courses held elsewhere in Africa was provided to four scientists.

2. **Regional monitoring tours**

    a) Bean Breeders' Monitoring Tour visited four stations in Ethiopia between 4-10 September 1988. Graduate participants were from Ethiopia (5) and one each from Uganda, Kenya, Malawi, Zambia and Tanzania

    b) A cropping systems tour of S.W.

Uganda nd N.E. Tanzania was held May 1988. This focussed on the banana-bean system.

3. **Short term training at CIAT**

The following young graduate scientists departed for CIAT on 2-3 month training periods:

Ethiopia (1) breeding
Somalia (2) breeding and entomology
Uganda (1) breeding

4. **Postgraduate training**

Three scientists who completed university coursework spent this period on thesis research. Two theses, on aspects of beanfly management, are being conducted in Africa. Several other candidates are awaiting university acceptance.

5. **Encourage NARS to organize research seminars**

Dr White (CIAT bean physiologist) gave a seminar to IAR scientists during a visit to Melkassa, Ethiopia. In discussions with Uganda Ministry of Agriculture officials, interest was expressed in reviving a local seminar series to motivate scientific exchange; CIAT staff have offered to contribute.

6. **Production and distribution of training materials**

The distribution of CIAT audiotutorial units is coordinated from Debre Zeit, Ethiopia. During 1988, 28 boxed sets (slides, cassette and study guides) and 138 study guides on 15 separate topics were distributed at the request of 23 scientists or institutions.

7. **Purchases of critical equipment for national bean programs**

The steering committee authorized the purchase of several items of equipment of critical importance to national programs. High priority was given this year to computerization of data handling at principal stations.

Regional Review

An informal mid-term review was carried out by USAID, CIDA and CIAT in April 1988. This involved considerable effort in collating performance statistics and expenditures, which are now computerized to facilitate future reviews. A revised budget for the remaining 2 1/2 years was submitted to CIDA and USAID.

Table 1: Performance of new candidate varieties for Ethiopia.

	Yield kg/ha 21 trials)	Maturity (days)	Resistance (CBB & Rust)	Food Quality
<u>White Peabeans</u>				
Ex-Rico 23	2416	91	Good	Excellent canning
BAT 338-IC	2364	91	Very Good	Good canning
check (Mexican 142)	2072	92	Fair	Excellent canning
<u>Food Beans</u>				
997-CH-173	2620	90	Good	Slow cooking time
A 176	2498	89	Good	Fast " "
Carioca	2572	89	Moderate	Fast " "
Local check (mean)	2390	89	Moderate	Average " "

Table 2: Bean Germplasm Evaluation In Ethiopia, 1988

Trials	No. of entries	AL	AM	AS	AO	AW	BK	DZ	HR	JM	KB	LB	MI	ML	PW	SR	UB	WH	WO	WD	YB	ZW
Verification																						
White peabean	3					1	1			1				1								
Food bean	4					1	1			1				1								
National Variety																						
White peabean	8		1	1		1	1		1	1		1		1			1	1		1	1	1
Medium food bean	10		1		1	1	1		1	1		1		1				1			1	
Large food bean	8		1		1	1	1		1	1				1				1		1	1	1
Prenational Variety																						
White Peabean	15				1	1	1			1				1								
Medium food bean	15					1	1			1				1								
Large food bean	15					1	1			1				1								
Nursery II																						
White Peabean	33					1	1	1		1				1	1							
Medium food bean	25				1	1	1			1				1	1							
Large food bean	25				1	1	1			1				1	1							
Nursery I (1987) (Introductions)	800	1				1								1	1							
Drought nursery	25										1		1	1		1			1			1
AFBYAN	25													1								
Introductions (open quarantine)	528													1								

Locations:

AL = Alemaya	AM = Ambo	AS = Asasa	AO = Asosa	AW = Awassa
BK = Bako	DZ = Debre Zeit	HR = Harbu	JM = Jimma	KB = Kobbo
LB = Lower Birr	MI = Miesso	ML = Melkassa	PW = Pawe	SR = Sirinka
UB = Upper Birr	WH = Wachu	WO = Wolenchiti	WD = Woldia	YB = Yabello

TABLE 3: Bean Variety Development in Uganda: Distribution of Trials, 1988B

Material or Trial	No. of Entries	Kawanda	Bukalasa (Luwero Distric)	Katchwekano (Kabale District)	Masindi	Variety Testing Centres (x5)	Rakai District	Mpigi District
On-Farm Verification	8		10	10			10	10
National Variety Trials								
- I	25	1	1	1		5		
- II	16	1	1	1		5		
Advanced Selections								
- Promising Lines		1	1					
- Different Cultivars		1						
- Sugar bean selections			1					
- Red Kidney selections			1					
- Rwanda climbers		1		1				
Nurseries								
- Angular Leaf Spot		1						
- CBB		1	1		1			
- Rust (CIAT)		1	1					
- Rust (Uganda)		1						
- Bruchid		1						
Introductions								
- Segregating Population			1					
- Segregating Materials CIAT			1					
- AFBYAN - 2		1						
- Germplasm			1					
- 87 VEF		1						
- 86 VEF		1	1	1				
Crossing Blocks								
- CBB		1	1					
- Ascochyta		1						
Seed Increases			1					

APPENDIX A: TRAINING

Training activities in the Bean Program during 1988 were designed and presented to support and strengthen national programs in the following ways:

1. Promotion of promising germplasm;

2. Multiplication of good quality seed from these lines;

3. Identification of factors limiting bean production;

4. Subsequent search for solutions and alternatives congruent with problems, resources and objectives of bean farmers;

5. Adaptation of technology thus generated to various farming and cropping systems through research conducted on-farm.

The Bean Program offers courses divided into phases and interphases. This has proved, over the last few years, to be an extremely effective course design. It is an efficient method for the generation, completion and follow-up of a training activity, that can be easily copied and incorporated into national programs.

The generative or initial phase of a course normally comprises a diagnostic analysis of the bean production constraints, and possible solutions to them, of a particular region .

The following phases and interphases are oriented toward the execution of, and follow up to, the strategies decided upon in Phase 1.

Example: Artesanal Seed Course

The Artesanal Bean Seed Project has received increased attention this year, in accordance with the needs and desires of national programs. In this case, courses are attended not only by scientists and technicians, but by bean farmers as well, who have been asked to join the project and grow artesanal seed on their land. Basic information is transferred extremely quickly and effectively through this immediate association of technology and farmer.

The first Phase of this course comprises a review of the agronomic management of the variety or line to be promoted for the artesanal seed project. In the first Interphase, the scientist-farmer team plants the first multiplication plots. Phase II comprises the harvesting and distribution of the seed. During Interphase II, the best seed is selected and multiplied further. Phase III of the Artesanal Bean Seed Project is designed for commercial seed production, technique diffusion, and the public promotion of the multiplied material.

This methodology will be transferred by the Bean Program training people to similar artesanal seed projects in El Salvador, Ecuador, Honduras, Nicaragua, Peru and Colombia.

Training at CIAT Headquarters

The development of training methods for research on bean production resulted in the following course type divisions:

1)Intensive Multidisciplinary Course
2)Intensive Course
3)Specialization Courses

A total of 65 scientists participated in these courses. Forty-seven of then came from Latin America and the Caribbean, 11 from Africa and 7 from developed countries. Four scientists completed their Masters or Ph.D theses this year at CIAT headquarters.

1. Intensive Multidisciplinary Course: The Fifth Intensive Multidisciplinary Course on Bean Production lasted five weeks and was attended by 18 visiting research scientists from 12 countries: Colombia 4, Honduras 3, Nicaragua 2, Angola 1, Bolivia 1, El Salvador 1, Spain 1, Guatemala 1, Mexico 1, Mozambique 1, Panama 1, and Peru 1.

2-3. Intensive and Specialization by Discipline:

On-Farm Research--The Fifth Course on On-Farm Research and Bean Production Systems was completed in nine weeks and was attended in 1988 by 21 visiting scientists.

The principal course site was at CIAT, with field work in Santander and Nariño. The principal objective of this course was to train these scientists in on-farm research methodologies. The goal of the on-farm research methodologies used is to facilitate the search for solutions to bean production problems faced by farmers with extremely limited resources.

Breeding and Pathology: Twenty-two scientists received training in these two areas (12 in Breeding and 10 in Pathology), and two of these received their Ph.Ds this year.

Artesanal Bean Seed Production: This 21-week course was attended by 7 scientists. The principal objective was to review current agronomic practices and to restructure them by working directly with the farmers involved. Secondary aspects of the course dealt with harvest, seed treatment, post-harvest storage, and quality control of seed. This course was specifically directed towards clearing a path through one of the largest bottlenecks in bean production---the availability of good quality seed for farmers. The seed unit at CIAT participated actively in this course.

Training Activities Outside CIAT

Latin America and the Caribbean:

The decentralization of training activities continued this year, permitting advanced training to be offered in seven countries: Ecuador, El SAlvador, Guatemala, Honduras, Nicaragua, Paraguay and Peru. These courses were predominantly concerned with On-Farm Research and Artesnanal Seed Production.

Seed Production Courses in these countries are supporting the multiplication of seed from the following varieties:
ECUADOR----INIAP 400, INIAP 402, INIAP 403, INIAP 404
PERU----ZAV 83099 and Blanco Salkantay
EL SALVADOR----CENTA Izalco
NICARAGUA----Catrachita

Africa

(SEE SECTIONS ON AFRICA)

The Great Lakes, Southern and Eastern African Bean Programs all maintain active training programs in their regions. There is an increased number of African scientists coming to CIAT in recent years for training, but most attend courses offered by one of the regional projects on home ground.

Observations on Training Activities 1980-1988

There has been a growing tendency for visiting scientists to participate in more than just one intensive course. Many now opt to take a specialization in a specific discipline as well. The specicialization most frequently requested is a course on On-Farm Research, as seen in the 100% increase of participants from last year to this. Another trend is the increased participation of visiting scientists from Africa as seen in the attendance this year of representatives from Zaire, Ethiopia, Somalia, Uganda, and Tanzania.

Future Training

Training activities will continue to be decentralized in 1989 with priorities given to artesanal seed production and on-farm research courses to be offered in Peru, Nicaragua, Brazil and Ecuador. Follow-up course activities will continue in El Salvador, Honduras, Costa Rica and Paraguay.

NUMBER OF PROFESSIONALS TRAINED IN THE BEAN PROGRAM, BY TRAINING CATEGORY BETWEEN 1980-1987, AND IN 1988.

	NUMBER TRAINED	
CATEGORIES	AVERAGE 1980-87	1988
INTENSIVE COURSE	10.25	2
INTENSIVE COURSE + SPECIALIZATION	15	16
SPECIALIZATION	21	38
MASTERS THESIS	3.26	3
PhD THESIS	2	1

NUMBER OF PROFESSIONALS TRAINED BY THE BEAN PROGRAM (BY DISCIPLINE) BETWEEN 1980-1987, AND IN 1988.

DISCIPLINES	NUMBER TRAINED AVERAGE 1980-87	1988
AGRONOMY	8.37	2
ECONOMICS AND SOCIAL SCIENCE	1.75	2
ENTOMOLOGY	3.00	1
ON-FARM SYSTEMS	11.37	21
PHYSIOLOGY	1.25	1
INTERDISCIPLINARY	10.62	2
BREEDING	11.50	12
MICROBIOLOGY/SOILS	2.22	6
OTHERS	0.25	1
PATHOLOGY	8.25	10
SEED PRODUCTION	1.62	7
GENETIC RESOURCES	1.00	

PROFESSIONALS TRAINED AT CIAT BY PROGRAM, UNIT, DISCIPLINE, SPECIALIZATION, AND TRAINING CATEGORY DURING 1988.

PROGRAM: BEANS	PHD THESIS	NO THESIS	MA THESIS	SPEC-IZATION	SPEC. DISC. + MULTI-COURSE	SPECIAL COURSE	INTENSIVE MULTIDISC COURSE	SUB-TOTAL
	TRAINING			CATEGORIES				
	# MONTHS	# MONTHS	# MONTHS	# MONTHS	# MONTHS	# MONTHS	# MONTHS	# MONTHS
<u>Latin America and the Caribbean</u>								
Argentina				2 (0.8)				2 (0.8)
Bolivia					1 (4.9)			1 (4.9)
Brazil				9 (20.8)				9 (20.8)
Colombia				2 (3.1)	2 (5.9)		2 (2.1)	6 (11.1)
Costa Rica				1 (1.0)				1 (1.0)
El Salvador				3 (5.1)	1 (4.7)			4 (9.8)
Guatemala			1 (5.7)		1 (3.0)			
Honduras					3 (12.3)			3 (12.3)
Mexico	1 (12.0)			3 (6.3)	1 (3.0)			5 (21.3)
Nicaragua				3 (4.7)	2 (10.5)			5 (15.2)
Panama			1 (2.6)		1 (4.9)			2 (7.5)
Paraguay				2 (4.2)				2 (4.2)
Peru				2 (2.9)	1 (4.3)			3 (7.2)
Dom. Rep.				2 (5.4)				2 (5.4)
<u>Africa</u>								
Angola					1 (2.6)			1 (2.6)
Burundi				1 (3.4)				1 (3.4)
Ethiopia				2 (4.0)				2 (4.0)
Mozambique					1 (3.5)			1 (3.5)
Somalia				2 (3.7)				2 (3.7)
Tanzania				2 (3.4)				2 (3.4)
Uganda				1 (2.8)				1 (2.8)
Zambia				1 (0.5)				1 (0.5)
<u>Developed Countries</u>								
Belgium		1(12.0)						1(12.0)
Bulgaria				1 (2.4)				1 (2.4)
Spain					1 (4.7)			1 (4.7)
USA	1 (2.2)		1 (11.3)					2 (13.5)
Great Britain	2 (19.0)							2 (19.0)
Program Total	4 (33.2)	1(12.0)	3 (19.6)	39 (74.5)	16 (64.3)		2 (2.1)	65 (205.7)

VISITING SCIENTISTS AT CIAT, 1988

PROGRAM: BEAN

NAME	COUNTRY	INSTITUTION	DISCIPLINE	SUPERVISOR	MAN MONTHS	STATUS
VISITING ASSOCIATES, No. THESIS						
SCHMIT VERONIQUE	BELGIUM	UNIV. OF GEMBLOUX	BREEDING	DAVIS J	12	P
VISITING ASSOCIATES, PhD. THESIS						
CARDENAS ALONSO MOISES RAMON	MEXICO	UNIVERSIDAD AUTONOMA DE CHAPINGO	PATHOLOGY	PASTOR C.M.	12	P
FAIRHEAD JAMES ROBERT	GR.BR.	UNIVERSITY OF LONDON	SOCIECONOMICS	DESSERT M	7	C
MULLIN BARBARA ANNE	U S A	CORNELL UNIVERSITY	PATOLOGIA	PASTOR C M	2.2	P
STONEHOUSE JOHN MICHAEL	GR.BR.	IMPERIAL COLLEGE UNIV. OF LONDON	FARMING SYSTEMS	PACHICO D	12	P
PARTICIPANTS IN THE INTENSIVE MULTIDISCIPLINARY PHASE						
GAONA RAMIREZ JENNY STELLA	COLOMBIA	CIAT	INTERDISCIPLINARY	LOPEZ M	1	C
GIRALDO SERNA HUMBERTO	COLOMBIA	CVC	INTERDISCIPLINARY	LOPEZ M	1.1	C
VISITING SCIENTISTS						
ALMARAZ SUAREZ JUAN JOSE	MEXICO	INIFAP	MICROBIOLOGY	NOLT J	2.4	C
ARCILA PULGARIN MARIA ISABEL	COLOMBIA	COMITE DE CAFETEROS	FARMING SYSTEMS	WOOLLEY J	3	C
ARGUETA P BUENAVENTURA	EL SALVADOR	CENTA	FARMING SYSTEMS	WOOLLEY J	2	C
BAKAMWANGIRAKI CHARLES W	UGANDA	KAWANDA RESEARCH STATION	BREEDING	TOHME J	2.8	C
BARRON FREYRE SABEL	MEXICO	INIFAP	FARMING SYSTEMS	WOOLLEY J	3	C
CAMARADA CASTRO PAULINO	ANGOLA	FACULTAD DE CIENCIAS AGRARIAS	FARMING SYSTEMS	WOOLLEY J	2.6	C
CARDONA GARZON WILLIAM DE J	COLOMBIA	SECRETARIA DE AGRICULTURA DE ANTIO	PATHOLOGY	CORRALES LOZA	1.1	C
CAVALCANTE V. JOSE	BRAZIL	EMBRAPA	PATHOLOGY	PACHICO D	3.1	C
CHIDIMASSAMBA ALBERTO JOSE	MOZAMBIQUE	GABINETE DAS ZONAS VERDES - INIA	FARMING SYSTEMS	WOOLLEY J	3.5	C
COTO MORAN OVIDIO ANIBAL	EL SALVADOR	UNIV. DE EL SALVADOR	MICROBIOLOGY	NOLT J	4.7	C
CUADRA AMADOR SERGIO IVAN	NICARAGUA	MIDINRA	SEED PRODUCTION	VOYSEST O	5.7	C
DANTUR NICOLAS CARLOS	ARGENTINA	ESTACION EXP. OBISPO COLOMBRES	BREEDING	SINGH S	0.2	C
DANTUR NICOLAS CARLOS	ARGENTINA	ESTACION EXP. OBISPO COLOMBRES	BREEDING	SINGH S	0.6	C
DIMOSO PETER RAMADHANI	TANZANIA	SOKOINE UNIVERSITY OF AGRICULTURE	BREEDING	KORNEGAY J	1.6	C
DOS SANTOS MAXIMO MANOEL	BRAZIL	EMATER	FARMING SYSTEMS	WOOLLEY J	2.1	C
DULCEY TORRES ROMAN GUILLERMO	COLOMBIA	ICA	FARMING SYSTEMS	WOOLLEY J	2.9	C
ESPINOZA C GERARDO ANDRES	PERU	PROYECTO ESPECIAL CHIRA-PIURA-INAD	SEED PRODUCTION	VOYSEST O	4.3	C
GIRMA TESHOME	ETHIOPIA	INST.OF AGRICULTURAL RESEARCH	BREEDING	KORNEGAY J	2.1	C
GOMEZ ESPANA ARNOLD	COLOMBIA	ICA	FARMING SYSTEMS	WOOLLEY J	2	C
GONZALEZ XEC PERFECTO A	GUATEMALA	ICTA	FARMING SYSTEMS	WOOLLEY J	3	C
IRIGOYEN Q ROSA	PERU	INST.NAL.DE INVEST.AGRARIA Y AGROI	AGRONOMY	VOYSEST O	2.6	C
JARQUIN BRICENO LORENA DEL S	NICARAGUA	MIDINRA	PATHOLOGY	PASTOR C M	2.2	C
KOSTOVA DIMITRINA P	BULGARIA	RESEARCH INST. VEGETABLE CROPS MAR	PATHOLOGY	MORALES F	2.4	C
LOPES CRUZ JAILSON	BRAZIL	EMBRAPA	PHYSIOLOGY	JEFFREY W	2.7	C
LOPEZ S DE B JEANNETTE V	NICARAGUA	MIDINRA	OTHER	LARREA L	0.8	C
MARENGE ELIZABETH T	TANZANIA	TANZANIA AGRICULT RESEARCH ORGANIZ	BREEDING	KORNEGAY J.	1.8	C
MEJIA GALEAS CARLOS MARIA	HONDURAS	SECRETARIA DE RECURSOS NATURALES	FARMING SYSTEMS	WOOLLEY J	2.8	C
MELO MANZUR SERGIO MANUEL	MEXICO	INIFAP	FARMING SYSTEMS	WOOLLEY J	2	C

PROGRAM: BEAN

NAME	COUNTRY	INSTITUTION	DISCIPLINE	SUPERVISOR	MAN MONTHS	STATUS
MODA CIRINO VANIA	BRAZIL	IAPAR	BREEDING	BEEBE S	0.8	C
MOHAMED ABUKAR MOALLIM	SOMALIA	SOMAL NATIONAL UNIVERSITY	ENTOMOLOGY	CARDONA C	1.6	C
MORAZAN VARELA JORGE ALBERTO	HONDURAS	SECRETARIA DE RECURSOS NATURALES	SEED PRODUCTION	VOYSEST O	4.7	C
MULILA JOYCE	ZAMBIA	MIN.OF AGRIC.AND WATER DEV	BREEDING	KORNEGAY J	0.5	C
NARVAEZ ROJAS LAZARO RAFAEL	NICARAGUA	MIDINRA	BREEDING	BEEBE S	1.7	C
NOVA SEGUNDO	DOMINICAN REP.	SECRETARIA DE ESTADO DE AGRICULTUR	FARMING SYSTEM	WOOLLEY J	1.8	C
NTAHIMPERA NEPHTALI	BURUNDI	ISABU	PATHOLOGY	CORRALES M P	3.4	C
OSMAN AWHUSSEIN AWYUSUF	SOMALIA	AGRICULTURAL RESEARCH STATION	BREEDUBG	KORNEGAY J	2.1	C
PEREIRA DA S ROBERTO PAIVA	BRAZIL	EPEAL	FARMINGY SYSTEM	WOOLLEY J	2.1	C
PINEDA MONGE ANA PAULINA	EL SALVADOR	UNIV. DE EL SALVADOR	MICROBIOLOGY	NOLT J	1.1	C
QUADROS RIBEIRO WALTER	BRAZIL	EMGOPA	MICROBIOLOGY	NOLT J	2.9	P
RAMOS GEROSA MARIA LUCRECIA	BRAZIL	EMGOPA	MICROBIOLOGY	NOLT J	2.9	P
RIQUELME MEDINA FAUSTO RAMON	PARAGUAY	SERVICIO DE EXTENSION AGRICOLA GAN	FARMING SYSTEM	WOOLLEY J	2.1	C
RIVAS CASTELLON ROLANDO ENRIQUE	NICARAGUA	MIDINRA	SEED PRODUCTION	VOYSEST O	4.8	C
RODRIGUEZ QUIEL EMIGDIO	PANAMA	IDIAP	SEED PRODUCTION	VOYSEST O	4.9	C
RUIZ ROCABADO EDITH	BOLIVIA	IBTA	SEED PRODUCTION	VOYSEST O	4.9	C
SANJUAN OLASO BERNARDO JOSE	SPAIN	UNIV. POLITECNICA DE VALENCIA	BREEDING	KORNEGAY J	4.7	C
SILVESTRO MILTON LUIZ	BRAZIL	ACARESC	FARMING SYSTEM	WOOLLEY J	2.1	C
SIMAO SCHWAN MARCELO	BRAZIL	EMCAPA	FARMING SYSTEM	WOOLLEY J	2.1	C
TAVAREZ CRUZ JOSE VIRGILIO	DOMINICAN REP.	SECRETARIA DE ESTADO DE AGRICULTUR	SEED PRODUCTION	VOYSEST O	3.6	C
TERRONES C SEGUNDO	PERU	INIAA	PATHOLOGY	PASTOR C M	0.3	C
TESFAYE BESHIR MOHAMED	ETHIOPIA	SCIENTIFIC PHYTOPATHOLOGICAL LABOR	PATHOLOGY	CORRALES M P	1.9	C
UCLES AGUILAR NOLVIA E	HONDURAS	SECRETARIA DE RECURSOS NATURALES	SOCIOECONOMICS	JANSSEN W	4.8	C
URIBE LORIO LIDIETH	COSTA RICA	UNIV. DE COSTA RICA	MICROBIOLOGY	NOLT J	1	C
VARGAS DE LEIVA MARIA ZULLY	PARAGUAY	SERVICIO DE EXTENSION AGRICOLA GAN	FARMING SYSTEMS	WOOLLEY J	2.1	C
VELASCO NUNO RAYMUNDO	MEXICO	INIFAP	FARMING SYSTEMS	WOOLLEY J	1.9	C
ZAMBRANO M FREDIS ANTONIO	EL SALVADOR	CENTA	FARMING SYSTEMS	WOOLLEY J	2	C
GUZMAN ALBUREZ MARCIAL ERNESTO	GUATEMALA	ICTA	PATHOLOGY	PASTOR C M	6.3	C
OREE AMOS	UGANDA	MINISTRY OF AGRICULTURE	BREEDING	ALLEN D	1	C

VISITING SCIENTISTS, MS. THESIS

ACOSTA NAVARRO MIGUEL ANGEL	PANAMA	IDIAP	AGRONOMIA	VOYSEST O	2.6	C
BAIER ANN HEATHER	U S A	UNIV. DE CALIFORNIA	FINCAS-SISTEMAS	WOOLLEY J	11.3	C
GUZMAN ALBUREZ MARCIAL ERNESTO	GUATEMALA	ICTA	PATOLOGIA	PASTOR C M	5.7	P

APPENDIX B. BEAN PROGRAM PERSONNEL (December 1988)

Pachico Douglas, Ph. D., Agricultural Economics, Bean Program Leader

Allen, David, Ph.D., Plant Pathology, Regional Coordinator, Southern African Bean Project (stationed in Arusha, Tanzania)
Beebe, Stephen, Ph.D., Plant Breeding
Cardona, Cesar, Ph.D., Entomology
Davis, Jeremy H.C., Ph.D., Plant Breeding. Regional Coordinator, Central Africa Bean Project (stationed in Rubona, Rwanda)
Dessert, Michael, Ph.D., Plant Breeding, Regional Coordinator, Central America Bean Project (stationed in San Jose, Costa Rica)
Edje, Todo Ohgenetsevbuko, Ph.D., Agronomy (stationed in Arusha, Tanzania)
Frias, Gustavo, Ph.D., Pathology (stationed in San Jose, Costa Rica)
Galvez, Guillermo E., Ph.D., Plant Pathology, Regional Coordinator, Andean Bean Project (stationed in Lima, Peru)
Graf, Willi, Dip. Ing. Ag. (stationed in Rubona, Rwanda)
Henry, Guy, Ph.D., Economics (Postdoctoral Fellow)
Janssen, Wilhelmus, Ph.D., Agricultural Economics
Kipe-Nolt, Judith, Ph.D., Microbiology
Kirkby, Roger A., Ph. D., Agronomist, Regional Coordinator East Africa Bean Project, (stationed in Ethiopia)
Kornegay, Julia L., Ph.D., Plant Breeding
Lynch, Jonathan, Ph.D., Physiology (Postdoctoral Fellow)
Morales, Francisco J., Ph.D., Virology
Orozco, Silvio H., MS., Agronomy, Central America Bean Project (stationed in Guatemala City, Guatemala)
Pastor-Corrales, Marcial, Ph.D., Plant Pathology
Singh, Shree P., Ph.D., Plant Breeding
Smithson, Barry, Ph.D., Plant Breeding, (stationed in Arusha, Tanzania)
Sperling Louise, Visiting Research Fellow in Social Sciences (Butare, Rwanda)
Thung, Michael D., Ph.D., Agronomy (stationed at CNPAF, Goiania, Brazil)
Tohme, Joseph, Ph.D., Plant Breeding (Postdoctoral Fellow)
Trutmann, Peter, Ph.D., Plant Pathology, Great Lakes Bean Project (stationed in Rubona, Rwanda)
Voss, Joachim, Ph.D., Cropping Systems Specialist, Great Lakes Bean Project (stationed in Rubona, Rwanda)
Voysest, Oswaldo, Ph.D., Agronomy
White, Jeffrey, Ph.D., Plant Physiology
Woolley, Jonathan, Ph.D., Agronomy, Cropping Systems
Wortmann, Charles, Ph.D., Agronomy, Cropping systems Specialist, East Africa Bean Project (stationed in Kawanda, Uganda)

Research associates and other staff

Castaño, Mauricio, Ing. Agr., Virology
Gutierrez, Jose Ariel, M.Sc., Plant Breeding
Guzman, Pablo, M. Sc., Pathology
van Herpen, Dorein, M.S., Economics
Londoño, Nohra Ruiz de, Ing. Agr., Economics
Luna, Carlos Adolfo, M.Sc., Economics
Maquet, Alain, Agronomy, M. Sc., CIAT Gembloux Project
Niessen, Andrea, M.Sc., Virology
Ochoa, Ivan, M.Sc., Breeding
Schmit, Veronique, M.Sc., Associate Expert, FAO

Research assistants

Beltrán, Jorge A., Ing. Agr., Cropping Systems
Cajiao, César, Ing. Agr., Plant Breeding
Castaño Jairo, Estatistics, Economics
Castillo, Jesús A., Ing. Agr., Physiology
Cortés, Maria Luisa, Ing. Agr., Entomology
Erazo, Oscar, Ing. Agr., Agronomy
Gaona Jenny, Ing. Agr., Economics
Gonzáles, Alonso, Biol., Physiology
Jara, Carlos, Ing. Agr., Plant Pathology
Lareo, Leonardo, Nutritionist, Nutrition
Lopez, Yolanda, Biol., Breeding
Martínez, Nelson, Ing. Agr., Agronomy
Montes de Oca, Gustavo, Ing. Agr., Agronomy
Ocampo, Gloria Isabel, Bact., Microbiology
Pino, Carlos, Ing. Agr., Physiology
Posso, Carmen Elisa, Biol., Entomology
Quiroz, Jairo, Ing. Agr., Breeding
Santacruz, Diego, Ing. Agr., Agronomy
Tejada, Gerardo, Ing. Agr., Agronomy
Trujillo, Fernando, Ing. Agr., Cropping Systems
Urrea, Carlos, Ing. Agr., Breeding
Valderrama, Hernando, Economics, Office of the Coordinator
Vargas, Herney, Ing. Agr., Microbiology

APPENDIX C. PUBLICATIONS

Journal Articles:

Cobo, S. and M.A. Pastor-Corrales (1987). Variacion patogenica y fuentes de resistencia a Colletotrichum lindemuthianum (Sacc / Magn) Scrib., patogeno de la antracnosis del frijol, en Colombia. **Acta Agronomica** 37 (1): 36-47.

Davis, J.H.C.; K.E. Giller,, J. Kipe-Nolt, and M. Awah. (1988). Nonnodulating mutants in common beans. **Crop Science** 28 no. 4.

Morales, F.(1988). Virus diseases of beans in the tropics. **Rev. Tropical Plant Path.** 3:405-419.

Morales, F.J. and A.Niessen (1988). Comparative responses of selected Phaseolus vulgaris germplasm inoculated artificially and naturally with bean golden mosaic virus. **Plant Disease** 72: 1020-1023.

Nienhuis, J. and S. P. Singh (1988). Genetics of seed yield and its components in common bean (Phaseolus vulgaris L.) of Middle-American origin. I. General combining ability. **Plant Breeding** 101:143-154.

Nienhuis, J. and S. P. Singh (1988). Genetics of seed yield and its components in common bean (Phaseolus vulgaris L.) of Middle-American origin. II. Genetic variance, heritability and expected response from selection. **Plant Breeding** 101:155-163.

Osborn, T. C.; D. C. Alexander, S. S. M. Sun, C. Cardona & F. A. Bliss (1988). Insecticidal activity and lectin homology of arcelin seed protein. **Science** 240: 207-210.

Pastor-Corrales, M. A. and G. S. Abawi (1988). Reactions of selected bean accessions to infection by Macrophomina phaseolina. **Plant Disease** 72(1): 39-41.

Pachico, D.; J. K. Lynam and P. G. Jones. (1987). The distribution of benefits from technical change among classes of consumers and producers: An ex ante analysis of beans in Brazil. **Research Policy** 16: 279-285.

Pastor-Corrales, M. A. and G. S. Abawi (1988). Bean accessions with resistance to Rhizoctonia solani under field conditions in Colombia. **Turrialba** 38: 87-92.

Working Papers and CIAT Documents:

Allen, D. J. and J. B. Smithson (1988). The regional program on beans (Phaseolus vulgaris L.) in Southern Africa: strategy and progress in plant improvement. IBPGR/UNEP/IITA Workshop on Plant Genetic Resources in Africa, Nairobi, Kenya 26-30 September, 1988.

Allen D. J.; and J.B.Smithson (1987) Proceedings of the Bean Fly Workshop, Arusha - Tanzania, November 16-20, 1986. Pan-African Workshop Series, No. 1. CIAT, Cali, Colombia.

Amijee, F.; O.T. Edje, E.K. Koinange, H.F. Bitanyi, S.J. Broderick, and K.E. Giller (1988). Nodulation and soil fertility studies in Phaseolus vulgaris L. in northern Tanzania. IIIe Conference AABN, 7-12 Nov 1988, Dakar, Senegal.

Araya C. A.; and M.A.Pastor-Corrales (1988). Variación patogenica de Colletotrichum lindemuthianum en Costa Rica. Abstract. American Phytopathological Society (Caribbean Division) San Andres, Sept. 1988.

Beebe, S. Mejoramiento de la resistencia al Apion: la contribucion del CIAT. II Taller Internacional sobre Apion, Danli, Honduras, C. A. Nov. 29 - Dec 1. 1988. Memorias.

Beltran J.A.; J.N.Woolley, J.H. Tobon. J. Arias (1988) La investigacion a nivel de finca: caso del sistema de relevo maiz-frijol en San Vicente, Colombia, 1982-1987. CIAT - ICA. Documento de trabajo no. 33. (#SB 540.053 159)

Borbon,E.; W. Janssen and G. Hernandez (1988). Factores que inciden en la adopcion de cultivares mejorados de frijol en diferentes zonas productoras de Costa Rica. Abstract. 34th PCCMCA, San Jose, Costa Rica, 21th to 25th of March, 1988.

Cardenas, M.; G. Abawi and M.A. Pastor-Corrales (1988). Observaciones preliminares sobre la mustia hilachosa del frijol en Colombia. Pag. 22-23. IX Congreso Ascolfi, Pasto, Colombia 22-24, 1988.

Cardona, C. (1988). Fuentes de resistencia a Apion spp: Resumen, 1988. pp. 38-40 In: II Taller Internacional sobre Apion, Danli, Honduras, 29 Nov-1 Dic. 1988. Secretaría de Recursos Naturales de Honduras, CIAT.

Cardona, C. and J. Kornegay (1988). Use of wild Phaseolus vulgaris to improve beans for resistance to bruchids. In: Proceedings of International Workshop on Breeding Common Beans. Nov. 7-11, 1988. CIAT, Cali, Colombia

Castillo, J. and J. W. White (1988). Management of drought trials. p. 242-260. In: Research on Drought Tolerance in Common Bean. White, J.W., G. Hoogenboom, F. Ibarra and S. P. Singh (eds.). Documento de Trabajo No. 41. Bean Program, CIAT; Cali, Colombia.(#SB 327.R38)

Davis, J. and W. Janssen (editors) (1988). El mejoramiento genetico de la habichuela en America Latina, Memorias de un Taller. CIAT, Documento de trabajo No. 30. Cali, Colombia, 1988.

Debouck, D. G.; R. Araya, W.G. Gonzalez and J. Tohme (1988). Presencia de formas silvestres de Phaseolus vulgaris L. en Costa Rica.Abstract. 34th PCCMCA, San Jose, Costa Rica, 21-25 de Marzo 1988, p.75.

Edje, O. T.; J.M.R. Semoka, and K.L. Haule (1988). Traditional forms of soil fertility maintenance. Soil Fertility Research Workshop for Bean Cropping Systems in Africa, Addis Ababa, Ethiopia, 5-9 Sept. 1988.

Galvez, G.; B. Mora, M. Rojas (1987). Vivero internacional de mustia hilachosa del frijol. Resultados 1973-1985. San Jose, Costa Rica. CIAT, Cali, Colombia (#SB 608.B4 V5)

Galvez, G. (1988). Informe del Seminario para la Planificacion de la Generacion y la transferencia de Tecnologia de Frijol en Peru. (Metodo PPO), Paper presented at Chaclacayo (Peru), 9-13 de Mayo de 1988. Programa Regional de Frijol Zona Andina, CIAT.

Galvez, G. (1988) Informe del Seminario para la Planificacion de la Generacion y transferencia de tecnologia del cultivo de frijol en Ecuador. Paper presented in Ibarra-Ecuador, del 15 - 18 de Agosto de 1988. Programa Regional de Frijol, Zona Andina. CIAT.

Graf, W. and P. Trutmann (1988). Methodology and results of diagnostic trials on common beans in Rwanda: a critical appraisal. In:Proceedings of a Workshop on Bean Research in Eastern Africa. Mukono, Uganda, June 22 - 25 1987. CIAT, African Workshop Series, No. 2. (Dcto. no. 29.792)

Graf, W. (1988).Intégration des engrais verts dans des systèmes de production basés sur le haricot; Colloque sur la jachère intensive; 11-12 nov. 1988; Nyabisindu (Rwanda)

Graf, W. and V.Ndoreyaho (1988). Agroforestry Research in Bean Based Cropping Systems of Africa; First Workshop on Soil Fertility Management in Bean Based Cropping Systems in Africa; 4-9 Sept. 1988; Addis Ababa (Ethiopia)

Hoogenboom, G.; J. W. Jones and J. W. White (1988). Use of models in studies of drought tolerance. p. 192-230. In: Research on Drought Tolerance in Common Bean. White, J. W., G. Hoogenboom, F. Ibarra and S. P. Singh (eds.). Documento de trabajo No. 41. Bean Program, CIAT; Cali, Colombia. (#SB 327.R38)

Janssen, W. (1988). El cultivo de la habichuela en varios paises de America Latina. In: El mejoramiento genetico de la habichuela en America Latina. (May 11-15, 1987, Cali, Colombia) Memorias de un Taller. Documento de trabajo no. 30. CIAT, Cali, Colombia (#SB 327.M38)

Janssen, W. (1988). Produccion y demanda de habichuela en paises en desarrollo (datos preliminares). In: El mejoramiento genetico de la habichuela en America Latina. (May 11-15, 1987, Cali, Colombia) Memorias de un Taller. Documento de trabajo no. 30. CIAT, Cali, Colombia (#SB 327.M38)

Janssen, W. (1988). A socio-economic perspective on earliness in beans. Paper presented at the Bean Breeders Workshop at CIAT, 7th to 12th of November, 1988, Cali, Colombia.

Janssen, W. (1988). Dry bean production and consumption in the year 2000: Projections, thoughts and guesses with emphasis on Latin America and Africa. Paper presented at the Bean Breeders Workshop at CIAT, 7th to 12th of November, 1988, Cali, Colombia.

Jara, C. and M.A. Pastor-Corrales (1988). Efecto de Phaeoisiaropsis griseola sobre los componentes de rendimiento en tres lineas de frijol comun, Phaseolus vulgaris, en Popayan. IX Congreso ASCOLFI, Pasto, Colombia, Junio 22-25, 1988.

Kipe-Nolt, J. and R. Bradley (1988). Manual:Simbiosis leguminosa-rizobio. Manual de metodos de evaluacion y manejo. Cali, Colombia (CIAT-SB 203.S541) Also in English.

Kirkby, R.A. (ed.) (1988). Proceedings of a Workshop on Bean Research in Eastern Africa. Muknono, Uganda June 22-25, 1987. CIAT African Workshop Series, No. 2.

Kirkby, R.A. A review of activities of the Eastern Africa Bean Programme, In: Proceedings of a Workshop on Bean Research in Eastern Africa. Mukono, Uganda 22-25 June 1987. CIAT African Workshop Series, No. 2.

Kirkby, R.A.; J.B. Smithson, D.J. Allen, and G.E. Habich (1987). CIAT's regional bean programs in Africa. Regional Workshop on Training Needs for Agricultural Research in Eastern & Southern Africa, Arusha, Tanzania, 20-24 July, 1987.

Kornegay, J. (1988).Estrategias para el mejoramiento de la produccion de habichuelas en CIAT, para la roya, mancha angular, ascochyta y mustia. In: El mejoramiento genetico de la habichuela en America Latina. Memorias de un taller, pp. 207-214. Cali, Colombia. CIAT. Documento de trabajo no. 30. (#SB 327.M38)

Kornegay, J. and C. Cardona (1988). Development of appropriate breeding strategies for resistance to Empoasca kraemeri in common beans. In: Proceedings of International Workshop on Breeding Common Beans. Nov. 7-11, 1988. CIAT, Cali, Colombia.

Lanter, J.M.; M.A Pastor-Corrales, J.G. Hancock (1987). Progress of angular leaf spot of beans grown on monocultures and bean-maize intercrops. Abstract. American Phytopathological Society Meeting, Cincinnati, Ohio, 1987.

Lareo, L. R. (1988). Nutritional quality and acceptability characteristics of common beans (P. vulgaris L.): a collection of unsolved problems. Cali, Colombia, CIAT 35 pp.

Lynam J. K. and W. Janssen (1988). Commodity Research Programs from the Demand Side. In: Trends in CIAT Commodities, Internal Document-Economics.

Montes de Oca, G. (1988). Mejoramiento genetico de la habichuela en el CIAT y resultado de viveros internacionales. In: El mejoramiento genetico de la habichuela en America Latina. Memorias de un taller, pp. 207-214. Cali, Colombia. CIAT. Documento de trabajo no. 30. (#SB 327.M38)

Morales, F. J. (1988). Bean Common Mosaic Virus. AAB Descriptions of Plant Virus. September, 1988. No. 337 (No. 73 revised).

Mbuya, O. S.; O.T.E. Edje, and P.A.M. Ndakidemi (1988). Yield of beans and maize grown in monoculture and in association with single and paired rows of maize. Seventh Bean Research Workshop. Sokoine University of Agriculture, Morogoro, Tanzania, September 28-30, 1988.

Mulder, Menno. (1988). The differences between urban marketing and consumption of vegetables versus staple foods. (A case study on snap bean consumption and marketing in Bogota, Colombia). March 1988. CIAT, Cali, Colombia.

Mullin, B.A.; G.S. Abawi and J. Kornegay (1988). Host suitability of bean germplasm to Meloidogyne incognita and M. hapla. Abstract. American Phytopathological Society Meeting, San Diego, CA. 1988.

Ndakidemi, P.A.M.; O.T.E. Edje, and O.S.Mbuya (1988). Effect of number of bean plants per hill in association with maize on yield. Seventh Bean Research Workshop, Sokoine University of Agriculture, Morogoro, Tanzania. September 20-30, 1988.

Orozco, S. H.(1988). Informe de viveros centroamericanos de adaptacion y rendimiento de frijol Vicar 1986. Abstract. 34th PCCMCA, San Jose, Costa Rica, 1988. 105 p.

Orozco, S. H.(1988). Algunas observaciones sobre manejo de control integrado del mosaico dorado del frijol (BGMV) en Guatemala. Abstract. 34th PCCMCA, San Jose, Costa Rica, 1988.

Orozco, S. H.(1988). Manejo agronómico del cultivo del frijol. Segundo Curso Internacional de Frijol, 17 a 28 Octubre 1988. Solola, Guatemala..

Orozco, S. H. (1988). El programa de Frijol de CIAT y sus relaciones con los programas de Frijol de Centroamerica y el Caribe. Segundo Curso Internacional de Frijol, 17 a 28 de Octubre 1988. Solola, Guatemala.

Orozco, S. H. and A. Morales (1988). Avance de los resultados de los viveros centroamericanos de adaptación y rendimiento, de frijol (Vicar 1987). Abstract. 34th PCCMCA, San Jose, Costa Rica, 1988.

Otoya, M. M.; M.A. Pastor-Corrales and G. Castellanos (1988). Reaccion de lineas seleccionadas de frijol a la infeccion de aislamientos brasileros y Colombianos de Fusarium oxysporum of. sp. solani. IX Congreso ASCOLFI, Pasto, Colombia. Junio 22-28, 1988.

Pachico, D. (1988) The potential of snap beans as a crop for small farmers in the tropics. In: El mejoramiento genetico de la habichuela en America Latina. Memorias de un Taller, pp. 207-214. Cali, Colombia. CIAT. Documento de trabajo no. 30. (SB 327.M38)

Pachico, D. (1988) The contribution of socioeconomics to agricultural research: A Review. In: Proceedings of a Workshop on Bean Research in Eastern Africa. R. A. Kirkby, ed. CIAT, African Workshop Series, No. 2. Cali, Colombia.

Pastor-Corrales, M. A. (1988). Estrategia de resistencia genetica en Frijol (Phaseolus vulgaris) al patogeno de la antracnosis (Colletotrichum lindemuthianum). Trabajo presentado en el IX congreso de ASCOLFI. Pasto, Colombia. Junio 22-25 de 1988.

Pastor-Corrales, M. A.; M.M. Otoya, G. Castellanos and L. Afanador (1988). La antracnosis del frijol y los objetivos del Taller de trabajo. Trabajo presentado en el Taller de Tabajo, Antracnosis del Frijol Comun, Phaseolus vulgaris, en America Latina. Junio 6-10, 1988. CIAT, Cali, Colombia.

Pastor-Corrales, M. A.(1988). Variacion patogenica de Colletotrichum lindemuthianum el agente causal de la antracnosis del frijol y una propuesta para su estandarizacion. Presentado en el Taller de Trabajo Antracnosis del Frijol Comun, Phaseolus vulgaris, en América Latina. Junio 6-10, 1988, CIAT, Cali, Colombia.

Pastor-Corrales, M. A. (1988). Biocontrol of bean rust with a virulent isolate of Uromyces appendiculitis under field conditions. Abstract. APS-CD. San Andres. Sept. 1988.

Pastor-Corrales, M. A. (1988). Population of Thanatephorus cucumeris on two bean varieties under mulching and ridging. Abstract. APS-CD, San Andres. Sept. 1988.

Ruiz, M.; A. Viana and S.H. Orozco (1988). Aceptacion y prognostico de impacto en Guatemala con la variedad de frijol ICTA-Ostua. Abstract. 34th PCCMCA, San Jose, Costa Rica, 1988.

Schmit, V. (1988). Catalogo de germoplasma de : Phaseolus coccineus y L. Phaseolus polyanthus Green.Documento de Trabajo 42. CIAT, Cali, Colombia.

Singh, S. P. and J. W. White (1988). Breeding common beans for adaptation to drought conditions. p. 261-284. In: Research on Drought Tolerance in Common Bean. White, J. W., G. Hoogenboom, F. Ibarra and S. P. Singh (eds.). Documento de Trabajo No. 41. CIAT; Cali, Colombia.

Trutmann P. (1988). Recherche sur l'efficacité d'enrobage des semences avant le semis contre les maladies transmis par semences, les maladies racinaires, et la mouche du haricot. In: Proceedings of '3ème Séminaire Régional sur le Haricot, Kigali 18-21 Novembre, 1987.

Trutmann P. (1988). Epidemiology in pure stands and varietal mixtures. In: Proceedings of the 1st African Bean Pathology Workshop, Kigali 14-16 November, 1987, CIAT/ISAR.

Trutmann P. and M. Dessert (1988). Résultats de la Pépinière Régionale pour l'Evaluation ders Lignées Avancées de l'Afrique Centrale (PRELAAC) et de la Pépinière Régionale pour l'Evaluation de Résistance (PRER). In: Proceedings of '3ème Séminaire Régional sur le Haricot, Kigali 17-21 Novembre, 1987.

Trutmann P. and W. Graf (1988). Les facteurs limitants de la production du haricot au Rwanda et stratégies pour leur contrôle. In: Séminaire sur les maladies et ravageurs des cultures vivrières en Afrique Centrale. Bujumbura 16-21 Février, 1987, ISABU/IRAZ/CIAT.

Viana, A. and E. Borbon (1988). Descripcion y analisis de estrategias para liberar, transferir y produccion de semilla con nuevas variedades de frijol en Centro America. Abstract. 34th PCCMCA, San Jose, Costa Rica 1988.

Voysest, O. and J. García (1988). Grados de coincidencia y discrepancia en el comportamiento de lineas de frijol en localidades de Costa Rica y Colombia. Abstract.34th PCCMCA, San José, Costa Rica, 1988.

Voysest, O. IBYAN 1989 (Marzo 1989 - Marzo 1990). CIAT - Cali, Colombia.

Voysest, O. International Bean Trials. Broad classification of CIAT International Bean Trials. CIAT - Cali, Colombia.

Voysest, O. Informe Final - VEF 1988. CIAT - Cali, Colombia.

White, J.W.; G. Hoogenboom, F. Ibarra and S. P. Singh (eds.). (1988). Research on drought tolerance in common bean. Proceedings.Documento de Trabajo No. 41. 299 pp. CIAT, Cali, Colombia. (CIAT# SB327.R38)

White, J. W. (1988). Preliminary results of the bean international drought yield trial (BIDYT). p. 126-145. In: Research on Drought Tolerance in Common Bean. White, J. W., G. Hoogenboom, F. Ibarra and S. P. Singh (eds.). Documento de Trabajo No. 41. CIAT; Cali, Colombia.

White, J. W. and J. Castillo (1988). Studies at CIAT on mechanisms of drought tolerance in beans. p. 146-164. In: Research on Drought Tolerance in Common Bean. White, J.W., G. Hoogenboom, F. Ibarra and S. P. Singh (eds.). Documento de trabajo No. 41. CIAT, Cali, Colombia.

White, J.W. and J. Castillo. (1988). Breeding common beans for adaptation to drought conditions. In: Research on Drought Tolerance in Common Bean. White, J.W., G. Hoogenboom, F. Ibarra and S. P. Singh (eds.). Documento de trabajo No. 41. CIAT, Cali, Colombia.

Woolley, J. N.; J. Beltran, and M. Melo. (1988). La investigacion a nivel de finca: Caso del frijol en Funes Colombia, 1982-1987. Mayo de 1988. CIAT - ICA. Documento de trabajo No. 34.

Woolley J. N.; J.Beltran, R. Vallejo, and M.Prager (1988). Identifying appropriate technologies for farmers: the case of the bean + maize system in Ipiales, Colombia, 1982-1986.Working document No. 31.CIAT, Cali, Colombia.

Book Chapters:

Debouck D. G. (1988). Phaseolus germplasm exploration. In: **Genetic Resources of Phaseolus Beans**, P. Gepts (ed.), Kluwer Academic Publishers, Dordrecht, Holland, p. 3-29. (SB 327.G47)

Hidalgo, R. (1988). The Phaseolus world collection. In: **Genetic Resources of Phaseolus Beans**, P. Gepts (ed.), Kluwer Academic Publishers, Dordrecht, Holland, p.67-90. (SB 327.G47)

Janssen, W. (1988). Snap beans in the developing world. In: **Snap Beans: Present Status in the Developing World and Bibliography of Research (1919-1987)**.Janssen, W.; S. Lopez, Gonzalez, V. (eds.) CIAT, Cali, Colombia. (Z 5074.S6 J3) (Dcto. 29.937)

Newsletters, Annual Reports:

Cardona, C.; Posso, C.E. (1987). Bean varietal resistance to stored grain weevils: sources, mechanisms and factors of resistance. Bean Newsletter 9 (2): 1-4.

CIAT. (1987,1988). Annual Report of the Bean Program. Cali, Colombia.

Davis, J.H.C. (1988). New bean varieties for Burundi. CIAT Bean Newsletter, Vol. 10 No.1, July 1988.

Davis, J.H.C.; K.E. Giller, J. Kipe-Nolt, and M. Awah (1988). Selecting for nonnodulating mutants. Bean Improvement Cooperative Annual Report 31.

Debouck, D. G.; H.Rubiano and M.Menendez del Carmen (1988). Determinate climbers among Argentinian materials of Phaseolus vulgaris L., Bean Improvement Cooperative Annual Report 3.

Harmsen, R.; F. A. Bliss, C. Cardona, C. E. Posso and T. C. Osborn (1988). Transferring genes for arcelin protein from wild to cultivated beans: implications for bruchid resistance. Bean Improvement Cooperative Annual Report 31.

Kipe-Nolt, J. and P.Pineda (1988). Una estrategia para mejorar la fijacion de nitrogeno: ejemplos de El Salvador. Hojas de Frijol 10(2):8-10.

Mukishi, P.M. and P. Trutmann (1988). Can diseases be effectively controlled in traditional varietal mixtures using resistant varieties? Bean Improvement Cooperative Annual Report 31.

Pachico, D. (1987). Demand in the world bean market: prospects for international trade. Michigan Dry Bean Digest 11 (3):8-10.

Pachico, D. (1987). Estudio de casos sobre cambio tecnologico en la produccion de frijol en America Latina. In: La investigacion de frijol en campos de agricultores de America Latina. Memorias de un Taller.Documento de trabajo no. 27. (#SB 327.1595) (Dcto. 30.686) CIAT, Cali, Colombia.

Schinkel, C.; S.P. Singh, and P. Gepts (1988). Patterns of genetic diversity in Phaseolus beans. Bean Improvement Cooperative Annual Report 31.

Singh, S. P. (1988). Mejoramiento del rendimiento del frijol comun. Hojas de Frijol para America Latina 10(2,:5-6.

Singh, S.P. (1988). Patrones de variacion en el frijol comun. Hojas de Frijol para America Latina 10 (2): 6-8.

Singh, S. P. (1988). Gene pools in cultivated dry bean. Bean Improvement Cooperative Annual Report 31.

Singh, S. P. (1988). Breeding common beans of Middle-American origin for seed yield in contrasting environments in tropics. Bean Improvement Cooperative Annual Report 31.

Singh, S.P. (1988). Breeding for dry bean yield. Bean Newsletter 10:5-6.

Singh, S. P. (1988). Patterns of variation in cultivated dry beans. Bean Newsletter 10:6-8.

Singh, S. P., C. Cajiao, J. A. Gutierrez, J. Garcia, M. A. Pastor-Corrales, and F. J. Morales (1988). Selection for bean yield under low and high stress environments. Bean Improvement Cooperative Annual Report 31.

Voss, J. (1988). Mezclas varietales de frijol en Africa Central: manejo y utilidad para el desarrollo de tecnologias estrategias. Hoja de Frijol para America Latina 10 (2): 1-4.

Voysest, O. and M. Dessert (1988). Market classes of dry edible beans grown commercially in the world. Michigan Dry Bean Digest Volume 12 Number 4:13-14.

Voysest, O. and M. Dessert (1988). Market classes of dry edible beans grown commercially in the world. Bean Improvement Cooperative Annual Report 31.

Audiotutorials on Beans

Allen, D.J. (1986). Bean Production Systems in Africa (French, English)

Allen, D.J. (1987). Principal Diseases of Beans in Africa (French, English)

Cardona, C. (1988). Main Insect Pests of Stored Beans and their Control (English,Spanish)

Cardona, C.; V. Salguero, O. Diaz, E. Garcia, and F. Monzon (1987).El Picudo de la Vaina del Frijol y su Control.

Davis, J.H.C. and J.B. Smithson (1986). Principles of Intercropping with Beans (English, French)

Debouck, D. and R. Hidalgo (1986). Morphology of the Common Bean Plant (English, Spanish, French)

Fernandez, F.; P. Gepts and M. Lopez (1986). Stages of Development of the Common Bean Plant (English, Spanish, French)

Hidalgo, R.; L. Song, and P. Gepts (1986) The Cultivated Species of Phaseolus (English, Spanish).

Kipe-Nolt, J. and R. Bradley (1988), Legume-Rhizobium symbiosis:selection, evaluation and agronomic management.

Morales, F.J. and M. Castano (1988) Principales Enfermedades Virales del Frijol en America Latina y su Control.

Pastor-Corrales, M. A. (1988). El Moho Blanco del Frijol y su Manejo.

Schwartz, H.F. and M.A. Pastor-Corrales (1988). El Moho Blanco de Frijol y su Manejo.

Voysest, O. and M. Lopez (1986). Mejoramiento del Frijol por Introduccion y Seleccion.

Voysest, O. (1987). Variedades de Frijol en America Latina y su Origen.

White, J.W. (1988). Conceptos Basicos de la Fisiologia del Frijol.